Limitations

AECOM Infrastructure & Environment UK Limited ("AECOM") has prepared this Report for the sole use of Oxfordshire County Council ("Client") in accordance with the Agreement under which our services were performed (47073843 May 2015). No other warranty, expressed or implied, is made as to the professional advice included in this Report or any other services provided by AECOM. This Report is confidential and may not be disclosed by the Client nor relied upon by any other party without the prior and express written agreement of AECOM.

The conclusions and recommendations contained in this Report are based upon information provided by others and upon the assumption that all relevant information has been provided by those parties from whom it has been requested and that such information is accurate. Information obtained by AECOM has not been independently verified by AECOM, unless otherwise stated in the Report.

The methodology adopted and the sources of information used by AECOM in providing its services are outlined in this Report. The work described in this Report was undertaken between May and August 2015 and is based on the conditions encountered and the information available during the said period of time. The scope of this Report and the services are accordingly factually limited by these circumstances.

Where assessments of works or costs identified in this Report are made, such assessments are based upon the information available at the time and where appropriate are subject to further investigations or information which may become available.

AECOM disclaim any undertaking or obligation to advise any person of any change in any matter affecting the Report, which may come or be brought to AECOM’s attention after the date of the Report.

Certain statements made in the Report that are not historical facts may constitute estimates, projections or other forward-looking statements and even though they are based on reasonable assumptions as of the date of the Report, such forward-looking statements by their nature involve risks and uncertainties that could cause actual results to differ materially from the results predicted. AECOM specifically does not guarantee or warrant any estimate or projections contained in this Report.

Copyright

© This Report is the copyright of AECOM Infrastructure & Environment UK Limited. Any unauthorised reproduction or usage by any person other than the addressee is strictly prohibited.
# Contents

1. **Introduction** ................................................................................................................................. 9
   1.1 Terms of Reference .......................................................................................................................... 9
   1.2 Background ..................................................................................................................................... 9
   1.3 Project Deliverables ....................................................................................................................... 12
   1.4 Previous Studies ............................................................................................................................ 12
   1.5 Level 1 SFRA Methodology .......................................................................................................... 12
   1.6 Stakeholder Consultation .............................................................................................................. 13

2. **Study Area** ...................................................................................................................................... 14
   2.1 Overview ........................................................................................................................................ 14
   2.2 Topography ..................................................................................................................................... 14
   2.3 Geology .......................................................................................................................................... 14
   2.4 Main Rivers in Oxfordshire ........................................................................................................... 15

3. **Legislative and Planning Policy Context** .......................................................................................... 17
   3.1 National Planning Policy Framework (2012) ..................................................................................... 17
   3.2 Planning Practice Guidance (2014) ................................................................................................. 17
   3.3 National Planning Policy for Waste ............................................................................................... 18
   3.4 The Flood and Water Management Act (2010) ............................................................................. 18
   3.5 Amendments to policy on Sustainable Drainage Systems ............................................................. 19
   3.6 Flood Risk Regulations ................................................................................................................... 20
   3.7 Oxfordshire Minerals and Waste Local Plan ................................................................................. 20

4. **Flood Risk in Oxfordshire** .................................................................................................................. 22
   4.1 Introduction ..................................................................................................................................... 22
   4.2 Review of Historic Flood Event Records ....................................................................................... 22
   4.3 Recent Significant Flood Events .................................................................................................... 22
   4.4 Flooding from Rivers ...................................................................................................................... 23
   4.5 Flooding from Surface Water .......................................................................................................... 25
   4.6 Flooding from Groundwater ......................................................................................................... 26
   4.7 Flooding from other sources ......................................................................................................... 27
   4.8 Climate Change ............................................................................................................................. 28
   4.9 Flood Risk Management Measures ............................................................................................... 29

5. **Mineral and Waste Area Assessments** ............................................................................................. 31
   5.1 Overview ........................................................................................................................................ 31
   5.2 Limitations ..................................................................................................................................... 32
   5.3 Assessment Results – Mineral Areas ............................................................................................ 32
   5.4 Assessment Results – Waste Areas ............................................................................................... 33
   5.5 Assessment Results – Radioactive Waste Management sites ..................................................... 34

6. **Guidance for Applying the Sequential and Exception Tests** ............................................................. 35
   6.1 Sequential Test ............................................................................................................................... 35
   6.2 Applying the Sequential Test – Plan-Making .................................................................................. 35
   6.3 Recommended stages for application of the Sequential Test ...................................................... 37
   6.4 Windfall Sites ................................................................................................................................. 38
   6.5 Exception Test ............................................................................................................................... 38
   6.6 Exception Test Exemptions ............................................................................................................. 39

7. **Guidance for preparing Site-Specific FRAs** ...................................................................................... 40
   7.1 Overview ........................................................................................................................................ 40
   7.2 When is a Flood Risk Assessment Required? ................................................................................ 40
   7.3 What should a Flood Risk Assessment address? .......................................................................... 40
   7.4 Guidance on Flood Risk Management Measures ......................................................................... 42

8. **Guidance for the Application of SuDS** ............................................................................................. 46
   8.1 Introduction ..................................................................................................................................... 46
   8.2 Type of SuDS ............................................................................................................................... 47
   8.3 National SuDS Standards ............................................................................................................. 48

9. **Summary and Recommendations** ..................................................................................................... 50
9.1 Mineral & Waste Planning Policy ................................................................. 50
9.2 Level 1 SFRA Update .................................................................................. 50

List of Appendices

Appendix A. Review of Historic Flood Event Records
Appendix B. Historic Flood Event Maps
Appendix C. Fluvial Flood Zone Maps
Appendix D. Risk of Flooding from Surface Water Maps
Appendix E. Areas Susceptible to Groundwater Flooding Maps
Appendix F. Mineral Broad Area Options and associated sites Flood Risk Assessment
Appendix G. Mineral Broad Preferred Areas and associated sites Flood Risk Assessment
Appendix H. Waste Broad Preferred Areas and associated sites Flood Risk Assessment

List of Tables

Table 1-1 Strategic Flood Risk Maps ......................................................................................................................... 13
Table 2-1 Main River in Oxfordshire ................................................................. 16
Table 4-1 Coverage of historic flood event records by flood type ................ 22
Table 4-2 Fluvial Flood Zones (extracted from the PPG, 2014) ......................... 24
Table 4-3 Recommended contingency allowances for net sea level rises .... 28
Table 4-4 Recommended national precautionary sensitivity ranges for peak rainfall intensity, peak river flow, offshore wind speed and wave height ....................................................................................... 28
Table 5-1 Definition of amount of land susceptible to groundwater flooding ........................................................................ 32
Table 6-1 Flood Risk Vulnerability Classification (PPG, 2014) ........................ 36
Table 6-2 Flood Risk Vulnerability and Flood Zone ‘Compatibility’ (PPG, 2014) .......................................................................................... 37
Table 7-1 Levels of Site-Specific Flood Risk Assessment ................................. 40
Table 8-1 Typical SuDS Components (Y = primary process, * = some opportunities, subject to design)......................... 47

List of Figures

Figure 1-1 - Taking flood risk into account in the preparation of a Local Plan ......................................................................................... 11
Figure 2-1 Map of Oxfordshire’s geodiversity .................................................... 14
Figure 2-2 Principal Watercourses of Oxfordshire .............................................. 15
Figure 4-1 Flooding of Abingdon Road looking northbound in 2014 .................... 23
Figure 6-1 Application of Sequential Test for Minerals and Waste Local Plan preparation ................................................................. 36
List of Acronyms

ABD  Areas Benefiting from Defences
AEP  Annual Exceedance Probability
AIMS Asset Information Management System
AOD  Above Ordnance Datum
AONB Area of Outstanding Natural Beauty
ASiGWF Areas Susceptible to Groundwater Flooding
ASiSWF Areas Susceptible to Surface water Flooding
AWS  Anglian Water Services Ltd
BGS  British Geological Survey
CDC  Cherwell District Council
CFMP Catchment Flood Management Plan
CRT  Canal and River Trust
DCLG Department for Communities and Local Government
Defra Department for Environment, Flood and Rural Affairs
FCERM National Strategy for Flood and Coastal Erosion Risk Management
FMfSW Flood Map for Surface Water
FRA Flood Risk Assessment
FRMP Flood Risk Management Plan
FSA Flood Storage Area
FWD Flood Warning Direct
FDWE Flood Warning and Evacuation Plan
FWMA Flood and Water Management Act 2010
GES  Good Ecological Status
GIS  Geographical Information System
HFM  Historic Flood Map
IDB  Internal Drainage Board
LDF  Local Development Framework
LFRMS Local Flood Risk Management Strategy
LiDAR  Light Detection and Ranging
LLFA  Lead Local Flood Authority
LPA  Local Planning Authority
LRF  Local Resilience Forum
MWLP-CS Minerals and Waste Local Plan: Part 1 (Core Strategy)
MWLP-SA Minerals and Waste Local Plan: Part 2 (Site Allocations)
NPPF  National Planning Policy Framework
NPPW National Planning Policy for Waste
NS  National Standards
OCC Oxfordshire County Council
OxCC Oxford City Council
PFRA Preliminary Flood Risk Assessment
PPG  Planning Practice Guidance
PPS  Planning Policy Statement
RBMP River Basin Management Plan
SA  Sustainability Appraisal
SFRA Strategic Flood Risk Assessment
SODC South Oxfordshire District Council
SPD Supplementary Planning Document
SPZ  Source Protection Zone
SuDS Sustainable Drainage Systems
TWUL Thames Water Utilities Limited
uFMfSW Updated Flood Map for Surface Water
VOWHDC Vale of White Horse District Council
WFD Water Framework Directive
WODC West Oxfordshire District Council
## Glossary of Terms

<table>
<thead>
<tr>
<th>GLOSSARY</th>
<th>DEFINITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1D Hydraulic Model</td>
<td>Hydraulic model which computes flow in a single dimension, suitable for representing systems with a defined flow direction such as river channels, pipes and culverts</td>
</tr>
<tr>
<td>2D Hydraulic Model</td>
<td>Hydraulic model which computes flow in multiple dimensions, suitable for representing systems without a defined flow direction including topographic surfaces such as floodplains</td>
</tr>
<tr>
<td>Annual probability</td>
<td>Annual probability of occurrence in any one year, expressed as a percentage. For example, a 1% annual probability event has a 1 in 100 chance of occurring in any year.</td>
</tr>
<tr>
<td>Areas Benefitting from Defences (ABD)</td>
<td>Areas Benefiting from Flood Defences shows those areas that would benefit from the presence of formal flood defences in the event of flooding from rivers with a 1% (1 in 100) chance in any given year. If the defences were not there, these areas would be flooded.</td>
</tr>
<tr>
<td>Asset Information Management System (AIMS)</td>
<td>Environment Agency database of assets associated with main rivers including defences, structures and channel types. Information regarding location, standard of service, dimensions and condition.</td>
</tr>
<tr>
<td>Aquifer</td>
<td>A source of groundwater comprising water bearing rock, sand or gravel capable of yielding significant quantities of water.</td>
</tr>
<tr>
<td>Attenuation</td>
<td>In the context of this report - the storing of water to reduce peak discharge of water.</td>
</tr>
<tr>
<td>Broad Areas</td>
<td>Geographical areas within which locations for working minerals or developing waste management facilities may come forward.</td>
</tr>
<tr>
<td>Catchment Flood Management Plan</td>
<td>A high-level planning strategy through which the Environment Agency works with their key decision makers within a river catchment to identify and agree policies to secure the long-term sustainable management of flood risk.</td>
</tr>
<tr>
<td>Climate Change</td>
<td>Long term variations in global temperature and weather patterns caused by natural and human actions. For fluvial events a 20% increase in river flow is applied and for rainfall events, a 30% increase. These climate change values are based upon information within the NPPF and Planning Practice Guidance.</td>
</tr>
<tr>
<td>Culvert</td>
<td>A channel or pipe that carries water below the level of the ground.</td>
</tr>
<tr>
<td>DG5 Register</td>
<td>A water-company held register of properties which have experienced sewer flooding due to hydraulic overload, or properties which are ‘at risk’ of sewer flooding more frequently than once in 20 years.</td>
</tr>
<tr>
<td>Exception Test</td>
<td>The exception test may fall to be applied following the application of the sequential test. Conditions need to be met before the exception test can be passed.</td>
</tr>
<tr>
<td>Flood Defence</td>
<td>Infrastructure used to protect an area against floods as floodwalls and embankments; they are designed to a specific standard of protection (design standard).</td>
</tr>
<tr>
<td>Flood Resilience</td>
<td>Measures that minimise water ingress and promotes fast drying and easy cleaning, to prevent any permanent damage.</td>
</tr>
<tr>
<td>Flood Resistant</td>
<td>Measures to prevent flood water entering a building or damaging its fabric. This has the same meaning as flood proof.</td>
</tr>
<tr>
<td>Flood Risk</td>
<td>The level of flood risk is the product of the frequency or likelihood of the flood events and their consequences (such as loss, damage, harm, distress and disruption).</td>
</tr>
<tr>
<td>Flood Zone</td>
<td>Flood Zones show the probability of flooding, ignoring the presence of existing defences</td>
</tr>
<tr>
<td>Fluvial Flooding</td>
<td>Flooding by a river or a watercourse.</td>
</tr>
<tr>
<td>Fluvial</td>
<td>Relating to the actions, processes and behaviour of a watercourse (river or stream).</td>
</tr>
<tr>
<td>Freeboard</td>
<td>Height of flood defence crest level (or building level) above designed water level</td>
</tr>
<tr>
<td><strong>Functional Floodplain</strong></td>
<td>Land where water has to flow or be stored in times of flood. See Section 4.4.4 for the full definition.</td>
</tr>
<tr>
<td>--------------------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Groundwater Flooding</strong></td>
<td>The emergence of groundwater at the ground surface away from perennial river channels or the rising of groundwater into man-made ground, under conditions where the 'normal' ranges of groundwater level and groundwater flow are exceeded.</td>
</tr>
<tr>
<td><strong>Lead Local Flood Authority (LLFA)</strong></td>
<td>As defined by the Flood and Water Management Act, in relation to an area in England, this means the unitary authority or where there is no unitary authority, the county council for the area. Oxfordshire County Council is therefore the LLFA.</td>
</tr>
<tr>
<td><strong>Local Planning Authority (LPA)</strong></td>
<td>Body that is responsible for controlling planning and development through the planning system.</td>
</tr>
<tr>
<td><strong>Main river</strong></td>
<td>Watercourse defined on a 'main river map designated by Defra. The Environment Agency has permissive powers to carry out flood defence works, maintenance and operational activities for main rivers. However overall responsibility for maintenance lies with the riparian owner.</td>
</tr>
<tr>
<td><strong>Mitigation measure</strong></td>
<td>An element of development design which may be used to manage flood risk or avoid an increase in flood risk elsewhere.</td>
</tr>
<tr>
<td><strong>Ordinary watercourse</strong></td>
<td>A watercourse that does not form part of a main river. This includes “all rivers and streams and all ditches, drains, cuts, culverts, dikes, sluices (other than public sewers within the meaning of the Water Industry Act 1991) and passages, through which water flows” according to the Land Drainage Act 1991.</td>
</tr>
<tr>
<td><strong>Residual Flood Risk</strong></td>
<td>The remaining flood risk after risk reduction measures have been taken into account.</td>
</tr>
<tr>
<td><strong>Return Period</strong></td>
<td>The average time period between rainfall or flood events with the same intensity and effect.</td>
</tr>
<tr>
<td><strong>Risk</strong></td>
<td>Risk is a factor of the probability or likelihood of an event occurring multiplied by consequence: Risk = Probability x Consequence. It is also referred to in this report in a more general sense.</td>
</tr>
<tr>
<td><strong>Sequential Test</strong></td>
<td>Aims to steer all development to areas of lowest flood risk.</td>
</tr>
<tr>
<td><strong>Sewer Flooding</strong></td>
<td>Flooding caused by a blockage or overflowing in a sewer or urban drainage system.</td>
</tr>
<tr>
<td><strong>Sites</strong></td>
<td>Specific locations for working minerals or developing waste management facilities.</td>
</tr>
<tr>
<td><strong>Source Protection Zone (SPZ)</strong></td>
<td>Defined areas in which certain types of development are restricted to ensure that groundwater sources remain free from contaminants.</td>
</tr>
<tr>
<td><strong>Surface Water</strong></td>
<td>Flooding caused when intense rainfall exceeds the capacity of the drainage systems or when, during prolonged periods of wet weather, the soil is so saturated such that it cannot accept any more water.</td>
</tr>
<tr>
<td><strong>Sustainable drainage systems (SuDS)</strong></td>
<td>Methods of management practices and control structures that are designed to drain surface water in a more sustainable manner than some conventional techniques.</td>
</tr>
<tr>
<td><strong>Topographic survey</strong></td>
<td>A survey of ground levels.</td>
</tr>
</tbody>
</table>
1 Introduction

1.1 Terms of Reference

AECOM Infrastructure and Environment UK Ltd (“AECOM”, previously URS Infrastructure and Environment UK Ltd) has been commissioned by Oxfordshire County Council (OCC) to prepare a Level 1 Strategic Flood Risk Assessment (SFRA) to assess the flood risk from fluvial, surface water and groundwater sources to broad areas that may be suitable for minerals extraction and strategic/non-strategic waste facilities in the Minerals & Waste Local Plan: Part 1 (Core Strategy (MWLP-CS)).

The Level 1 SFRA also looks at flood risk to sites that have so far been identified as possible locations for minerals and waste development.

1.2 Background

OCC is in the process of preparing a new Minerals and Waste Local Plan (MWLP) \(^1\) to provide up to date minerals and waste planning policies and proposals for the period to 2031. It is being prepared in two parts; Part 1: Core Strategy and Part 2: Site Allocations. A revised Part 1: Core Strategy \(^2\) has been prepared, which includes all relevant work done in the preparation of the previous (withdrawn) plan. A draft Proposed Submission Document was presented in a report to Cabinet in November 2014 and in March 2015 gained Council approval to be published for representations on soundness.

The MWLP forms part of the statutory Development Plan for Oxfordshire which delivers the spatial planning strategy for the area. Each Plan, including the MWLP, has to undergo a Sustainability Appraisal (SA) which assists OCC in ensuring their policies fulfil the principles of sustainability.

A Level 1 SFRA was produced by Scott Wilson (now part of AECOM) in 2009 for OCC and Cherwell and West Oxfordshire District Councils: this considered possible areas for mineral development in those Districts and possible sites for minerals and waste development. A second Level 1 study was produced by Scott Wilson in October 2010 \(^3\), identifying flood risk associated with future minerals and waste development sites and areas across the whole of Oxfordshire. As with the previous study, all potential sources of flooding were assessed.

Amongst the study’s conclusions, it was noted that the majority of mineral sites were found to be located in Flood Zones 2 and 3, whilst the majority of waste sites were found to be located in Flood Zone 1, although it was stated that 27 of the 85 possible waste sites were identified to be at risk from surface water flooding. Both studies also concluded that a Level 2 SFRA was unlikely to be required for waste sites or mineral developments (notwithstanding their locations within Flood Zone 2 and Flood Zone 3).

Since their publication, a number of changes in planning policy have occurred. In addition to this, updated datasets have been made available, namely the Environment Agency’s updated Flood Map for Surface Water (uFMfSW) and the British Geological Survey’s (BGS) SuDS Infiltration Map. The decision was made within OCC to update the Level 1 SFRA to reflect these changes.

The relevant sections of the National Planning Policy Framework \(^4\) (NPPF) and associated Planning Practice Guidance (PPG) for Flood Risk and Coastal Change \(^5\) emphasise the active role Local Planning Authorities (LPAs) such as OCC should take to ensure that flood risk is understood and managed effectively and sustainably throughout all stages of the planning process.

The NPPF outlines that Local Plans should be supported by a SFRA and LPAs should use the findings to inform strategic land use planning. Figure 1-1 overleaf, reproduced from the PPG, illustrates how flood risk should be taken into account in

---

\(^1\) https://www.oxfordshire.gov.uk/cms/content/new-minerals-and-waste-plan
the preparation of the Local Plan for OCC. The purpose of the Level 1 SFRA is to collate and analyse the most up to date flood risk information from all sources to provide an overview of flood risk issues affecting those parts of the County that could be affected by future minerals and waste development.

SFRA Position Statement  
June 2015

In line with the strategic nature of the MWLP-CS, it has been agreed following a meeting between the Environment Agency, Oxfordshire County Council and AECOM that an initial Level 1 SFRA update is to be produced, incorporating updated policy and informed by the most up to date flood risk data. This Level 1 SFRA will focus on flood risk from fluvial, surface water and groundwater sources to provide a high level overview of flood risk to the broad areas identified for mineral extraction and strategic/non-strategic waste facilities. This will inform the Council’s selection of strategies and locations for minerals and waste development using the Sequential Test.

Following the adoption of the MWLP-CS, the Council will prepare the MWLP-SA as a separate development plan document, which will identify specific sites for minerals and waste developments within the parameters set by the Core Strategy. A further update of the Level 1 SFRA will then be required to inform the Site Allocations document, as there is a need to address flood risk from sources not considered in this study. Allocation of mineral and waste sites, and specifically, those sites which have gone through the Sequential Test and may be located in Flood Zones 2 or 3, must be based on suitably up to date data.
The SFRA also provides flood risk evidence to underpin planning policy.

The authority uses the SFRA to:
(i) Inform the scope of the Sustainability Appraisal for consultation; and
(ii) Identify where development can be located in areas with a low probability of flooding.

The authority assesses alternative development options using the Sustainability Appraisal, considering flood risk (including the potential impact of the development on surface water run-off) and other planning objectives.

Can sustainable development be achieved through new development located entirely within areas with a low probability of flooding?

Yes

Use the SFRA to apply the Sequential Test and identify appropriate allocation sites and development. If the Exception Test needs to be applied, consider the need for a Level 2 SFRA.

Assess alternative development options using Sustainability Appraisal, balancing flood risk against other planning objectives.

Use the Sustainability Appraisal to inform the allocation of land in accordance with the Sequential Test. Include a policy on flood risk considerations and guidance for each site allocation. Where appropriate, allocate land to be used for flood risk management purposes.

Include the results of the application of the Sequential Test (and Exception Test where appropriate) in the Sustainability Appraisal Report. Use flood risk indicators and Core Output Indicators to measure the Plan’s success.

Figure 1-1 - Taking flood risk into account in the preparation of a Local Plan (Adapted from the Planning Practice Guidance for Flood Risk and Coastal Change, p6)
1.3 Project Deliverables

The Level 1 SFRA is structured as follows:
- Section 1: Introduction
- Section 2: Study Area
- Section 3: Legislative and Planning Policy Context
- Section 4: Flood Risk in Oxfordshire
- Section 5: Mineral and Waste Area Assessments
- Section 6: Guidance for Applying the Sequential and Exception Tests
- Section 7: Guidance for preparing Site-Specific FRAs
- Section 8: Guidance for the Application of SuDS
- Section 9: Conclusions
- Section 10: Next Steps

1.4 Previous Studies

An initial assessment for each of the potential mineral and waste sites and broad areas was undertaken by AECOM in March 2015, establishing how the extent of flood risk from fluvial and surface water flooding has changed and the potential risk from groundwater flooding, through a comparison of the 2010 and 2015 datasets. This assessment was used as evidence alongside the Level 1 SFRA published in 2010 to support consideration of MWLP-CS by Council in March 2015.

The majority of local authorities within Oxfordshire have either individually, or in partnership with adjacent authorities, produced SFRAs to support their proposed development allocations as part of their Local Development Framework (LDF) process. Level 1 SFRAs prepared by the Oxfordshire Districts concentrate on mapping flood risk against proposed development: only one considered minerals and waste sites and areas. However, they are a good base upon which to build this county-wide Level 1 Minerals and Waste SFRA. Within the OCC boundary, the following SFRAs have been produced:
- Cherwell and West Oxfordshire Level 1 SFRA (2009) – Including Minerals and Waste Site Allocations
- Oxford City Level 1 SFRA (March 2011) and Level 2 SFRA (February 2012)
- Oxfordshire County Council Preliminary Flood Risk Assessment (PFRA) (June 2011) – a broad scale assessment of flood risk from local sources (surface runoff, groundwater and ordinary watercourses) across the County.
- South Oxfordshire and Vale of White Horse Level 1 SFRA (June 2013)
- Witney Level 2 SFRA (March 2015)

1.5 Level 1 SFRA Methodology

This Level 1 SFRA is a desk-based study, using readily available existing information and datasets to enable OCC to apply the Sequential Test to the broad areas identified as options for minerals and waste development in the MWLP-CS and to identify whether the Exception Test may be required for specific sites (leading to the need for a Level 2 SFRA). The main tasks in preparing the Level 1 SFRA are described below.

1.5.1 Gathering data and analysing it for suitability

Under Section 10 of the NPPF, the risk of flooding from all sources must be considered as part of a Level 1 SFRA, including flooding from rivers (fluvial), land (overland flow and surface water), groundwater, sewers and artificial sources.

---

7 Scott Wilson (2009) Cherwell and West Oxfordshire Level 1 SFRA
8 Oxford City Council (2011) SFRA for Oxford City
9 Atkins (2012) Oxford City Level 2 SFRA
10 JBA Consulting (2011) Oxfordshire County Council PFRA
11 JBA Consulting (2013) SFRA for Vale of White Horse and South Oxfordshire District Councils
12 WHS (2015) Witney Level 2 SFRA
Flooding from the sea is not relevant to the study area. However, given the strategic nature of the MWLP-CS, this SFRA focuses on flooding from rivers, land and groundwater. Flooding from artificial sources and sewer flooding is acknowledged to be relevant to site allocations, but no appraisal of this type of flood risk is required for MWLP-CS.

In order to undertake this assessment of flood sources across the County, a number of datasets were obtained. This information was subject to a quality review and gap analysis by the project team to determine the best datasets for inclusion in the Level 1 SFRA update. Further details of the datasets are included in Section 4.

1.5.2 Producing strategic flood risk maps, GIS deliverables and a technical report

A series of GIS maps were produced using the data gathered during the initial part of the study. The mapping deliverables are identified in Table 1-1.

Table 1-1 Strategic Flood Risk Maps

<table>
<thead>
<tr>
<th>Figure Number</th>
<th>Figure Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appendix B Figure 1</td>
<td>Historic Fluvial Flood Events</td>
</tr>
<tr>
<td>Appendix B Figure 2</td>
<td>Historic Surface Water Flood Events</td>
</tr>
<tr>
<td>Appendix B Figure 3</td>
<td>Historic Groundwater Flood Events</td>
</tr>
<tr>
<td>Appendix C Figure 1 - 5</td>
<td>Environment Agency Fluvial Flood Zones</td>
</tr>
<tr>
<td>Appendix D Figure 1 - 5</td>
<td>Risk of Flooding from Surface Water</td>
</tr>
<tr>
<td>Appendix E Figure 1 - 5</td>
<td>Areas Susceptible to Groundwater Flooding</td>
</tr>
</tbody>
</table>

1.5.3 Providing suitable guidance

Sections of this report provide specific guidance for OCC on policy considerations, the application of the Sequential Test, guidance on the preparation of site specific FRAs and guidance of the application of SuDS in the study area.

1.6 Stakeholder Consultation

This report has been undertaken in conjunction with the Environment Agency and OCC. A meeting between the Environment Agency, OCC and AECOM was held in April 2015 to agree the strategic scope of the initial Level 1 SFRA update. The following stakeholders are currently being consulted as part of the MWLP-CS publication process:

- Cherwell District Council;
- West Oxfordshire District Council;
- Oxford City Council;
- Vale of White Horse District Council;
- South Oxfordshire District Council;
- Thames Water; and
- Canal and River Trust.

Following the adoption of the MWLP-CS, it has been agreed that there will be a need for a further update of the Level 1 SFRA to inform the MWLP-SA at which point further consultation will take place with the stakeholders listed above.
2 Study Area

2.1 Overview

Oxfordshire is the most rural county in the South East with 635,500 residents across an area of 2,600km². The County has the lowest population density in the South East and includes three designated Areas of Outstanding National Beauty (AONB) including the Chilterns, Cotswolds and North Wessex Downs AONBs.

The administrative area of OCC comprises five LPA areas; Cherwell District Council (CDC), Oxford City Council (OxCC), South Oxfordshire District Council (SODC), Vale of White Horse District Council (VWHDC) and West Oxfordshire District Council (WODC).

2.2 Topography

Central Oxfordshire is characterised by open, gently undulating lowland farmland through which the upper reaches of the River Thames flows in an easterly and southerly direction, intersected by a ridge of low-lying limestone hills stretching east–west from the Vale of Aylesbury in Buckinghamshire to Swindon. From the lowland farmland, the landscape rises to the north west in the form of a steep scarp which represents the Cotswolds. To the south east and south west of the County, the topography also rises up to the rolling Chalk hills of the Chilterns and North Wessex Downs respectively.

2.3 Geology

The underlying geology can influence the presence and nature of groundwater in an area, and therefore the potential flood risk from groundwater. The geology can also impact on the potential for infiltration based drainage systems. Figure 2-1 (from the OCC website) shows the underlying geology within OCC.

![Figure 2-1 Map of Oxfordshire’s geodiversity](https://www.oxfordshire.gov.uk/cms/content/geodiversity)

---

13 https://www.oxfordshire.gov.uk/cms/public-site/about-oxfordshire
14 https://www.oxfordshire.gov.uk/cms/content/geodiversity
The bedrock geology of OCC consists of a number of different formations as shown in Figure 2-1. The Oxfordshire Geology Trust\(^1\) summarises the bedrock geology into four common rock types as listed below:

- Clays – consisting of the Lias group, Kellaways and Oxford Clay formation, West Walton, Ampthill Clay and Kimmeridge Clay formations;
- Limestones – consisting of the Great Oolite group, Inferior Oolite group, Corallian group and Portland group;
- Chalk – consisting of the Grey chalk subgroup, and White chalk subgroup; and
- Sands – consisting of the Gault and Upper Greensand formations, Wealdon Group and Lower greensand group.

Superficial (sand and gravel) deposits are dispersed throughout the County. River Terrace Deposits are predominantly found along the corridor following the River Thames, but with smaller pockets along the River Evenlode, River Cherwell and River Ray corridors. Alluvium deposits are also found along these river corridors, as well as the Alluvium deposits associated with the wetland area of Otmoor to the north east of Oxford. To the south east of the County, there is a broad area of Clay-with-flints associated with the Chilterns. Isolated sections of Till are dispersed across the County.

Superficial deposits are otherwise absent in large sections of the County, particularly in the north.

2.4 Main Rivers in Oxfordshire

The hydrology of Oxfordshire is dominated by the River Thames and its many tributaries, including other Main Rivers such as the River Cherwell, River Thame and River Windrush (Figure 2-2). These rivers are an important component of the County’s topography, character and identity. The river corridors are frequently of value for landscape, nature conservation and heritage, as well as providing public access opportunities and a focus for recreation. Table 2-1 lists the main rivers in Oxfordshire.

Figure 2-2 Principal Watercourses of Oxfordshire (Contains Ordnance Survey data © Crown copyright and database right 2015)

\(^1\) [http://www.ogt.discoveringfossils.co.uk/information.htm](http://www.ogt.discoveringfossils.co.uk/information.htm)
Table 2-1 Main River in Oxfordshire

<table>
<thead>
<tr>
<th>River Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>River Thames</td>
</tr>
<tr>
<td>River Cole(^{16})</td>
</tr>
<tr>
<td>River Ock</td>
</tr>
<tr>
<td>River Thame</td>
</tr>
<tr>
<td>River Cherwell</td>
</tr>
<tr>
<td>Padbury Brook</td>
</tr>
<tr>
<td>River Stour(^{17})</td>
</tr>
<tr>
<td>River Great Ouse(^{18})</td>
</tr>
<tr>
<td>River Ray</td>
</tr>
<tr>
<td>River Evenlode</td>
</tr>
<tr>
<td>River Windrush</td>
</tr>
</tbody>
</table>

These watercourses are designated Main Rivers, defined as watercourses shown on the statutory Main River maps held by the Environment Agency and the Department for Environment, Flood and Rural Affairs (Defra). The Environment Agency has permissive powers to carry out works necessary for flood defence purposes on these rivers. The overall responsibility for maintenance however, lies with the riparian owner.

\(^{16}\) The River Cole flows along the border between Wiltshire and Oxfordshire in the south west of the county, and therefore has associated floodplain within Oxfordshire.

\(^{17}\) The upper catchment of the River Stour and associated floodplain is within Oxfordshire to the north west of the county.

\(^{18}\) The River Great Ouse flows along the border between Northamptonshire and Oxfordshire in the north east of the county, and therefore has associated floodplain within Oxfordshire.
3 Legislative and Planning Policy Context

3.1 National Planning Policy Framework (2012)\(^4\)

The NPPF was published on 27th March 2012 together with accompanying Technical Guidance\(^4\). The NPPF revoked most of the previous Planning Policy Statements (PPS) and Planning Policy Guidance. However, the NPPF did not revoke the PPS25: Development and Flood Risk Practice Guide\(^5\). This was revoked on the 6th March 2014 along with the NPPF Technical Guidance, when it was replaced by the relevant section of the Planning Practice Guidance (PPG) on Flood Risk and Coastal Change\(^6\).

The NPPF consists of a framework within which councils and local people can produce local and neighbourhood plans that reflect the needs and priorities of their communities.

The overall approach to flood risk is broadly summarised in NPPF Paragraph 103:

“When determining planning applications, local planning authorities should ensure flood risk is not increased elsewhere and only consider development appropriate in areas at risk of flooding where, informed by a site-specific FRA following the Sequential Test, and if required the Exception Test, it can be demonstrated that:

- Within the site, the most vulnerable development is located in areas of lowest flood risk unless there are overriding reasons to prefer a different location, and
- Development is appropriately flood resilient and resistant, including safe access and escape routes where required, and that any residual risk can be safely managed, including by emergency planning; and it gives priority to the use of sustainable drainage systems.”

Each LPA within the study area is responsible for preparing an SFRA to inform the allocation of development sites within their administrative areas in accordance with their established SA. In a similar manner, as the Minerals and Waste Planning Authority for Oxfordshire, OCC is responsible for following the same guidelines in consideration of future development sites for use in waste management and mineral extraction. Further detail regarding the application of the Sequential and Exception Tests is included in Section 6.

3.2 Planning Practice Guidance (2014)\(^5\)

The NPPF is supported by a series of Planning Practice Documents referred to as the Planning Practice Guidance. The PPG: Flood Risk and Coastal change document outlines how LPAs should use the SFRA, as follows:

- SFRAs should assess the flood risk from all sources within a specified potential site or area identified for development, both in the present day, and in the future. The impacts of climate change should be considered when assessing future flood risk;
- The impact on flood risk of future development and changes to land use should also be considered;
- The SFRA should provide the foundation from which to apply the Sequential and Exception Tests in the development allocation and development control process (see Flood Zone 1- Flood Zone 3b). Where decision-makers 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 SFRA (to a Level 2 SFRA) to provide the information necessary for application of the Exception Test;
- The SFRA should inform the sustainability appraisal of the Local Plan;
- The SFRA should outline requirements for site-specific FRAs, with specific requirements for particular locations;
- The SFRA should define the flood risk in relation to emergency planning’s capacity to manage flooding;
- Opportunities to decrease the existing flood risk within the study areas should be explored, such as surface water management, provision of flood storage and managing conveyance of flood flows.

SFRAs should be prepared in consultation with the Environment Agency, emergency response and drainage authority functions of the LPA, Lead Local Flood Authorities (LLFAs) and where appropriate Internal Drainage Boards (IDBs).

3.3 National Planning Policy for Waste

The National Planning Policy for Waste (NPPW) sets out detailed waste planning policies for waste planning authorities. Appendix B of the policy document describes locational criteria that waste planning authorities should consider when testing the suitability of sites and areas in the preparation of Local Plans and in determining planning applications.

This Level 1 SFRA Report seeks to provide initial information to support the consideration of criteria a) as follows:

‘Protection of water quality and resources and flood risk management: Considerations will include the proximity of vulnerable surface and groundwater or aquifers. For landfill or land-raising, geological conditions and the behaviour of surface water and groundwater should be assessed both for the site under consideration and the surrounding area. The suitability of locations subject to flooding, with consequent issues relating to the management of potential risk posed to water quality from waste contamination, will also need particular care’.

3.4 The Flood and Water Management Act (2010)

Following the devastating national floods of 2007, one of the recommendations from Sir Michael Pitt’s review was that “the role of local authorities should be enhanced so that they take on responsibility for leading the co-ordination of flood risk management in their areas”.

The Flood and Water Management Act (FWMA) (2010) brings in new roles and responsibilities for local authorities. In particular, the Act defines the role of the LLFA, which includes Unitary Authorities or County Councils. OCC is the LLFA for Oxfordshire, which includes Cherwell District, Oxford City, South Oxfordshire District, Vale of White Horse District and West Oxfordshire District. LLFAs are encouraged to bring together relevant bodies and stakeholders to effectively manage local flood risk, which may include County, City and District/Borough Councils, IDBs, highways authorities, water companies and the Environment Agency. Local flood risk is defined as the risk of flooding from surface water runoff, groundwater and small ditches and watercourses (collectively known as ordinary watercourses).

The Act also formalises the flood risk management roles and responsibilities for other organisations including the Environment Agency, water companies and highways authorities. The responsibility for a strategic overview of the management of all sources of flooding and coastal erosion remains that of the Environment Agency. The Agency also has operational responsibility for managing the risk of flooding from main rivers, reservoirs, estuaries and the sea.

3.4.1 National Strategy for Flood and Coastal Erosion Risk Management

In accordance with the Act, the Environment Agency has developed a National Strategy for Flood and Coastal Erosion Risk Management (FCERM) in England. This Strategy provides a framework for the work of all flood and coastal erosion risk management authorities.

The National FCERM Strategy sets out the long-term objectives for managing flood and coastal erosion risks and the measures proposed to achieve them. It sets the context for, and informs the production of local flood risk management strategies by LLFAs, which will in turn provide the framework to deliver local improvements needed to help communities manage local flood risk.

3.4.2 Oxfordshire County Council Local Flood Risk Management Strategy (LFRMS)

As a LLFA, OCC has a statutory duty under the FWMA to develop, maintain, apply and monitor a strategy for local flood risk management. In December 2014, OCC published their LFRMS which sets out their approach for the management of flood risk associated with local sources of flooding such as surface water, ordinary watercourses and groundwater.

3.4.3 Thames Catchment Flood Management Plan (CFMP)

A CFMP is a high-level strategic planning document that provides an overview of the main sources of flood risk and how these can be managed in a sustainable framework for the next 50 to 100 years. The Environment Agency engages stakeholders within the catchment to produce policies in terms of sustainable flood management solutions whilst also considering local land use changes and effects of climate change.

---

20 HMSO (2010) The Flood and Water Management Act
24 Environment Agency (December 2009) Thames Catchment Flood Management Plan
The CFMPs are used to inform and support planning policies, statutory land use plans and implementation of the Water Framework Directive, so that future development in the catchment is sustainable in terms of flood risk. Awareness of the role of CFMPs among land-use planners is in its infancy at the time of this report.

The approach that the Environment Agency would like to see taken to flood risk management within Oxfordshire is outlined in the Thames CFMP (2009). The CFMP aims to identify flood risk management policies for the catchment and sets out the preferred plan for sustainable flood risk management in the Thames region over the next 50 to 100 years.

CFMPs are due to be replaced by Flood Risk Management Plans (FRMPs) in 2015. The policy options listed below are used to identify an appropriate approach to flood risk management across all CFMPs, and will continue to be used in the FRMPs:

- Policy 1 – No active intervention (including Flood Warning and Maintenance). Continue to monitor and advise.
- Policy 2 – Reduce existing flood risk management actions (accepting that flood risk will increase over time).
- Policy 3 – Continue with existing or alternative actions to manage flood risk at current levels.
- Policy 4 – Take further action to sustain the current level of flood risk into the future (responding to the potential increases in risk from urban development, land use change and climate change).
- Policy 5 – Take further action to reduce flood risk.
- Policy 6 – Take action with others to store water or manage runoff in locations that provide overall flood risk reduction or environmental benefits.

Oxfordshire falls into the ‘Upper Thames’ policy unit and the preferred policy for OCC in the CFMP is Policy 6 - Take action with others to store water or manage run-off in locations that provide overall flood risk reduction or environmental benefits.

3.5 Amendments to policy on Sustainable Drainage Systems

Following a consultation by Defra on the delivery of SuDS in 2014 the Department for Communities and Local Government (DCLG) issued a Written Statement outlining the Government’s response regarding the future of SuDS. This was followed by a consultation exercise carried out in December 2014 by DCLG on the proposal to make LLFAs statutory consultees for planning applications with regards to surface water management, and the Government published its formal response in March 2015. The PPG has subsequently been amended to reflect the new approach to implementation of SuDS in development.

The proposed approach is to strengthen the planning system as a way of delivering SuDS, rather than implement Schedule 3 of the FWMA, as written, which would have established a new SuDS Approval Body that would have sat outside the existing planning system.

From 6th April 2015 LPAs, will be expected to ensure that local planning policies and decisions on planning applications relating to major development include SuDS for the management of run-off, unless demonstrated to be inappropriate. Minor developments with drainage implications would continue to be subject to existing planning policy (Section 103 of the NPPF) and smaller developments in flood risk areas should still give priority to the use of SuDS.

The PPG has been amended to state:

“Sustainable drainage systems may not be practicable for some forms of development (for example, mineral extraction). New development should only be considered appropriate in areas at risk of flooding if priority has been given to the use of sustainable drainage systems. Additionally, and more widely, when considering major development, sustainable drainage systems should be provided unless demonstrated to be inappropriate.”

LPAs should consult the relevant LLFA when considering major development. In considering planning applications LPAs will need to:

- Consult OCC, as the LLFA, on the management of surface water for major development,
- Satisfy themselves that the proposed minimum standards of operation are appropriate, and

25 Defra / DCLG (September 2014) Delivering Sustainable Drainage Systems: Consultation
26 Department for Communities and Local Government (Dec 2014) House of Commons Written Statement (HCWS161) Sustainable Drainage Systems.
27 DCLG (December 2014) Consultation on Further changes to statutory consultee arrangements for the planning application process
28 DCLG (March 2015) Further changes to statutory consultee arrangements for the planning application process: Government response to consultation.
29 The definition for Major and Minor developments are set out in the Town and Country Planning Order 2010
Ensure through the use of planning conditions or planning obligations that there are clear arrangements in place for ongoing maintenance over the lifetime of the development.

"Local planning authorities are also advised to consult as appropriate:

- The relevant sewerage undertaker where a connection with a public sewer is proposed.
- The Environment Agency, if the drainage system directly or indirectly involves the discharge of water into a main river.
- The relevant highway authority for an affected road.
- The Canal and River Trust, if the drainage system may directly or indirectly involve the discharge of water into or under a waterway managed by them.
- An Internal Drainage Board, if the drainage system may directly or indirectly involve the discharge of water into an ordinary watercourse (within the meaning of section 72 of the Land Drainage Act 1991) within the board's district."

"The decision on whether a sustainable drainage system would be inappropriate in relation to a particular development proposal is a matter of judgement for the local planning authority. In making this judgement the local planning authority will seek advice from the relevant flood risk management bodies, principally the lead local flood authority."

OCC, as the LLFA, has become a statutory consultee for planning applications for major developments that have a drainage implication. As a statutory consultee, the LLFA has a duty to respond to the LPA and report on their performance on providing a substantive response within deadlines set out in legislation.

### 3.6 Flood Risk Regulations

As well as the duties under the Act to prepare a LFRMS, OCC have legal obligations under the EU Floods Directive, which was transposed into UK Law through the Flood Risk Regulations 2009 (‘the Regulations’).

#### 3.6.1 Preliminary Flood Risk Assessment

Under the Regulations, all LLFAs were required to prepare a PFRA report. This is a high level screening exercise to identify areas of significant risk as Indicative Flood Risk Areas across England where 30,000 people or more are at risk from flooding for reporting to Europe.

OCC prepared a PFRA to provide a high level overview of flood risk from local flood sources and includes flooding from surface water (i.e. rainfall resulting in overland runoff), groundwater, ordinary watercourses (smaller watercourses and ditches) and canals. It excludes flood risk from main rivers, the sea and reservoirs, as these are assessed nationally by the Environment Agency.

The PFRA report looks at past flooding and where future flooding might occur across the area and the consequences it might have to people, properties and the environment. No areas of ‘significant risk’ were identified: the report was, however, used to help OCC in the development of their Local Flood Risk Management Strategy required under the FWMA.

#### 3.6.2 River Basin District draft Flood Risk Management Plans

Under the EU Floods Directive and UK Flood Risk Regulations, LLFAs must prepare FRMPs in formally identified Flood Risk Areas where the risk of flooding from local sources is significant (i.e. surface water, groundwater, ordinary watercourses), and the Environment Agency is required to prepare FRMPs for all of England covering flooding from main rivers, the sea and reservoirs.

As such, the Thames Draft River Basin District FRMP has been published and consulted on by the Environment Agency setting out the proposed measures to manage flood risk in the Thames River Basin District from 2015 to 2021 and beyond. The first cycle of FRMPs are due to be published in December 2015.

### 3.7 Oxfordshire Minerals and Waste Local Plan

The County Council is responsible for minerals and waste planning in Oxfordshire and is reviewing the current planning policies for mineral working and waste management. A new Oxfordshire MWLP is currently being produced and a Part 1
(Core Strategy) (MWLP-CS) is due to be adopted in 2016. This will replace the existing Minerals and Waste Local Plan adopted in 1996.

### 3.7.1 Part 1: Core Strategy

The MWLP-CS will provide the planning strategies and policies for the development that will be needed for the supply of minerals and management of waste in Oxfordshire over the period to 2031. It will set out policies to guide minerals and waste development over the plan period, including common core policies which address development management issues relevant to both minerals and waste (below). Specific policies identify broad areas suitable for mineral development (policy M3) and for strategic/non-strategic waste management facilities (policy W4). Except for two existing sites identified as suitable for the development of facilities to manage/dispose of radioactive waste (policy W9), specific sites are not identified in the MWLP-CS. Site allocation will be undertaken in the Part 2 Site Allocations Plan (MWCS-SA). The MWLP-CS is expected to be published in July 2015 for representations to be made as to its soundness.

The Core Strategy includes two general policies relevant to flood risk and management, and water quality:

**Policy C3: Flooding**

Minerals and waste development will, wherever possible, take place in areas that are not at risk of flooding. Where development takes place in an area of identified flood risk this should only be where alternative locations in areas of lower flood risk have been explored and discounted (using the Sequential Test and Exceptions Test as necessary) and where a flood risk assessment is able to demonstrate that the risk of flooding is not increased from any source, including:

- an impediment to the flow of floodwater;
- the displacement of floodwater and increased risk of flooding elsewhere;
- a reduction in existing floodwater storage capacity;
- an adverse effect on the functioning of existing flood defence structures;
- the discharge of water into a watercourse.

The opportunity should be taken to increase flood storage capacity in the flood plain where possible, particularly through the restoration of sand and gravel workings.

**Policy C4: Water environment**

Proposals for minerals and waste development will need to demonstrate that there would be no unacceptable adverse impact on or risk to:

- The quantity or quality of surface or groundwater resources required for habitats, wildlife and human activities;
- The quantity or quality of water obtained through abstraction unless acceptable alternative provision can be made;
- The flow of groundwater at or in the vicinity of the site.

Proposals for minerals and waste development should ensure that the River Thames and other watercourses and canals of significant landscape, nature conservation or amenity value are adequately protected.

### 3.7.2 Part 2: Site Allocations

The MWLP-SA will be prepared as a separate development plan document and will identify specific sites for minerals and waste developments within the parameters set by the Core Strategy. Work on this will commence following adoption of Part 1: Core Strategy.
4 Flood Risk in Oxfordshire

4.1 Introduction

This Section provides the strategic assessment of the flood risk across the study area from each of the sources of flooding outlined in the NPPF. For each source of flooding, a review of the Oxfordshire LPA SFRAs and PFRA has been carried out, a historical flood event register has been compiled, and the datasets used for the assessment are described and details of any historical incidents provided. This Section should be read in conjunction with the mapping in Appendices A, B, C and D.

4.2 Review of Historic Flood Event Records

Since the production of the previous Level 1 SFRA (2010) for the Oxfordshire Minerals & Waste Development Framework, a number of new SFRA’s have also been produced for the respective LPA’s within Oxfordshire as listed in Section 1.4. A review of the historic flood event records that these SFRAs are based upon has been undertaken and provided in Appendix A. Table 4-1 provides a summary of the level of coverage provided by each SFRA in terms of historic flood event records and should be considered when viewing the historic flood event maps in Appendix B.

Table 4-1 Coverage of historic flood event records by flood type

<table>
<thead>
<tr>
<th>Local Planning Authority</th>
<th>Fluvial</th>
<th>Surface Water</th>
<th>Groundwater</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxford City</td>
<td>Good</td>
<td>None</td>
<td>Good</td>
</tr>
<tr>
<td>Cherwell District</td>
<td>Good</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>West Oxfordshire</td>
<td>Good</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>South Oxfordshire</td>
<td>Partial</td>
<td>Partial</td>
<td>Partial</td>
</tr>
<tr>
<td>Vale of White Horse</td>
<td>Partial</td>
<td>Partial</td>
<td>Partial</td>
</tr>
</tbody>
</table>

4.3 Recent Significant Flood Events

As the LLFA, OCC routinely receives and records details of flooding incidents, with records dating back to April 2011. A review of the flood incidents has been carried out to provide an indication as to when the most significant flooding occurred. The greatest numbers of flood incidents were reported during the 2012/13 winter (between October 2012 and March 2013) and 2013/14 winter. The incidents were found to occur across the County. A review of media reports has also been undertaken, which further backs up the flood reports as collected by OCC.

Throughout the winter of 2013/14, prolonged heavy rainfall across the UK led to saturated ground and widespread surface water flooding, as well as causing rivers to burst their banks, such as the River Bure in Bicester. Flooding in Oxfordshire received significant media coverage and was well documented in media sources such as the BBC.

---

33 It should be noted that, some of the reports are relatively recent, and therefore the presence of a flood or cause of the flood is yet to be determined. Additionally, it is unlikely that all flood events that have occurred within the county have been captured.
34 http://www.oxfordmail.co.uk/news/10898516.Weather_latest_Elderly_residents_flooded_out_in_Bicester/
35 http://www.bbc.co.uk/news/uk-england-26153209
36 http://www.bbc.co.uk/news/uk-england-oxfordshire-26119625
The flooding experienced in the 2012/13 winter was seen across the West Thames area, as a result of the previously wet summer where the rivers across the area were already at or close to capacity prior to the onset of further winter rainfall.

The severity of the summer flooding in 2007 was also widely reported in the media, as well as being repeatedly noted in each of the five LPA SFRA’s. The flooding experienced generated changes in the way flooding is managed locally and nationally, with the Government commissioning ‘The Pitt Review – Learning Lessons from the 2007 Floods’, and subsequently enacting the FWMA 2010 in response to recommendations of The Pitt Review. Flooding from all sources was experienced across the County, and it is estimated in the PFRA that around 2,100 properties were flooded from all sources.

4.4 Flooding from Rivers

The SFRA’s of the five LPAs (listed in Section 1.4) have been used to identify watercourses in the study area and their designation (i.e. Main River or Ordinary Watercourse). There are numerous Main Rivers and ordinary watercourses within the study area. The principal rivers have been described in Table 2-1 in Section 2.4.

4.4.1 Historic Records

The draft FRMP for the Thames River Basin District highlights a number of flood events affecting the Thames RBD. In 1947, a combination of heavy rain on a frozen catchment caused high run-off rates, followed by a rapid thaw which resulted in extensive flooding. These very large scale floods affected more than 10,000 properties across the RBD. More recently, specifically affecting the City of Oxford, flooding on the River Thames in autumn/winter 2000, New Year 2003 and winter 2013/14 was caused by heavy rainfall on a saturated catchment.

Records of historic fluvial flood events have been extracted, where possible, from each of the LPA SFRA’s and collated by settlement into a single database and presented in Figure 1 in Appendix B. Mapping demonstrates that many settlements across the County have experienced one or two flood events in the past, mostly as a result of the major flooding in 2007 (all sources of flood risk). A list of the most affected parishes and cities during the 2007 floods is also provided in the PFRA, however, this list should be read with caution as the extensive (county wide) and complex (multiple flood sources) nature of the 2007 flood event makes it difficult to accurately record every affected settlement.

---

37 http://www.airexperiences.co.uk/aerial-photography/uk-floods-oxford-water/
40 Due to the variety of data sources, lack of specific detail in terms of severity and the various types of data used to represent flood events (i.e. sandbag requests, flood grant claimants, etc.), it has been considered that the most appropriate means of consolidating flood event data is to represent the events as the total number of repeat flood events in the same settlement location. It does not represent severity of individual flood events or number of properties affected.
The majority of historic fluvial flood events are shown to be associated with the middle and lower reaches of the River Thames within Oxfordshire, affecting settlements including the City of Oxford, Botley, Abingdon, Wallingford and Henley on Thames. Notable fluvial flood events have occurred in 1894, 1947, 1977, 1979, 2000, 2003, 2007, 2012 and the winter of 2013/14. The upper reach of the Thames is described in the SO & VOWH SFRA\textsuperscript{11} as a ‘wide rural floodplain and does not pose a high risk to property’.

Historic fluvial flooding has also been recorded in 1947, 1979, 1992, 2003, 2007 and 2012 in the River Ock catchment. In the upper reaches of the catchment, affected villages include Stanford in the Vale (Frogmore Brook), Charney Bassett and Lyford (Ock) and Wantage, Grove and East Hanney (Letcombe Brook).

The River Cherwell to the north of the County has caused flooding in Banbury in 1932, 1975, 1982, 2007 and 2008, with the most severe event occurring in 1998. In West Oxfordshire, the majority of recorded flood events have been associated with the River Windrush affecting Witney in 1947, 1960, 1990 and 1998.

The Environment Agency has supplied details of historic flooding from fluvial sources in the form of their Historic Flood Map which is presented in Figure 1 Appendix B.

### 4.4.2 Flood Zone Maps

The risk of flooding is a function of the probability that a flood will occur and the consequence to the community or receptor as a direct result of flooding. The NPPF seeks to assess the probability of flooding from rivers by categorising areas within the fluvial floodplain into zones of low, medium and high probability, as defined in Table 4-2 and presented on the ‘Flood Map for Planning (Rivers and Sea)’ available on the Environment Agency website. These Flood Zones have also been presented in Figures 1 – 5 in Appendix C.

<table>
<thead>
<tr>
<th>Flood Zone</th>
<th>Fluvial Flood Zone Definition</th>
<th>Probability of Flooding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flood Zone 1</td>
<td>Land having a less than a 0.1% Annual Exceedance Probability (AEP) (1 in 1,000 chance of flooding in any one year). Shown as clear on the Flood Map – all land outside Flood Zones 2 and 3.</td>
<td>Low</td>
</tr>
<tr>
<td>Flood Zone 2</td>
<td>Land having between a 1% AEP (1 in 100 chance of flooding in any one year) and 0.1% AEP (1 in 1,000 chance of flooding in any one year).</td>
<td>Medium</td>
</tr>
<tr>
<td>Flood Zone 3a</td>
<td>Land having a 1% AEP (1 in 100 chance of flooding in any one year) or greater.</td>
<td>High</td>
</tr>
<tr>
<td>Flood Zone 3b (Functional Floodplain)</td>
<td>Land where water has to flow or be stored in times of flood based on flood modelling of a 5% AEP event (1 in 20 chance of flooding in any one year) or greater, or land purposely designed to be flooded in an extreme flood event (0.1% AEP). Where detailed modelling is not available, it is assumed that the extent of Flood Zone 3b is equal to Flood Zone 3a.</td>
<td>Very High</td>
</tr>
</tbody>
</table>

### 4.4.3 Flood Map for Planning (Rivers and Sea)

The ‘Flood Map for Planning (Rivers and Sea)’ provides information on the areas that would flood if there were no flood defences or buildings in the “natural” floodplain. The ‘Flood Map for Planning (Rivers and Sea)’ dataset is available on the Environment Agency website\textsuperscript{41} and is the main reference for planning purposes as it contains Flood Zones 1, 2 and 3a which are referred to in the NPPF and presented in Table 4-2.

The ‘Flood Map for Planning (Rivers and Sea)’ was first developed in 2004 using national generalised modelling (JFLOW) and is now routinely updated and revised using the results from the Environment Agency’s programme of catchment studies, entailing topographic surveys and hydrological and/or hydraulic modelling as well as previous flood events.

It should be noted that a separate map is available on the Environment Agency website which is referred to as ‘Risk of Flooding from Rivers and Sea’\textsuperscript{42}. This map takes into account the presence of flood defences and so describes the actual chance of flooding, rather than the chance if there were no defences present. While flood defences reduce the level of risk they don’t completely remove it as they can be overtopped or fail in extreme weather conditions, or if they are in poor

\textsuperscript{41} Environment Agency Flood Map for Planning (Rivers and Sea) http://apps.environment-agency.gov.uk/wiyby/37837.aspx

\textsuperscript{42} Environment Agency ‘Risk of Flooding from Rivers and Sea’ http://watermaps.environment-agency.gov.uk/wiyby/wiyby.aspx?topic=floodmap&x=237038&y=161974&scale=1
condition. As a result the maps may show areas behind defences which still have some risk of flooding. This mapping has been made available by the Environment Agency as the primary method of communicating flood risk to members of the public, however for planning purposes the ‘Flood Map for Planning (Rivers and the Sea)’ and associated Flood Zones remains the primary source of information.

4.4.4 Functional Floodplain (Flood Zone 3b)

For the purposes of this SFRA, the Functional Floodplain is defined as:

| Land where water has to flow or be stored in times of flood based on flood modelling of a 5% AEP event (1 in 20 chance of flooding in any one year) or greater, or land purposely designed to be flooded in an extreme flood event (0.1% AEP). Where detailed modelling is not available, it is assumed that the extent of Flood Zone 3b is equal to Flood Zone 3a. |

The Functional Floodplain (also referred to as Flood Zone 3b), is not separately distinguished from Flood Zone 3a on the Flood Map for Planning. Rather the SFRA is the place where LPAs should identify areas of Functional Floodplain in discussion with the Environment Agency and LLFA.

The PPG states that the identification of functional floodplain should take account of local circumstances and not be defined solely on rigid probability parameters. However, land which would naturally flood during a 5% AEP or greater event, or is designed to flood (such as a flood attenuation scheme) in an extreme (0.1% AEP) flood, should provide a starting point for consideration and discussions to identify the functional floodplain.

The PPG states that ‘areas which would naturally flood, but which are prevented from doing so by existing defences and infrastructure or solid buildings, will not normally be defined as functional floodplain’. There may be opportunities to reinstate areas which can operate as functional floodplain through the use of previously developed land adjacent to watercourses to provide space for flood water to reduce the risk to new and existing development.

Due to the strategic nature of this Level 1 SFRA, the functional floodplain has not been mapped at this stage, although outputs from the hydraulic models associated with specific watercourses can been obtained from the Environment Agency. A written definition has been provided (above) at this stage of plan preparation. Mapping of Flood Zone 3b Functional Floodplain will be undertaken when the Level 1 SFRA is updated as part of the MWLP-SA.

4.5 Flooding from Surface Water

Overland flow and surface water flooding typically arise following periods of intense rainfall, often of short duration, that is unable to soak into the ground or enter drainage systems. It can run quickly off land and result in localised flooding.

A subset of surface water flooding is typically referred to as highway flooding, which can be defined as flooding caused by heavy rainfall or overflowing from blocked drains and gullies causing water to pond within the highway network. Responsibility for management of this type of flooding depends on the ownership of the highway being flooded.

The PPG states that an SFRA should identify areas at risk from surface water flooding and drainage issues, taking account of the surface water flood risk published by the Environment Agency as well as other available information.

4.5.1 Historic Records

Records of historic surface water flood events have been extracted, where possible, from each of the LPA SFRA’s and collated by settlement into a single database and presented in Figure 2 in Appendix B⁴⁰. Due to the limited availability of flood event data within the five LPA SFRA’s for surface water, Figure 2 Appendix B is not considered to be a complete representation of the distribution of surface water flood events in Oxfordshire, and this information should be used in parallel with Environment Agency mapping described in Section 4.5.2 below. A review of the historic flood event records has been undertaken and provided in Appendix A. This under representation may also be due to the following reasons;

- Can occur suddenly and without warning, and be gone just as suddenly as it had appeared,
- Can be misreported as a different type of flooding,
- Can occur in combination with other flood sources, making it difficult to distinguish, and
- Incidents can be too numerous to report all individual occurrences of surface water flooding.
The majority of surface water flood events have been reported in South Oxfordshire, with some settlements including Nuneham Courtney and Wheatley reporting three to four individual events. Outside of South Oxfordshire, reports of one to two flood events have been reported in the PFRA and displayed in Figure 2 Appendix B.

4.5.2 Environment Agency updated Flood Map for Surface Water

The Environment Agency has undertaken modelling of surface water flood risk at a national scale and produced mapping identifying those areas at risk of surface water flooding during three annual exceedance probability (AEP) events: 1 in 30 year (3.33% AEP), 1 in 100 year (1% AEP and 1 in 1,000 year (0.1% AEP). The latest version of the mapping, published in 2013, is referred to as the ‘updated Flood Map for Surface Water’ (uFMfSW) and the extents have been made available to planning authorities as GIS layers. This dataset is also available of the Environment Agency website, and is referred to as ‘Risk of Flooding from Surface Water’.

The uFMfSW provides all relevant stakeholders, such as the Environment Agency, OCC, and the public access to information on surface water flood risk which is consistent across England and Wales. The modelling helps the Environment Agency take a strategic overview of flooding, and assists OCC (as the LLFA) in their duties relating to the management of surface water flood risk. For the purposes of this SFRA, the mapping allows an improved understanding of areas within the study area which may have a surface water flood risk. The mapping is presented in Figures 1 – 5 in Appendix D.

The modelling represents a significant improvement on previous mapping, namely the FMfSW (2010) and the Areas Susceptible to Surface Water Flooding (AStSWF) (2009), for example:

- Increased model resolution to 2m grid;
- Representation of buildings and flow routes along roads and manual editing of the model for structural features such as flyovers;
- Use of a range of storm scenarios;
- Incorporation of appropriate local mapping, knowledge and flood incident records.

However, it should be noted that this national mapping has the following limitations:

- Use of a single drainage rate for all urban areas;
- It does not show the susceptibility of individual properties to surface water flooding;
- The mapping has significant limitations for use in flat catchments;
- No explicit modelling of the interaction between the surface water network, the sewer systems and watercourses;
- In a number of areas, modelling has not been validated due to a lack of surface water flood records;
- As with all models, the uFMfSW is affected by a lack of, or inaccuracies, in available data.

These datasets provide a picture of surface water flooding across the County and identify that the risk is widespread across most of the County. As shown in Figures 1 – 5 in Appendix D, surface water is shown to pond in natural low points along the fluvial floodplains and through the valleys which form tributaries of the Main Rivers in the County. Particular areas of note in the north of the County include the floodplain of the River Cherwell to the east and upstream of Cropredy, tributaries of the River Cherwell and their associated valleys flowing in a west-east direction, and the River Evenlode and its floodplain around Bruern Abbey and the Cotswold Railway Line. To the south, the low lying areas in the upper Thames floodplain to the north of Faringdon, numerous tributaries of the River Ock, and the catchments associated with the Cuttle Brook south of Thame and Haseley Brook east of Great Haseley.

4.6 Flooding from Groundwater

Groundwater flooding usually occurs in areas underlain by permeable rock and aquifers that allow groundwater to rise to the surface through the permeable subsoil following long periods of wet weather. Low lying areas may be more susceptible to groundwater flooding because the water table is usually at a much shallower depth and groundwater paths tend to travel from high to low ground.

4.6.1 Historic Records

Records of historic groundwater flood events have been extracted, where possible, from each of the LPA SFRA’s and collated by settlement into a single database and presented in Figure 3 in Appendix B. Due to the limited availability of flood event data within the five LPA SFRA’s for groundwater, Figure 3 Appendix B is not considered to be a complete

---

43 Environment Agency (2013) ‘What is the updated Flood Map for Surface Water?’
representation of the distribution of historic groundwater flood events in Oxfordshire. A review of the historic flood event records has been undertaken and provided in Appendix A.

A clustering of groundwater flood events has occurred in and around the City of Oxford, including areas such as New Hinksey, Grandpont, Oxford University, Headington and Botley. It is recognised in the PFRA\[16\] that groundwater flooding in these areas may have occurred in combination with fluvial flooding, causing groundwater levels in the alluvial deposits to rise and flood basements.

The Assendon Spring (an ephemeral groundwater fed ordinary watercourse), has caused groundwater flooding in Stonor, Middle Assendon, Lower Assendon, and Henley where five separate groundwater flood events have been reported in the SO & VOWH SFRA\[11\].

Single groundwater flood events have largely been reported in settlements throughout the majority of the County. Often these incidents have been reported in settlements located in close proximity to a watercourse such as Clifton Hampden and Sutton Courtenay (River Thames), Banbury and Steeple Aston (River Cherwell), and in the headwaters of the brooks and streams in West Oxfordshire. A Defra report\[44\] into groundwater flooding identified the Environment Agency's Thames West Area (covering VOWH and South Oxfordshire Districts) as having had the second highest number of groundwater flooding incidents from hard rock aquifers for all Environment Agency regions in 2000/1 and 2003. The draft Thames FRMP\[42\] further supports this evidence by making reference to groundwater flooding occurring across much of the chalk down land in the catchment in 2000 and 2013/14.

### 4.6.2 Areas Susceptible to Groundwater Flooding

As part of the SFRA, an assessment of the risk of groundwater flooding needs to be considered; however, a quantified assessment of risk from groundwater flooding is difficult to undertake, especially on a strategic scale. This is due to lack of groundwater level records, the variability in geological conditions and the lack of predictive tools (such as modelling) that can be used to make assessments of groundwater flow and risk of groundwater flooding following rainfall events.

Figures 1 – 5 in Appendix E presents the Environment Agency’s dataset: Areas Susceptible to Groundwater Flooding (AStGWF), which indicates where groundwater may emerge due to certain geological and hydrogeological conditions. This information is shown as a proportion of 1km grid squares where there is potential for groundwater emergence. The data does not show where flooding is likely to occur, but instead should be used at a strategic level to indicate areas for further investigation.

As described in Section 2.3, the bedrock geology of OCC consists of a number of different formations as shown in Figure 2-1. The bedrock geology follows bands running in a south west to north east direction. The oolitic limestone of the Cotswolds in the north-west, followed by a band of Oxford clays, mudstone, siltstone and sandstone and into the chalk to the south and south east forming the hills of the North Wessex Downs and the Chilterns. Within river catchments, where river terrace gravels and superficial deposits are present, the risk of groundwater flooding is likely to be greatest.

Minerals workings in most cases excavate below the natural water table, which during periods of heavy rainfall may rise. Mineral workings often operate a pumped system and can therefore interfere with groundwater flow. These issues would be most appropriately addressed in an FRA at the planning application stage for each site.

### 4.7 Flooding from other sources

Due to the strategic nature of Part 1: Core Strategy of the NMWP, and as agreed with the Environment Agency, it has not been considered appropriate to address the flood risk posed by sewers and other artificial sources in this Level 1 SFRA. Descriptions of these sources of flood risk have been provided in this Section, but a more detailed assessment will be performed in the updated Level 1 SFRA which will accompany Part 2: Site Allocations of the NMWP when site specific details are known.

#### 4.7.1 Sewers / Highway Drains

During heavy rainfall, flooding from the sewer system may occur if:

- The rainfall event exceeds the capacity of the sewer system/drainage system:
  - Sewer systems are typically designed and constructed to accommodate rainfall events with a 3.3% AEP or less. Therefore, rainfall events with a return period of frequency greater than 3.3% AEP would be expected to result in surcharging of some of the sewer system. While the sewerage undertakers for Oxfordshire (Anglian Water Services (AWS) and Thames Water Utilities Ltd (TWUL)) are concerned about the frequency

---

of extreme rainfall events, it is not economically viable to build sewers that could cope with every extreme rainfall event.

b. The system becomes blocked by debris or sediment:
   • Over time there is potential that road gullies and drains become blocked from fallen leaves, build-up of sediment and debris (e.g. litter).

c. The system surcharges due to high water levels in receiving watercourses:

Within Oxfordshire there is potential for surface water outlets to become submerged due to high river levels. When this happens, water is unable to discharge. Once storage capacity within the sewer system itself is exceeded, the water will overflow onto the surface. Where the local area is served by ‘combined’ sewers (i.e. containing both foul and storm water), if rainfall entering the sewer exceeds the capacity of the combined sewer and storm overflows are blocked by high water levels in receiving watercourses, surcharging and surface flooding may again occur but in this instance floodwaters will contain untreated sewage.

4.7.2 Reservoirs, Canals and other Artificial Sources

The failure of a reservoir, canal, pond or other artificially impounded waterbody has the potential to cause catastrophic damage due to the sudden release of large volumes of water. The PPG encourages LPAs to identify any impounded waterbodies and evaluate how they might modify the existing flood risk in the event of a flood in the catchment it is located within, and / or whether emergency draw-down of the waterbody will add to the extent of flooding. The Risk of Flooding from Reservoirs map is available on the Environment Agency website.\(^{45}\)

4.8 Climate Change

Rising global temperatures is considered to be the most obvious consequence of climate change, however, in relation to Oxfordshire, its impact on changing weather patterns and the hydrological cycle is likely to be more significant. Predicted increases in peak rainfall intensity and river flow could result in more frequent and severe flood events. Climate change is therefore perceived to represent an increasing risk to low lying areas of England, and it is anticipated that the frequency and severity of flooding will change measurably within our lifetime.

Recommended contingency allowances for net sea level rises, and recommended national precautionary sensitivity ranges for peak rainfall intensity, peak river flow, offshore wind speed and wave height suitable for use in the planning system are derived from Department for Environment, Food and Rural Affairs FCDPAG3 Economic Appraisal Supplementary Note to Operating Authorities – Climate Change Impacts, October 2006\(^{46}\) and presented in Table 4-3 and Table 4-4. (These values are subject to change in accordance with data from UKCP09).

Table 4-3 Recommended contingency allowances for net sea level rises (Net sea level rise (mm per year) relative to 1990)

<table>
<thead>
<tr>
<th>Region</th>
<th>1990 to 2025</th>
<th>2025 to 2055</th>
<th>2055 to 2085</th>
<th>2085 to 2115</th>
</tr>
</thead>
<tbody>
<tr>
<td>East of England, east midlands, London, south-east England (south of Flamborough Head)</td>
<td>4.0</td>
<td>8.5</td>
<td>12.0</td>
<td>15.0</td>
</tr>
</tbody>
</table>

Table 4-4 Recommended national precautionary sensitivity ranges for peak rainfall intensity, peak river flow, offshore wind speed and wave height

<table>
<thead>
<tr>
<th>Parameter</th>
<th>1990 to 2025</th>
<th>2025 to 2055</th>
<th>2055 to 2085</th>
<th>2085 to 2115</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak rainfall intensity</td>
<td>+5%</td>
<td>+10%</td>
<td>+20%</td>
<td>+30%</td>
</tr>
<tr>
<td>Peak river flow</td>
<td>+10%</td>
<td>+20%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Offshore wind speed</td>
<td>+5%</td>
<td>+10%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extreme wave height</td>
<td>+5%</td>
<td></td>
<td>+10%</td>
<td></td>
</tr>
</tbody>
</table>

Hydraulic modelling studies for the fluvial watercourses in the County, which include simulations that take into account the effect on climate change, have not been assessed as part of this Level 1 SFRA which accompanies the Part 1: Core Strategy of the NMWP. Modelled flood extents which take account of climate change will be used as part of the updated Level 1 SFRA in accompaniment with Part 2: Site Allocation of the NMWP.

---


\(^{46}\) This document has now been superseded by Environment Agency Adapting to Climate Change: Advice for flood and coastal erosion risk management authorities, July 2011, but the allowances are considered suitable for use in the planning system. Further information can be found on the Environment Agency standing advice pages here: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/296964/UT_8496_53066a.pdf
4.9 Flood Risk Management Measures

Flood risk management can reduce the probability of occurrence through the management of land, river systems and flood defences, and reduce the impact through influencing development in flood risk areas, flood warning and emergency response.

4.9.1 Flood Defences

Flood defences are structures which affect flow in times of flooding and therefore prevent water from entering property. They generally fall into one of two categories; ‘formal’ or ‘informal’.

A ‘formal’ flood defence is a structure which has been specifically built to control floodwater. It is maintained by its owner or statutory undertaker so that it remains in the necessary condition to function. In accordance with the FWMA, the Environment Agency has powers to construct and maintain defences to help protect against flooding. OCC has similar powers on ordinary watercourses throughout the County.

An ‘informal’ defence is a structure that has not necessarily been built to control floodwater and is not maintained for this purpose. This includes road and rail embankments and other linear infrastructure (buildings and boundary walls) which may act as water retaining structures or create enclosures to form flood storage areas in addition to their primary function.

A study of informal flood defences has not been made as part of this assessment. Should any changes be planned in the vicinity of road or railway crossings over rivers in the study area it would be necessary to assess the potential impact on flood risk to ensure that flooding is not made worse either upstream or downstream. Smaller scale informal flood defences should be identified as part of site specific FRAs and the residual risk of their failure assessed.

A high level review of formal flood defences using data from the Environment Agency Flood Map will be carried out as part of the Part 2: Site Allocations.

4.9.2 Residual Risk

In producing Flood Zone maps the Environment Agency takes the presence of defences into account by showing the areas that benefit from the defence (ABD). This area can also be deemed an area which is at risk of defence overtopping or failure. It can therefore also be described as a residual risk zone. Residual flood risks can arise due to:

- The failure of flood management infrastructure such as a breach of a raised flood defence, blockage of a surface water conveyance system or culvert, overtopping of an upstream storage area, or failure of a pumped drainage system;
- A severe flood event that exceeds a flood management design standard and results in, for example, overtopping.

Residual risk and ABDs will be identified and assessed on a site by site basis, as part of the Part 2: Site Allocations.

4.9.3 Flood Warning Systems

The Environment Agency provides a free flood warning service for many areas at risk of flooding from rivers and the sea. In some parts of England, including South Oxfordshire, the Environment Agency may be able to provide warnings when flooding from groundwater is possible in the form of groundwater situation reports. The Environment Agency free flood warning service can provide advance notice of flooding and can provide time to prepare for a potential flood event.

The Environment Agency issue flood warnings to homes and businesses when flooding to properties is expected. Upon receipt of a flood warning, occupants should take immediate action.

The Environment Agency also issue flood alerts when flooding to low lying land and roads is expected. Flood alerts cover larger areas than flood warnings and are issued more frequently. Upon receipt of an alert, occupants should be prepared for flooding and to take action.

Flood warnings and flood alerts are signed up to separately, however when signing up for flood warnings homes and businesses must agree to receive flood alerts.

If a flood alert from groundwater is available this does not mean that a particular property is definitely at risk. It is very difficult to predict the exact location of flooding from groundwater as it is often related to local geology. To help people, the Environment Agency provides flood alerts for large areas that could be affected if groundwater levels were high.

Flood alert and flood warning areas can be viewed on the Environment Agency website (http://apps.environment-agency.gov.uk/wiby/37835.aspx). All stages of warning are disseminated via Floodline Warnings Direct (FWD), which is a free service that provides warnings to registered customers by telephone, mobile, email, SMS text message and fax.
Further information on Flood Warnings in force and Flood Warning Areas can be found from the Environment Agency website, under Flood Warnings and South-East Region.

4.9.4 Flood Evacuation Plans

OCC’s Emergency Planning Unit is responsible for the production, maintenance, and development of plans for an integrated response to any major emergency. This involves working closely with the emergency services, other OCC departments, other local authorities, voluntary agencies and industry to ensure that any response to a major incident is carefully managed to ensure a return to normality as quickly as possible. OCC includes flooding as an emergency situation.

OCC has a Joint Severe Weather Plan which is the main guidance for all key officers in dealing with major flood emergencies. All departments should have emergency procedures in place to guide staff in their tasks where they differ from their normal work practices, such as providing care for evacuees at Emergency Rest Centres.

As LLFA, OCC provides flood advice on its website. The website directs users to the Environment Agency website to view the flood warnings in place (as described in Section 4.9.3) and to view properties at risk of flooding from main rivers, surface water and reservoirs. OCC’s website offers a link to the Environment Agency’s website for advice on how to protect homes from flooding, and provides information on what to do in the event of a flood. The website also provides information on who to contact should flooding occur.

It is recommended that OCC’s Joint Severe Weather Plan is reviewed and updated in light of the findings of the SFRA to ensure that safe evacuation and access for emergency services is possible during times of flood both for existing mineral and waste sites and those being promoted as possible sites within the NMWP.

48 https://www.oxfordshire.gov.uk/cms/public-site/emergency-planning
5 Mineral and Waste Area Assessments

5.1 Overview

A high level assessment of flood risk has now been undertaken using the most up to date flood risk datasets for each of the Broad Area Options (2010), Broad Preferred Areas for minerals and waste (2015) and the associated mineral and waste sites within each of the areas.

Prior to undertaking this Level 1 SFRA update, an initial assessment was undertaken in March 2015 and this helped to determine the extent to which the SFRA update was required. The initial assessment established and quantified the change in flood risk from fluvial and surface water sources, as well as the change in potential flood risk from groundwater, for each of the broad area options for minerals and broad areas for waste, through a comparison between the 2010 and 2015 datasets. A high level assessment also identified where a change of flood risk occurred at a particular site or area (±5% difference between datasets).

Appendix F contains a list of the mineral Broad Area Options and the associated sites. Appendix G contains a list of the mineral Broad Preferred Areas and associated sites, and Appendix H contains a list of the waste Broad Preferred Areas and associated sites. Within each appendix, the current flood risk to each area and site, as determined by updated flood risk datasets, has been provided.

It should be noted that the individual mineral and waste sites may be subject to revision during MWLP-SA. All possible sites will be further assessed in the future update to this Level 1 SFRA which will be prepared as part of the MWLP-SA work.

The initial assessment identified a number of cases where flood risk had increased or decreased since 2010, but OCC concluded (in conjunction with the Environment Agency) that the changes did not appear to be of such significance as to have a fundamental bearing on the emerging MWLP-CS.

5.1.1 Mineral Areas

The Mineral Areas assessed in Appendix F and Appendix G include the resource areas identified as options for the working of crushed rock, soft sand and sand and gravel. During the course of plan preparation these resource areas have been assessed for their suitability to deliver the required amounts of mineral during the plan period, and refined to provide a smaller number of preferred areas for future working. The previous SFRA helped inform the development of these areas, as shown in Appendices C, D and E of the previous Level 1 SFRA report. The preferred areas of working for aggregate minerals are outlined in Policy M3 of the Revised Core Strategy, and criteria for the selection of future sites outlined in Policy M4. Section 5.3 below summarises the flood risk to each of the preferred areas of working as identified in these policies.

5.1.2 Waste Areas

The broad areas for waste, assessed in Appendix H, have been developed during the preparation of the plan and represent the broad areas from which locations (or sites) for strategic and non-strategic waste management facilities may be identified, as described in Policy W4. Policy W5 of the MWLP-CS outlines criteria for the siting of waste management facilities - being land that:

− ‘is already in waste management or industrial use; or
− is previously developed, derelict or underused; or
− is at an active mineral site; or
− involves existing agricultural buildings and their curtilages; or
− is at a waste water treatment works.’

Section 5.4 summarises the flood risk to each of the broad areas identified in these policies.

5.1.3 Radioactive Waste Management Sites

Policy W9 identifies two sites for the future management and disposal of radioactive waste (at Harwell in the Vale of White Horse District and Culham in the South Oxfordshire District). Section 5.5 summarises the flood risk to each site.
5.2 Limitations

5.2.1 Surface Water Flood Risk

For the purposes of identifying flood risk from surface water, the original Oxfordshire Minerals and Waste SFRA (2010) referred to Environment Agency Areas Susceptible to Surface Water Flooding (AStSWF) maps. The AStSWF dataset was produced using only the 1 in 200 year (0.5% AEP) storm event, a return period which is not represented in the uFMfSW dataset (including 1 in 30 year (3.33% AEP), 1 in 100 year (1% AEP) and 1 in 1000 year (0.1% AEP) storm events).

The uFMfSW dataset provides considerable refinement to the modelling of surface water flood risk and this dataset should be used in combination with local surface water flood records to undertake any surface water flood risk analysis for sites and areas.

5.2.2 Groundwater Flood Risk

Further information on the AStGWf dataset can be found in the Environment Agency Areas Susceptible to Groundwater Flooding Guidance. Within the guidance note, it is noted that

"Unless an area identified as ‘susceptible to groundwater flooding’ is also identified as ‘at risk from surface water flooding’, it is unlikely that this location would actually experience groundwater flooding to any appreciable depth, and therefore it is also unlikely that the consequences of such flooding would be significant."

Table 5-1 provides a definitive description of the proportion of land within 1km² that is susceptible to groundwater flooding.

<table>
<thead>
<tr>
<th>Proportion of 1km² that is susceptible to groundwater flood emergence</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>None of this land is susceptible to groundwater emergence</td>
</tr>
<tr>
<td>&lt;25%</td>
<td>A very small proportion of this land is susceptible to groundwater emergence</td>
</tr>
<tr>
<td>25% - 50%</td>
<td>A small proportion of this land is susceptible to groundwater emergence</td>
</tr>
<tr>
<td>50% - 75%</td>
<td>A moderate proportion of this land is susceptible to groundwater emergence</td>
</tr>
<tr>
<td>&gt;75%</td>
<td>A large proportion of this land is susceptible to groundwater emergence</td>
</tr>
</tbody>
</table>

5.3 Assessment Results – Mineral Areas

CS 1 – Burford - South of A40 (Crushed Rock)
- The majority of this area is in Flood Zone 1 (99%).
- Considered to be the least at risk mineral area from surface water flooding (98% of area not at any risk).
- 65% of this area is considered to have a ‘very small’ proportion of land susceptible to groundwater emergence.

CS 2 – East / South East of Faringdon (Crushed Rock)
- The majority of this area is in Flood Zone 1 (99%).
- Considered to be the third least at risk mineral area from surface water flooding (96% of area not at any risk).
- 65% of this area is considered to have a ‘small’ proportion of land susceptible to groundwater emergence.

CS 3 – North West of Bicester (Crushed Rock)
- The majority of this area is in Flood Zone 1 (99%).
- Considered to be the second least at risk mineral area from surface water flooding (97% of area not at any risk).
- 51% of this area is considered to have a ‘small’ proportion of land susceptible to groundwater emergence.

CS 4 – Thames Valley - Caversham to Shiplake (Sharp sand and gravel)
The majority of this area is in Flood Zone 3 (92%).
Considered to be the second most at risk mineral area from surface water flooding (61% of area not at any risk).
65% of this area is considered to have a ‘moderate’ proportion of land susceptible to groundwater emergence.

**CS 5a – Thames, Lower Thames Valley - Kennington to Cholsey (Sharp sand and gravel)**
- The majority of this area is in Flood Zone 3 (54%).
- Considered to be the third most at risk mineral area from surface water flooding (66% of area not at any risk).
- 49% of this area is considered to have a ‘moderate’ proportion of land susceptible to groundwater emergence.

**CS 5b – Thames, Lower Thames Valley - Oxford to Cholsey (Sharp sand and gravel)**
- The majority of this area is in Flood Zone 1 (61%).
- 62% of this area is considered to have no land susceptible to groundwater emergence.

**CS 5c – Thames, Lower Thames Valley - Oxford to Cholsey (Sharp sand and gravel)**
- The majority of this area is in Flood Zone 1 (49%).
- Considered to be the most at risk mineral area from surface water flooding (51% of area not at any risk).
- 96% of this area is considered to have no land susceptible to groundwater emergence.

**CS 5d – Thames, Lower Thames Valley - Oxford to Cholsey (Sharp sand and gravel)**
- The majority of this area is in Flood Zone 1 (49%).
- 70% of this area is considered to have no land susceptible to groundwater emergence.

**CS 5e – Thames, Lower Thames Valley - Oxford to Cholsey (Sharp sand and gravel)**
- The majority of this area is in Flood Zone 1 (75%).
- 49% of this area is considered to have no land susceptible to groundwater emergence.

**CS 6 – Thames, Lower Windrush & Evenlode Valley - Standlake to Yarnton (Sharp sand and gravel)**
- The majority of this area is in Flood Zone 3 (53%).
- 66% of this area is considered to have no land susceptible to groundwater emergence.

**CS 7 – Corallian Ridge - Oxford to Faringdon (Soft Sand)**
- The majority of this area is in Flood Zone 1 (97%).
- 59% of this area is considered to have a ‘small’ proportion of land susceptible to groundwater emergence.

**CS 8 – Duns Tew Area (Soft Sand)**
- The majority of this area is in Flood Zone 1 (99%).
- 64% of this area is considered to have a ‘small’ proportion of land susceptible to groundwater emergence.

### 5.4 Assessment Results – Waste Areas

**WA_1_Witney**
- The majority of this area is in Flood Zone 1 (92%).
- Considered to be the third least at risk waste area from surface water flooding (83% of area not at any risk).
- 58% of this area is considered to have a ‘small’ proportion of land susceptible to groundwater emergence.

**WA_2_Wantage**
- The majority of this area is in Flood Zone 1 (94%).
- Considered to be the most at risk waste area from surface water flooding (80% of area not at any risk).
- 44% of this area is considered to have a ‘small’ proportion of land susceptible to groundwater emergence.
WA_3_Didcot
- The majority of this area is in Flood Zone 1 (87%).
- Considered to be the least at risk waste area from surface water flooding (90% of area not at any risk).
- 34% of this area is considered to have no land susceptible to groundwater emergence.

WA_4_Oxford
- The majority of this area is in Flood Zone 1 (91%).
- Considered to be the third most at risk waste area from surface water flooding (82% of area not at any risk).
- 33% of this area is considered to have a ‘small’ proportion of land susceptible to groundwater emergence.

WA_5_Banbury
- The majority of this area is in Flood Zone 1 (89%).
- 44% of this area is considered to have a ‘small’ proportion of land susceptible to groundwater emergence.

WA_6_Bicester
- The majority of this area is in Flood Zone 1 (89%).
- Considered to be the second most at risk waste area from surface water flooding (80% of area not at any risk).
- 64% of this area is considered to have a ‘small’ proportion of land susceptible to groundwater emergence.

WA_7_Abingdon
- The majority of this area is in Flood Zone 1 (72%).
- Considered to be the second least at risk waste area from surface water flooding (84% of area not at any risk).
- 57% of this area is considered to have no land susceptible to groundwater emergence.

5.5 Assessment Results – Radioactive Waste Management sites

Site 53 – UKAEA Laboratory
- The site is entirely within Flood Zone 1 (100%).
- The majority of the site (95%) is not at any risk from surface water flooding.
- 81% of this site is considered to have no land susceptible to groundwater emergence.

Site 242 – JET Laboratories
- The site is entirely within Flood Zone 1 (100%).
- The majority of the site (43%) is not at any risk from surface water flooding.
- The entire site (100%) is considered to have a ‘large’ proportion of land susceptible to groundwater emergence.
6 Guidance for Applying the Sequential and Exception Tests

6.1 Sequential Test

The Sequential Test is a decision-making tool designed to ensure that sites at little or no risk of flooding are developed in preference to sites at higher risk, so avoiding the development of sites that are inappropriate on flood risk grounds. Where this cannot be avoided, application of an Exception Test allows for the possibility of some development in flood risk areas taking place if flood risk is clearly outweighed by other sustainability drivers.

The Sequential Test is applied at all stages of the planning process, both between different Flood Zones and within a Flood Zone. All opportunities to locate new developments (except Water Compatible) in reasonably available areas of little or no flood risk should be explored, prior to any decision to locate them in areas of higher risk.

It is acknowledged within the NPPF that minerals have to be extracted where they are located but their operational workings ‘should not increase flood risk elsewhere and need to be designed, worked and restored accordingly’. For this reason, sand and gravel extraction sites are classified as ‘Water Compatible’ development notwithstanding that such development can still give rise to flooding problems.

Where sand and gravel workings are located within the floodplain, steps should be taken to apply a sequential approach within the site itself to ensure that ancillary and supporting infrastructure and buildings are located in areas of lowest flood risk to reduce the risk of being adversely affected by flooding or increasing flood risk elsewhere.

It should also be noted that essential ancillary sleeping or residential accommodation for staff required by all Water Compatible development including sand and gravel workings are subject to a specific flood warning and evacuation plan. OCC should assess whether the requirement for the mineral could first be met from areas at no risk of flooding and, if not, that there is justification for the level of development that may ultimately need to take place in areas that are at risk of flooding.

If a location is recorded as having experienced repeated flooding from the same source this should be acknowledged within the Sequential Test.

6.2 Applying the Sequential Test – Plan-Making

OCC (as Minerals and Waste Planning Authority) must demonstrate that it has considered a range of possible options. The Flood Zone and vulnerability information from the SFRA allows these options to be Sequentially Tested in terms of flood risk and, where necessary, an Exception Test applied in the site allocation process. Figure 6-1 illustrates the approach for applying the Sequential Test that OCC should adopt in the preparation of the MWLP. The Sequential Test should be undertaken by OCC and accurately documented to ensure decision processes are consistent and transparent.
Figure 6-1 Application of Sequential Test for Minerals and Waste Local Plan preparation

This process anticipates that a Local Plan will be a single document that will include specific sites for development. The MWLP is a two part plan (with the exception of policy W9), with site allocation undertaken at stage 2 (MWLP-SA). This has been taken into consideration, and recommended stages in how to apply the sequential test to both the MWLP-CS and MWLP-SA have been provided in Sections 6.3.1 and 6.3.2 respectively.

The Sequential Test requires an understanding of the Flood Zones in the County and the vulnerability classification of proposed forms of development. Flood Zone definitions are provided in Table 4-2 and mapped in Figures 1 – 5 Appendix C (and the Flood Map for Planning (Rivers and Sea) on the Environment Agency website). A summary of the vulnerability classifications for waste and mineral sites and their various installations, as defined in the PPG, is provided in Table 6-1.

Table 6-1 Flood Risk Vulnerability Classification (PPG, 2014)

<table>
<thead>
<tr>
<th>Vulnerability Classification</th>
<th>Development Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highly Vulnerable</td>
<td>Installations requiring hazardous substances consent. (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”).</td>
</tr>
<tr>
<td>More Vulnerable</td>
<td>Landfill and sites used for waste management facilities for hazardous waste.</td>
</tr>
<tr>
<td>Less Vulnerable</td>
<td>Waste treatment (except landfill and hazardous waste facilities). Minerals working and processing (except for sand and gravel working).</td>
</tr>
<tr>
<td>Water-Compatible Development</td>
<td>Sand and gravel working. Essential ancillary sleeping or residential accommodation for staff required by uses in this category, subject to a specific warning and evacuation plan.</td>
</tr>
</tbody>
</table>

The NPPF acknowledges that some areas will (also) be at risk of flooding from sources other than fluvial. All sources must be considered when planning for new development including: flooding from land or surface water runoff; groundwater; sewers; and artificial sources.

If a location is recorded as having experienced repeated flooding from the same source this should be acknowledged within the Sequential Test.
The recommended steps in undertaking the Sequential Test are detailed below. This is based on the Flood Zone and Flood Risk Vulnerability and is summarised in Table 6-2. Table 6-2 indicates the compatibility of different development types with the Flood Zones.

Table 6-2 Flood Risk Vulnerability and Flood Zone 'Compatibility' (PPG, 2014)

<table>
<thead>
<tr>
<th>Flood Zone</th>
<th>Flood Risk Vulnerability Classification</th>
<th>Essential Infrastructure</th>
<th>Water Compatible</th>
<th>Highly Vulnerable</th>
<th>More Vulnerable</th>
<th>Less Vulnerable</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>✓</td>
<td>✓</td>
<td>Exception Test Required</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>3a</td>
<td>3a Exception Test Required</td>
<td>✓</td>
<td>×</td>
<td>Exception Test Required</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>3b</td>
<td>3b Exception Test Required</td>
<td>✓</td>
<td>×</td>
<td>×</td>
<td>×</td>
<td></td>
</tr>
</tbody>
</table>

✓ - Development is appropriate  × - Development should not be permitted

6.3 Recommended stages for application of the Sequential Test

6.3.1 Part 1 – MWLP Core Strategy

For minerals, the Sequential Test has previously been applied to the various option areas identified for each form of mineral using data from the previous SFRA. The Sequential Test should be re-applied using the classification in Table 6-1:

- Soft Sand working and processing is Less Vulnerable development. Working in Flood Zone 1 is preferred but can take place in Flood Zone 2 and Flood Zone 3a without application of the Exception Test. Development should not be permitted in Flood Zone 3b.
- Crushed Rock working and processing – as above.
- Sand and gravel working and processing – as above.
- Sand and gravel working is water compatible development. Working in FZ1 is preferred but can take place in Flood Zone 2, Flood Zone 3a and Flood Zone 3b without application of the Exception Test. Processing plant (and associated development – such as stockpiles) should only be accommodated on a part of the site that lies in Flood Zone 2 or Flood Zone 3a.

For waste, it is more difficult to apply the Sequential Test. The broad areas for strategic/non-strategic waste management facilities could accommodate any of the types of waste facilities referred to in Table 6-1. From data presented in the previous SFRA it was known that these areas included extensive areas in Flood Zone 1 and sequential testing was not considered necessary in arriving at a preferred waste planning strategy. An assessment could, however, be usefully undertaken using data in this study to identify the availability of land to accommodate the most vulnerable form of waste development - hazardous waste facilities requiring hazardous substances consent which can only be accommodated in Flood Zone 1 or, subject to satisfying the Exceptions Test, Flood Zone 2. The outcome of this assessment would thereby provide a ‘worse case’ scenario, identifying the extent to which each of the broad areas provide opportunity for any of the variety of waste developments that are susceptible to flooding in some form.

6.3.2 Part 2 – MWLP Site Allocation

Following the adoption of the MWLP-CS, the MWLP-SA will be prepared as a separate development plan document, identifying specific sites for minerals and waste developments within the parameters set by the Core Strategy. Allocation of mineral and waste sites, and specifically, to those sites which have gone through the Sequential Test and may be located in Flood Zones 2 or 3, must be based on suitably up to date data.

a. Assign potential sites with a vulnerability classification (Table 6-1).

b. The location and identification of potential sites should be recorded.

c. The Flood Zone classification of potential mineral and waste sites should be determined based on a review of the Flood Map for Planning (Rivers and Sea). Where these span more than one flood zone, all zones should be noted.
d. The design life of the development should be considered with respect to climate change. Design life for commercial / industrial developments will be variable, however a 75 year design life may be assumed, unless demonstrated otherwise.

e. Identify existing flood defences serving the potential development sites. However, it should be noted that for the purposes of the Sequential Test, flood zones ignoring defences should be used.

f. Highly Vulnerable developments to be accommodated within the planning area should be located in those sites identified as being within Flood Zone 1. If these cannot be located in Flood Zone 1, because the identified sites are unsuitable or there are insufficient sites in Flood Zone 1, sites in Flood Zone 2 can then be considered. Highly Vulnerable developments in Flood Zone 2 will require application of the Exception Test.

g. Within each flood zone Highly Vulnerable development should be directed, where possible, to the areas at lowest risk from all sources of flooding. Highly Vulnerable development is not appropriate in Flood Zones 3a and 3b.

h. More Vulnerable development should be located in any unallocated sites in Flood Zone 1. Where these sites are unsuitable or there are insufficient sites remaining, sites in Flood Zone 2 can be considered. If there are insufficient sites in Flood Zone 1 or 2 to accommodate More Vulnerable development, sites in Flood Zone 3a can be considered. More Vulnerable developments in Flood Zone 3a will require application of the Exception Test.

i. Within each flood zone More Vulnerable development should be directed to areas at lowest risk from all sources of flooding. More Vulnerable development is not appropriate in Flood Zone 3b.

j. Less Vulnerable development should be located in any remaining unallocated sites in Flood Zone 1, continuing sequentially with Flood Zone 2, then Flood Zone 3a. Less Vulnerable development types are not appropriate in Flood Zone 3b – Functional Floodplain.

k. Essential Infrastructure should be preferentially located in the lowest flood risk zones, however this type of development may be located in Flood Zones 3a and 3b, provided the Exception Test is satisfied.

l. Water Compatible development has the least constraints with respect to flood risk and it is considered appropriate to allocate these sites last. The sequential approach should still be followed in the selection of sites; however it is appreciated that Water Compatible development by nature often relies on access and proximity to water bodies.

m. On completion of the Sequential Test, the planning authority may have to consider the risks posed to a site within a flood zone in more detail in a Level 2 SFRA. By undertaking the Exception Test, this more detailed study should consider the detailed nature of flood hazard to allow a sequential approach to site allocation within a flood zone. Consideration of flood hazard within a flood zone would include:

- Flood risk management measures,
- The rate of flooding,
- Flood water depth,
- Flood water velocity.

Where the development type is Highly Vulnerable, More Vulnerable, Less Vulnerable or Essential Infrastructure and a site is found to be impacted by a recurrent flood source (other than tidal or fluvial), the site and flood sources should be investigated further regardless of any requirement for the Exception Test.

6.4 Windfall Sites

Windfall sites are those which have not been specifically identified through the Local Plan process. They are sites which do not have planning permission, but could be available for development. In cases where development cannot be fully met through the provision of site allocations, planning authorities are expected to make a realistic allowance for windfall development, based on past trends.

Sites that come forward as planning applications which have not been allocated, or in advance of, the MWLP-SA must be the subject of sequential testing. In these cases it is the responsibility of the applicant to present this with the application for assessment by OCC. It would normally be expected that the area of search be commensurate with the county boundary, although this may need to be adjusted and include parts of other administrative areas where locations are close to the county boundary.

6.5 Exception Test

The purpose of the Exception Test is to ensure that certain new development (Table 6-2) is only permitted in Flood Zone 2 and Flood Zone 3 where flood risk is clearly outweighed by other sustainability factors and where the development will be safe during its lifetime, considering climate change.
For the Exception Test to be passed:

- "It must be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk, informed by the SFRA where one has been prepared; and"
- "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."

Both elements of the test will have to be passed for development to be allocated or permitted in the MWLP-SA.

When determining planning applications, OCC should ensure flood risk is not increased elsewhere and only consider development appropriate in areas at risk of flooding where, informed by a site-specific FRA following the Sequential Test, and if required the Exception Test, it can be demonstrated that:

- Within the site, the most vulnerable development is located in areas of lowest flood risk unless there are overriding reasons to prefer a different location; and
- Development is appropriately flood resilient and resistant, including safe access and escape routes where required, and that any residual risk can be safely managed, including by emergency planning; and it gives priority to the use of SuDS.

There are a number of ways a new development can be made safe:

- Avoiding flood risk by not developing in areas at risk from floods;
- Substituting higher vulnerability land uses for lower vulnerability uses in higher flood risk locations and locating higher vulnerability uses in areas of lower risk on a strategic scale, or on a site basis;
- Providing adequate flood risk management infrastructure which will be maintained for the lifetime of the development; and
- Mitigating the potential impacts of flooding through design and resilient construction.

In order to determine part 1) of the Exception Test, the proposed scheme should be assessed against the objectives within the Oxfordshire Sustainability Appraisal.

### 6.5.1 Part 1 – MWLP Core Strategy

The Exception Test can only be applied to development proposed in site specific locations. With only two exceptions, the Core Strategy does not seek to allocate sites. The Exception Test cannot be applied to the broad areas for minerals and waste development identified.

### 6.5.2 Part 2 – MWLP Site Allocations

All mineral development is defined as either ‘Water Compatible’ or ‘Less Vulnerable’ in terms of fluvial flood risk. Table 6-2 confirms that the Exceptions Test does not need to be applied to development in these categories.

The Exception Test may need to be undertaken before a site can be identified as suitable for certain types of waste development as follows:

- Landfill and sites used for waste management facilities for hazardous waste – where located in Flood Zone 3a.
- Installations requiring Hazardous Substances Consent – where located in Flood Zone 2.

### 6.6 Exception Test Exemptions

It is noted that applications for minor development and change of use are exempt from the Exception Test (see Notes to the Flood Risk Vulnerability and Flood Zone ‘Compatibility’ table (PPG, 2014)); however site-specific FRAs are still required, as detailed in Section 7.

---

7 Guidance for preparing Site-Specific FRAs

7.1 Overview

This Level 1 SFRA provides a high level assessment of the flood risk posed to the County. However, this document has a strategic scope and therefore it is essential that site-specific Flood Risk Assessments (FRAs) are also developed for individual development proposals and that where necessary and appropriate, suitable mitigation measures are incorporated.

This Section presents recommendations and guidance for site-specific FRAs prepared for submission with planning applications for mineral and waste sites in Oxfordshire. It should be noted that the type of development proposed as part of a mineral or waste site will vary significantly, and therefore not all of the mitigation measures included in this Section will always be relevant and appropriate. Consideration should be made of the type of development when preparing a site-specific FRA.

7.2 When is a Flood Risk Assessment Required?

The NPPF states that a site-specific FRA is required in the following circumstances:

- For proposals of 1 hectare or greater in Flood Zone 1;
- All proposals for new development (including minor development and change of use) in Flood Zones 2 and 3, or in an area within Flood Zone 1 which has critical drainage problems (as notified to the LPA by the EA); and,
- Where proposed development or a change of use to a more vulnerable class may be subject to other sources of flooding.

A FRA should be proportionate to the degree of flood risk as well as the scale, nature and location of the proposed development.

7.3 What should a Flood Risk Assessment address?

The NPPF states that site-specific FRAs should always be proportionate to the degree of flood risk and make optimum use of readily available information, for example the mapping presented within this SFRA. FRAs should also be appropriate to the scale, nature and location of the development.

The CIRIA publication C624 presents a staged approach to the preparation of site-specific FRAs, and identifies typical sources of information that can be used. A summary of the three levels of FRAs is described in Table 7-1 below.

Table 7-1 Levels of Site-Specific Flood Risk Assessment

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1 Screening</td>
<td>study to identify whether there are any flooding or surface water management issues related to a development site that may warrant further consideration. This should be based on readily available existing information. The screening study will ascertain whether a FRA Level 2 or 3 is required. Typical sources of information include:</td>
</tr>
<tr>
<td></td>
<td>- SFRA</td>
</tr>
<tr>
<td></td>
<td>- Flood Map for Planning (Rivers and Sea)</td>
</tr>
<tr>
<td></td>
<td>- Local flood risk policy documentation (such as RBD Flood Risk Management Plan, Catchment Flood Risk Management Plan, Shoreline Management Plan and Local Flood Risk Management Strategy)</td>
</tr>
<tr>
<td>Level 2 Scoping</td>
<td>study to be undertaken if the Level 1 FRA indicates that the site may lie within an area that is at risk of flooding, or the site may increase flood risk due to increased run-off. This study should confirm the sources of flooding which may affect the site. The study should include:</td>
</tr>
<tr>
<td></td>
<td>- An appraisal of the availability and adequacy of existing information;</td>
</tr>
<tr>
<td></td>
<td>- A qualitative appraisal of the flood risk posed to the site, and potential impact of the development on flood risk elsewhere; and</td>
</tr>
</tbody>
</table>

50 CIRIA, 2004, Development and flood risk – guidance for the construction industry C624
7.3.1 Proposed Development in Low Probability Flood Zone 1
FRAs within Flood Zone 1 should primarily take consideration of how the ability of water to soak into the ground may change with development, along with how the proposed layout of development may affect drainage systems. This is to ensure surface water generated by the site is managed in a sustainable manner and does not increase the burden on existing infrastructure and/or flood risk to neighbouring property. The assessment of surface water flood risk should take account for the impact of climate change over the lifetime of the development. SuDS techniques must be employed to ensure there is no increase in flooding elsewhere.

The uFMfSW dataset (Appendix D) should be used to indicate broad areas with a potential surface water flood risk. More detailed site investigations will also be required to determine local conditions and suitability of drainage techniques.

7.3.2 Proposed Development in Medium Probability Flood Zone 2
For all sites within Medium Probability Flood Zone 2, a Level 2 Scoping FRA should be prepared based upon readily available existing flooding information, sourced from the Environment Agency. If a significant flood risk from other sources (e.g. surface water, groundwater or sewer flooding) is identified then a more detailed FRA should be prepared. It will be necessary to demonstrate that the residual risk of flooding to the property is effectively managed throughout, for example, the provision of raised floor levels and the provision of planned evacuation routes or safe havens.

SuDS techniques must be employed on all sites in line with paragraph 103 of the PPG, regardless of the flood zone that they sit within. If a site is located within Flood Zone 2 or 3, where possible the SuDS features associated with that site should be located outside of high risk fluvial flood zones to ensure sufficient capacity during surface water events which coincide with fluvial flooding.

7.3.3 Proposed Development in High Probability Flood Zone 3a
All FRAs supporting proposed development within High Probability Flood Zone 3a should assess the proposed development against all elements of the Council’s flood policy, and include an assessment of the following:

- The vulnerability of the development to flooding from other sources (e.g. surface water drainage, groundwater) as well as from river flooding. This will involve discussion with the Council and the Environment Agency to confirm whether a localised risk of flooding exists at the proposed site.
- The vulnerability of the development to flooding over the lifetime of the development (including the potential impacts of climate change), i.e. maximum water levels, flow paths and flood extents within the site and surrounding area.
- The design life of the proposed development should be considered with respect to climate change (this is typically 75 years (up to 2090) for commercial / industrial developments, but may vary for specific waste facilities);
- For sites within the floodplain of the main rivers applicants should consult the Environment Agency to obtain information on the modelled flood levels associated with these watercourses. Where this information is of suitable quality, modelled flood levels for the relevant annual probability events should be compared with site topographic information to more accurately determine the flood risk to the site.
- Where the quality and/or quantity of information for any of the flood sources affecting a site are insufficient to enable a robust assessment of the flood risk, further investigation may be required. For example, where hydraulic modelling is not available for ordinary watercourses, the scope of the FRA should be increased to include modelling to ensure details of flooding mechanisms are fully understood and that the proposed development incorporates appropriate mitigation measures.
- The potential of the development to increase flood risk elsewhere through the addition of hard surfaces, the effect of the new development on surface water runoff, and the effect of the new development on depth and speed of flooding to adjacent and surrounding property. This will require a detailed assessment to be carried out by a suitably qualified engineer.
− The FRA should consider the vulnerability of those that could occupy and use the development including arrangements for safe access. The FRA should also take account of the vulnerability classification (Table 6-1) and the status of the site in relation to the Sequential and Exception Tests.

− The localised risk of flooding that may occur. This is typically associated with local catchment runoff following intense rainfall.

− A demonstration that residual risks of flooding (after existing and proposed flood management and mitigation measures are taken into account) are acceptable. Measures may include flood defences, flood resistant and resilient design, escape/evacuation, effective flood warning and emergency planning.

− Details of existing site levels, proposed site levels and proposed ground floor levels. All levels should be stated relevant to Ordnance Datum.

− It is essential that developers thoroughly review the existing and future structural integrity of informal defences, if present, upon which the development will rely (i.e. over the lifetime of the development), and ensure that emergency planning measures are in place to minimise risk to life in the unlikely event of a defence failure.

− SuDS techniques must be employed where appropriate to ensure no worsening of existing flooding problems elsewhere within the area.

− Any development which removes capacity from the flood plain should provide compensatory storage.

− At all stages, the LPA, and where necessary the Environment Agency and/or the Statutory Water Undertaker should be consulted to ensure the FRA provides the necessary information to fulfil the requirements for Planning Applications.

7.3.4 Proposed Development in Functional Floodplain Flood Zone 3b

In line with the NPPF, development will not normally be allowed in the Functional Floodplain unless it is classified as a ‘Water Compatible’ or ‘Essential Infrastructure’ use. Table 2 from the NPPF (refer to Table 6-1 of this report), details the type of developments classified as ‘Water Compatible’ or ‘Essential Infrastructure.’

7.4 Guidance on Flood Risk Management Measures

7.4.1 Sequential approach within development sites

Flood risk should be considered at an early stage in deciding the layout and design of a site to provide an opportunity to reduce flood risk within the development and to ensure flood risk is not increased elsewhere. The sequential approach should be applied within development sites to locate the most vulnerable elements of a development in the lowest risk areas e.g. parking, open space or proposed landscaped areas can be placed on lower ground with a higher probability of flooding. Whilst traditionally applied to the risk of river flooding, this approach should also be implemented when considering the risk of surface water flooding across a site.

It is acknowledged within the NPPF that minerals have to be extracted where they are located but their operational workings ‘should not increase flood risk elsewhere and need to be designed, worked and restored accordingly’. Where minerals workings are located within the floodplain, steps should be taken to ensure that ancillary and supporting infrastructure and buildings are located in areas of least flood risk to reduce the risk of being adversely affected by flooding.

7.4.2 Finished Floor Levels

Where developing in fluvial flood risk areas is unavoidable, the recommended method of mitigating flood risk to people, is to ensure internal floor levels are raised a freeboard distance above peak flood water levels. Finished floor levels should be set a minimum of 300mm above the 1% AEP plus climate change peak flood level. The peak flood water level should be derived for the immediate vicinity of the site (i.e. relative to the extent of a site along a water course as flood levels are likely to vary with increasing distance downstream) as part of a site-specific FRA.

The Environment Agency’s requirements for a freeboard above the peak flood level for finished internal floor levels within Less Vulnerable developments vary, depending upon the proposals. For such land uses, finished internal floor levels may not be required to be raised. However, it is strongly recommended that internal access is provided to upper floors (first floor or a mezzanine level) to provide safe refuge for any occupants who may be on the site in a flood event. Such refuges will have to be permanent and accessible to all occupants and users of the site.

Further consultation with the Environment Agency will therefore be required during the undertaking of any detailed FRA. For both Less and More Vulnerable developments where internal access to higher floors is provided, the associated plans showing this should be included within any site-specific FRA.
7.4.3 Safe Access and Egress

Safe access and egress is required to enable the evacuation of people from the development, provide the emergency services with access to the development during times of flood and enable flood defence authorities to carry out any necessary duties during periods of flood.

A safe access/egress route should allow occupants to safely enter and exit the mineral or waste development and associated buildings, and be able to reach land outside the flooded area using public rights of way without the intervention of emergency services or others during design flood conditions, including climate change allowances.

For developments located in areas at flood risk the Environment Agency consider ‘safe’ access/egress to be in accordance with ‘FRA Guidance for new Developments FD 2320’ (Defra and Environment Agency 2005). The requirements for safe access and egress from new developments are as follows in order of preference:

− Safe, dry route for people and vehicles;
− Safe, dry route for people;
− If a dry route for people is not possible, a route for people where the flood hazard, in terms of depth and velocity of flooding, is low and should not cause risk to people;
− If a dry route for vehicles is not possible, a route for vehicles where the flood hazard (in terms of depth and velocity of flooding) is low to permit access for emergency vehicles;

7.4.4 Floodplain Compensation Storage

Where proposed development results in an increase in building footprint, the developer must ensure that it does not impact upon the ability of the floodplain to store water and that it does not impact upon floodwater flow conveyance.

Similarly, where ground levels are elevated to raise the development out of the floodplain, or where bunds are incorporated into the site design for the purpose of screening, compensatory floodplain storage within areas that currently lie outside the floodplain may, depending on local flow dynamics and flood risk receptors, need to be provided to ensure that the total volume of the floodplain storage is not reduced.

The Environment Agency should be consulted on compensation storage requirements to ensure up to date guidance at the time of application is followed. Requirements may be site-specific and determined by the nature of the flood risk and local consequence.

The requirement for no loss of floodplain storage means that it is not possible to modify ground levels on sites which lie completely within the floodplain (when viewed in isolation), as there is no land available for lowering to bring it into the floodplain. It is possible to provide off-site compensation within the local area e.g. on a neighbouring or adjacent site, however, this would be subject to detailed investigations and agreement with the Environment Agency to demonstrate that the proposals would improve and not worsen the existing flooding situation.

7.4.5 Flood Routing

In order to demonstrate that ‘flood risk is not increased elsewhere’, development in the floodplain will need to prove that flood routing is not adversely affected by the development, for example giving rise to backwater affects or diverting floodwaters onto other properties.

Potential overland flow paths should be determined and appropriate solutions proposed to minimise the impact of the development, for example by configuring road and building layouts to preserve existing flow paths and improve flood routing, whilst ensuring that flows are not diverted towards other properties elsewhere. For example, conveyors on stations should be raised to avoid impact on flood flows.

Careful consideration should be given to the use of fences, landscaping walls and proposed bunding, so as to prevent causing obstruction to flow routes and increasing the risk of flooding to the site or neighbouring areas.

7.4.6 Riverside Development

Under Section 109 of the Water Resources Act 1991 and/or Environment Agency Byelaws, any works on, over, under or near a statutory Main River (both open channels and culverted sections), flood or sea defence, or to make changes to any structure that helps control floods requires Environment Agency consent. This includes any works (including temporary) that affect flow within the channel of any Main River (such as in channel structures or diversion of watercourses) or may impede any drainage work.

In addition, the Environment Agency seek an 8 metre wide undeveloped buffer strip alongside Main Rivers and behind flood defences, and would also ask developers to explore opportunities for river restoration as part of any development. A buffer zone of 8m alongside ordinary watercourses is encouraged by the LLFA.

As of 6th April 2012 responsibility for the consenting of works by third parties on Ordinary Watercourses under Section 23 of the Land Drainage Act 1991 (as amended by the FWMA) has transferred from the Environment Agency to OCC as the LLFA. OCC now has responsibility for the consenting of works to Ordinary Watercourses and has powers to enforce un-consented and non-compliant works. As with main rivers, this includes any permanent or temporary works that affect flow within the channel of any Ordinary Watercourse. Responsibility for consenting of third party works on main rivers is retained by the Environment Agency.

Consent is refused if the works would result in an increase in flood risk, a prevention of operational access to the watercourse, if they would damage an asset or cause bank instability issues and/or they pose an unacceptable risk to nature conservation.

7.4.7 Flood Warning and Evacuation Plans

Evacuation is where flood alerts and warnings provided by the Environment Agency enable timely actions by residents or occupants to allow evacuation to take place unaided, i.e. without the deployment of trained personnel to help people from their homes, businesses and other premises. Rescue by the emergency services is likely to be required where flooding has occurred and prior evacuation has not been possible.

For all development proposed in Flood Zone 2 or 3a, a Flood Warning and Evacuation Plan should be prepared to demonstrate what actions site users will take before, during and after a flood event to ensure their safety, and to demonstrate their development will not impact on the ability of the local authority and the emergency services to safeguard the current population.

Essential ancillary sleeping or residential accommodation for staff required by all Water Compatible development including sand and gravel workings are subject to a specific flood warning and evacuation plan.

It may also be necessary to prepare a Flood Warning Evacuation Plan for development in Flood Zone 1 where the area surrounding the site and/or any potential egress routes away from the site may be at risk of flooding during the 1% annual probability flood event including an allowance for climate change.

Flood warning and evacuation plans should include:

- How flood warning is to be provided, such as:
  - availability of existing flood warning systems;
  - where available, rate of onset of flooding and available flood warning time; and,
  - how flood warning is given.

- What will be done to protect the development and contents, such as:
  - How easily damaged items (including parked cars) or valuable items (important documents) will be relocated and stored securely on site or removed from site;
  - How to close down site operations;
  - How services can be switched off (gas, electricity, water supplies);
  - The use of flood protection products (e.g. flood boards, airbrick covers);
  - The availability of staff/occupants/users to respond to a flood warning, including preparing for evacuation, deploying flood barriers across doors etc.; and,
  - The time taken to respond to a flood warning.

- Ensuring safe occupancy and access to and from the development, such as:
  - Occupant awareness of the likely frequency and duration of flood events, and the potential need to evacuate;
  - Safe access route to and from the development;
  - If necessary, the ability to maintain key services during an event;
  - Vulnerability of occupants, and whether rescue by emergency services will be necessary and feasible;
• Expected time taken to re-establish normal use following a flood event (clean-up times, time to re-establish services etc.); and,
• Whether flooding might occur without a warning e.g. breach or surface water flooding.

The Environment Agency has a tool on their website to create a Personal Flood Plan\textsuperscript{52}. The Plan comprises a checklist of things to do before, during and after a flood and a place to record important contact details.

There is no statutory requirement for the Environment Agency or the emergency services to approve evacuation plans. The planning authority is accountable via planning condition or agreement to ensure that plans are suitable. This should be done in consultation with the planning authority emergency planning staff.

\textsuperscript{52} Environment Agency Tool ‘Make a Flood Plan’. \url{https://www.gov.uk/government/publications/personal-flood-plan}
8 Guidance for the Application of SuDS

8.1 Introduction

The PPG, which accompanies the NPPF, indicates that priority should be given to the use of SuDS in new developments. It is recognised that infiltration SuDS techniques may not always be appropriate on waste or mineral sites, due to issues of contamination. However SuDS should still be considered to provide treatment before water is discharged to a watercourse or sewer. The appropriate deployment of SuDS within a development can offer benefits in terms of reductions in flood risk, improvements to water quality, quicker replenishment of groundwater and improved visual amenity. If SuDS are not going to be used then sufficient evidence should be provided to explain why, and it should be shown that traditional drainage methods can provide benefits above those that can be provided by SuDS.

SuDS are typically softer engineering solutions inspired by natural drainage processes, such as ponds and swales, which manage water as close to its source as possible. Wherever possible, a SuDS technique should seek to contribute to each of the three goals identified below with the preferred system contributing significantly to each objective. Where possible SuDS solutions for a site should seek to:

1) Reduce flood risk (to the site and neighbouring areas),
2) Reduce pollution, and
3) Provide landscape and wildlife benefits.

These goals can be achieved by utilising a management plan incorporating a chain of techniques, as outlined in the Interim Code of Practice for Sustainable Drainage Systems, where each component adds to the performance of the whole system:

<table>
<thead>
<tr>
<th>Prevention</th>
<th>Good site design and upkeep to prevent runoff and pollution (e.g. limited paved areas, regular pavement sweeping).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source Control</td>
<td>Runoff control at / near to source (e.g. rainwater harvesting, green roofs, pervious pavements).</td>
</tr>
<tr>
<td>Site Control</td>
<td>Water management from a multitude of catchments (e.g. route water from roofs, impermeable paved areas to one infiltration/holding site).</td>
</tr>
<tr>
<td>Regional Control</td>
<td>Integrate runoff management systems from a number of sites (e.g. into a detention pond).</td>
</tr>
</tbody>
</table>

The application of SuDS is not limited to a single technique per site. The use of multiple treatments stages may be necessary to ensure the correct level of treatment before runoff can be discharged. Often a successful SuDS solution will utilise a combination of techniques, providing flood risk, pollution and landscape/wildlife benefits. In addition, SuDS can be employed on a strategic scale, for example with a number of sites contributing to large scale jointly funded and managed SuDS. It should be noted, each development site must offset its own increase in runoff and attenuation cannot be “traded” between developments.

SuDS techniques can be used to reduce the rate and volume and improve the water quality of surface water discharges from sites to the receiving environment (i.e. natural watercourse or public sewer etc.). The SuDS Manual identifies several processes that can be used to manage and control runoff from developed areas. Each option can provide opportunities for storm water control, flood risk management, water conservation and groundwater recharge.

− Infiltration: the soaking of water into the ground. This is the most desirable solution as it mimics the natural hydrological process. The rate of infiltration will vary with soil type and condition, the antecedent conditions and with time. The process can be used to recharge groundwater sources and feed baseflows of local watercourses, but where groundwater sources are vulnerable or there is risk of contamination, infiltration techniques are not suitable. Additionally shallow groundwater and low infiltration rates will prevent the application of infiltration SuDS.

− Detention/Attenuation: the slowing down of surface flows before their transfer downstream, usually achieved by creating a storage volume and a constrained outlet. In general, though the storage will enable a reduction in the peak rate of runoff, the total volume will remain the same, just occurring over a longer duration.
− Conveyance: the transfer of surface runoff from one place to another, e.g. through open channels, pipes and trenches.
− Water Harvesting: the direct capture and use of runoff on site, e.g. for domestic use (flushing toilets) or irrigation of urban landscapes. The ability of these systems to perform a flood risk management function will be dependent on their scale, and whether there will be a suitable amount of storage always available in the event of a flood.

8.2 Type of SuDS

SuDS designs should aim to reduce runoff by integrating storm water controls throughout the site in small, discrete units. Through effective control of runoff at source, the need for large flow attenuation and flow control structures becomes minimised.

As part of any SuDS scheme, consideration should be given to the long-term maintenance of the SuDS to ensure that it remains functional for the lifetime of the development. Table 8-1 has been reproduced from the SuDS Manual, CIRIA C697 and outlines typical SuDS options and details their typical components.

**Table 8-1 Typical SuDS Components (Y = primary process. * = some opportunities, subject to design)***

<table>
<thead>
<tr>
<th>Technique</th>
<th>Description</th>
<th>Conveyance</th>
<th>Detention</th>
<th>Infiltration</th>
<th>Harvesting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pervious Surfaces</td>
<td>Pervious surfaces allow rainwater to infiltrate through the surface into an underlying storage layer, where water is stored before infiltration to the ground, reuse, or release to surface water.</td>
<td>Y</td>
<td>Y</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Filter Drains</td>
<td>Linear drains/trenches filled with a permeable material, often with perforated pipe in the base of the trench. Surface water from the edge of paved areas flows into the trenches, is filtered and conveyed to other parts of the site.</td>
<td>Y</td>
<td>Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Filter Strips</td>
<td>Vegetated strips of gently sloping ground designed to drain water evenly from impermeable areas and filter out silt and particulates.</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Swales</td>
<td>Shallow vegetated channels that conduct and/or retain water, and can permit infiltration when unlined.</td>
<td>Y</td>
<td>Y</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Ponds</td>
<td>Depressions used for storing and treating water.</td>
<td>Y</td>
<td>*</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Wetlands</td>
<td>As ponds, but the runoff flows slowly but continuously through aquatic vegetation that attenuates and filters the flow. Shallower than ponds. Based on geology these measures can also incorporate some degree of infiltration.</td>
<td>*</td>
<td>Y</td>
<td>*</td>
<td>Y</td>
</tr>
<tr>
<td>Detention Basin</td>
<td>Dry depressions designed to store water for a specified retention time.</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soakaways</td>
<td>Sub-surface structures that store and dispose of water via infiltration.</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infiltration Trenches</td>
<td>As filter drains, but allowing infiltration through trench base and sides.</td>
<td>*</td>
<td>Y</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Infiltration Basins</td>
<td>Depressions that store and dispose of water via infiltration.</td>
<td>Y</td>
<td>Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Green Roofs</td>
<td>Green roofs are systems which cover a building’s roof with vegetation. They are laid over a drainage layer, with other layers providing protection, waterproofing and insulation. It is noted that the use of brown/green roofs should be for betterment purposes and not to be counted towards the provision of on-site storage for surface water. This is because the hydraulic performance during extreme events is</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
similar to a standard roof (CIRIA C697).

| Rainwater Harvesting | Storage and use of rainwater for non-potable uses within a building, e.g. toilet flushing. It is noted that storage in these types of systems is not usually considered to count towards the provision of on-site storage for surface water balancing because, given the sporadic nature of the use of harvested water, it cannot be guaranteed that the tanks are available to provide sufficient attenuation for the storm event. | * | * | * | Y |

When planning drainage requirements for new developments, the aim should be to discharge surface run off as high up the following hierarchy of drainage options as reasonably practicable:

- into the ground (infiltration);
- to a surface water body;
- to a surface water sewer, highway drain, or another drainage system;
- to a combined sewer.

As well as treating water quality before discharge to watercourses and sewers it may be necessary for surface water to pass through a series of treatment stages before infiltration.

For further guidance on SUDS, the following documents and websites are recommended as a starting point:

- Oxfordshire LLFA;
- Defra Non-statutory technical standards for SuDS (March 2015);55
- The NPPF and associated Planning Policy Guidance technical notes;
- The SuDS Manual – CIRIA C697 (2007) provides the best practice guidance on the planning, design, construction, operation and maintenance of Sustainable Drainage Systems and facilitates their effective implementation within developments;
- CIRIA C644 – Green Roofs (2007) provides guidance on the design, construction and operation of Green Roofs. The guidance also describes how ‘quick wins’ for biodiversity can be achieved in the built environment by incorporating nesting and roosting boxes for bird, bats and other animals;
- Interim Code of Practice for Sustainable Drainage Systems, National SuDS Working Group, 2004;
- www.ciria.org.uk/suds/

### 8.3 National SuDS Standards56

A set of National Standards (NS) have been published which set the requirements for the design, construction, maintenance and operation of SuDS. The NS are intended to be used alongside the NPPF and PPG.

The NS that are of chief concern in relation to the consideration of flood risk to and from development relating to runoff destinations, peak flow control and volume control are presented below:

#### 8.3.1 Peak flow control

SuDS NS2 ‘For greenfield developments, the peak runoff rate from the development to any highway drain, sewer or surface water body for the 1 in 1 year rainfall event and the 1 in 100 year rainfall event must not exceed the peak greenfield runoff rate for the same event’.

SuDS NS3 ‘For developments which were previously developed, the peak runoff rate from the development to any drain, sewer or surface water body for the 1 in 1 year rainfall event and the 1 in 100 year rainfall event must be as close as reasonably practicable to the greenfield runoff rate from the development for the same rainfall event, but should never exceed the rate of discharge from the development prior to redevelopment for that event’.

---

56 DEFRA (Sustainable Drainage Systems (March 2015) Non-statutory technical standards for sustainable drainage systems)
8.3.2 Volume control

SuDS NS4 ‘Where reasonably practicable, for greenfield development, the runoff volume from the development to any highway drain, sewer or surface water body in the 1 in 100 year, 6 hour rainfall event should never exceed the greenfield runoff volume for the same event’.

SuDS NS5 ‘Where reasonably practicable, for developments which have been previously developed, the runoff volume from the development to any highway drain, sewer or surface water body in the 1 in 100 year, 6 hour rainfall event must be constrained to a value as close as is reasonably practicable to the greenfield runoff volume for the same event, but should never exceed the runoff volume from the development site prior to redevelopment for that event’.

SuDS NS6 ‘Where it is not reasonably practicable to constrain the volume of runoff to any drain, sewer or surface water body in accordance with SuDS NS4 or SuDS NS5 above, the runoff volume must be discharged at a rate that does not adversely affect flood risk’.

8.3.3 Flood risk within the development

SuDS NS7 ‘The drainage system must be designed so that, unless an area is designated to hold and/or convey water as part of the design, flooding does not occur on any part of the site for a 1 in 30 year rainfall event’.

SuDS NS8 ‘The drainage system must be designed so that, unless an area is designated to hold and/or convey water as part of the design, flooding does not occur during a 1 in 100 year rainfall event in any part of: a building (including a basement); or in any utility plant susceptible to water (e.g. pumping station or electricity substation) within the development’.

SuDS NS9 ‘The design of the site must ensure that, so far as is reasonably practicable, flows resulting from rainfall in excess of a 1 in 100 year rainfall event are managed in exceedance routes that minimise the risks to people and property’.
9 Summary and Recommendations

This Level 1 SFRA has been prepared in accordance with the NPPF\(^4\), associated PPG\(^5\) and in agreement made between Oxfordshire County Council and the Environment Agency. The most up to date flood risk information from fluvial, surface water and groundwater sources has been collated and analysed to provide a high level overview of flood risk to the broad areas identified for mineral extraction and strategic/non-strategic waste facilities.

This SFRA will be used by OCC as the Minerals and Waste Planning Authority to inform decisions regarding mineral and waste site allocations and policies. The SFRA should be used as an evidence base from which to direct new development where possible to areas of low flood risk, and where development cannot be located in Flood Zone 1, the SFRA flood maps should be used to apply the sequential approach to the remaining land use allocations.

The initial study presented a comparison of old (2010) and new (2015) flood risk data, and quantified the change in flood risk from fluvial and surface water sources, as well as the change in potential flood risk from groundwater, for:

- The preferred broad areas for minerals;
- The preferred broad areas for strategic/non-strategic waste management facilities; and
- The possible sites for minerals and waste development.

As a consequence of the updated flood risk datasets, one broad area for minerals has been assessed as having an increase in flood risk greater than 5% (CS5e – Thames, Lower Thames Valley - Oxford to Cholsey) and one mineral area assessed as having a decrease in flood risk (CS6 – Thames, Lower Windrush & Evenlode Valleys). One broad area for strategic/non-strategic waste management facilities was assessed as having a decrease in flood risk (WA3 Didcot).

Through the application of updated flood risk datasets, an assessment of flood risk has been undertaken for the preferred broad areas for minerals and the broad areas for strategic/non-strategic waste management facilities. Nine of the broad areas for minerals are predominantly located in Flood Zone 1, with the remaining three areas (associated with the extraction of sharp sand and gravel) being mostly located within Flood Zone 3. Across the twelve mineral areas, the proportion of area considered to be at High Risk (3.33% AEP or 1 in 30 year) from surface water flooding ranged between 0.2% and 7.5% of the total area.

The seven broad areas for waste are predominantly located in Flood Zone 1. Across the seven waste areas, the proportion of each area considered to be at High Risk (3.33% AEP or 1 in 30 year) from surface water flooding ranged between 0.75% and 2.8% of the total area.

The SFRA also provides significant guidance as to site specific flood risk assessments, flood control measures such as sustainable drainage techniques, and how to apply the sequential and exception tests.

9.1 Mineral & Waste Planning Policy

The MWLP for Oxfordshire and supporting guidance documents should continue to include policies to:

- Protect the functional floodplain from development;
- Direct vulnerable development away from flood affected areas;
- Ensure all new development is ‘safe’ for its lifetime, meaning that dry pedestrian access to and from the development is possible without passing through the 1 in 100 year plus climate change floodplain, and emergency vehicular access is possible;
- Ensure that all new developments do not cause flood risk to be increased elsewhere; and
- Promote the use of SUDS in all Flood Zones for both Brownfield and Greenfield sites, with space set-aside for SUDS.

9.2 Level 1 SFRA Update

This Level 1 SFRA allows OCC to assess their various mineral option areas using the Sequential Test. For waste, this SFRA does not provide sufficient detail on flood risk from all sources to allow for the application of the Sequential Test. Instead, it identifies the extent of opportunity for the allocation of waste developments of all vulnerabilities within each of
the broad areas for waste, and in the process also assists OCC with the identification of available land suitable to accommodate the most vulnerable form of waste development (hazardous waste facilities).

It should be made clear that, at this stage of development of the MWLP, detailed site allocation information is not currently available, and therefore the Sequential Test can only be applied to the broad areas in this document.

An update to this Level 1 SFRA will be prepared to accompany the MWLP-SA, to include any updated data since this SFRA was produced and to include data on sewer and artificial sources of flooding. The updated Level 1 SFRA document will address flood risk to all of the allocated mineral and waste sites, and specifically, to those sites which have been sequentially tested and subsequently been located in Flood Zones 2 or 3, thus requiring the application of the Exception Test as described in Section 6.

The updated Level 1 SFRA document would include the following:

− A detailed assessment of flood risk from sewers to each mineral and waste site;
− A detailed assessment of flood risk from reservoirs, canals and other artificial sources to each mineral and waste site;
and
− Guidance on the preparation of FRAs for sites with varying flood risk across the Flood Zone.

The updated Level 1 SFRA will also determine if a Level 2 SFRA needs to be carried out. The data required for a Level 2 SFRA will depend upon which, if any, of the allocated sites remain in Flood Zones 2 and 3 following application of the Sequential Test and hence where the Exception Test needs to be applied.

The updated Level 1 SFRA will also determine if a Level 2 SFRA needs to be carried out for any allocated waste sites which remain in Flood Zones 2 or 3 following application of the Sequential Test and hence require application of the Exception Test. The data required for a Level 2 SFRA will depend upon which of the allocated waste sites remain in Flood Zones 2 and 3 and the mechanisms of flooding affecting the site.

Level 2 SFRA outputs typically include:

− Maps showing distribution of flood hazard (as a function of flood depth and velocity) within Flood Zones;
− Guidance on appropriate policies for the development of sites which satisfy the Exception Test i.e. are safe for occupants / users over their lifetime, do not increase flood risk and where possible reduce flood risk overall;
− Guidance on the preparation of FRAs for sites with varying flood risk across the Flood Zone.
Appendix A. Review of Historic Flood Event Records

A.1 Oxfordshire PFRA

Records have often been replicated from LPA SFRAs, confirming the location and date of certain flood events. Care has been taken to ensure, as far as possible, that no duplication of flood records has occurred.

For fluvial, surface water and groundwater flood events, ‘Table 4-1 Summary of past flooding with adverse consequences in Oxfordshire’, as well as all references to historic flood events in Section 4 ‘Past Flood Risk’ with a specific settlement and date of occurrence have been used.

A.2 Oxford City Council (OxCC) Level 1 SFRA (Mar 2011) Level 2 SFRA (Feb 2012)

Historic surface water flood events in Oxford City are under-represented in the mapping produced for these SFRA updates. Specific event details (location and date) were not available in the LPA SFRAs.

A.2.1 Applicable historic data

Fluvial: ‘Table 3 – Historic Flood Events in Oxford’. This table lists when nine separate flood events occurred in Oxford between 1947 and 2007. These floods affected numerous areas/roads of Oxford, but in line with the strategic nature of this SFRA, individually affected areas have not been considered.

Surface Water: No historic flood event records.

Groundwater: ‘Table 2 – The Groundwater Register’ (from the Environment Agency). This table provides dates, location, grid reference and details on groundwater flooding incidents which occurred between 2000 and 2009.

A.3 Cherwell District Council (CDC) Level 1 SFRA (2009)

Historic flood events in the Cherwell District from surface water and groundwater sources of flood risk are under-represented in the mapping produced for this Level 1 SFRA update. Specific event details (location and date) were not available in the LPA SFRA.

A.3.1 Applicable historic data

Fluvial: Table 7.1 Summary of Historic Flood Events in Cherwell District

Surface Water: No suitable historic flood event records, with the exception of 2007 data which is noted in this SFRA but no suitable means of mapping these records (too numerous and no specific locations mentioned).

Groundwater: No suitable historic flood event records.

A.3.2 Non-applicable historic data

For surface water, the SFRA identifies areas located on low lying impervious ground where there may be limited surface water drainage and therefore may be at increased risk of flooding from surface water. This does not represent ‘actual’ flood events.

For groundwater, the SFRA identifies settlements that lie at the base of steep sided valleys where the potential for receiving and passing on ground water are at greatest risk of groundwater flooding. This does not represent ‘actual’ flood events.

A.4 West Oxfordshire District Council (WODC) Level 1 SFRA (2009)

Historic flood events in West Oxfordshire from surface water and groundwater sources of flood risk, are under-represented in the mapping produced for this SFRA update. Specific event details (location and date) were not available in the LPA SFRA.

A.4.1 Applicable historic data
Fluvial: Table 9.1 Historical Flooding in West Oxfordshire

Surface Water: No suitable historic flood event records, with the exception of 2007 data, as described in the document ‘Flooding – July 2007: A summary’ (WODC), which is noted in this SFRA but no suitable means of mapping these records (too numerous and no specific locations mentioned).

Groundwater: No suitable historic flood event records.

A.4.2 Non-applicable historic data
For surface water, the SFRA identifies areas located on low lying impervious ground where there may be limited surface water drainage and therefore may be at increased risk of flooding from surface water. This does not represent ‘actual’ flood events.

For groundwater, the SFRA identifies settlements that lie at the base of steep sided valleys where the potential for receiving and passing on ground water are at greatest risk of groundwater flooding. This does not represent ‘actual’ flood events.

A.5 South Oxfordshire District Council (SODC) (Level 1 SFRA (June 2009)

Historic flood events in South Oxfordshire, from all sources of flood risk, are under-represented in the mapping produced for this SFRA update. Some data is not considered suitable to indicate location of ‘actual’ flood events, as explained by the limitations described below.

A.5.1 Applicable historic data
Fluvial: Flood events recorded by year of occurrence and settlement affected for the River Thames, River Cole and River Thame.

Surface Water: List of settlements which have suffered surface water flooding and in what year the event occurred.

Groundwater: Lists those settlements which have suffered groundwater flooding and in what year the event occurred. This has been combined with a visual inspection of Map 6.1 Areas Susceptible to Groundwater Flooding which contains groundwater flood event data as provided by the Environment Agency.

A.5.2 Non-applicable historic data
Flood incident database based on requests for sandbags. It is recommended in the SFRA that the data should be considered as indicative only of a flooding ‘problem’, due to the following limitations;

- Only includes incidents where the district council were notified, normally to request sandbags. Very short flash floods will result in property flooding before a request can be made to the district council. In other cases, residents/businesses make their own arrangements for protecting properties.
- Reason for flooding based on inspection of incident only
- Incidents only indicate when flooding was thought likely to have occurred (i.e. sandbags may have been requested in anticipation of a property being flooded)
- Records do not distinguish between the different flood sources
- Records do not represent actual flood events

The list of flooding records by settlement and year which highlights 2007 as the most significant year of flooding in the district, followed by 2000 and 2003. This should be read in conjunction with map 8A.1: Historical Flooding (SODC).

The number of flood investigations carried out between 2009 and 2013 by settlement has also been used.

A.6 Vale of White Horse District Council (VOWH) Level 1 SFRA (June 2009)

Historic flood events in the Vale of White Horse District, from all sources of flood risk, are under-represented in the mapping produced for this SFRA update. Some data is not considered suitable to indicate the location of ‘actual’ flood events, as explained by the limitations described below.

A.6.1 Applicable historic data
Fluvial: Flood events recorded by year of occurrence and settlement affected for the River Thames and River Ock.
Surface Water: List of settlements which have suffered surface water flooding and in what year the event occurred.

Groundwater: Lists those settlements which have suffered groundwater flooding and in what year the event occurred. This has been combined with a visual inspection of Map 6.2 Areas Susceptible to Groundwater Flooding which contains groundwater flood event data as provided by the Environment Agency.

**A.6.2 Non-applicable historic data**

Flood incident database based on requests for sandbags. It is recommended in the SFRA that the data should be considered as indicative only of a flooding ‘problem’, due to the following limitations;

- Only includes incidents where the district council were notified, normally to request sandbags. Very short flash floods will result in property flooding before a request can be made to the district council. In other cases, residents/businesses make their own arrangements for protecting properties.
- Reason for flooding based on inspection of incident only
- Incidents only indicate when flooding was thought likely to have occurred (i.e. sandbags may have been requested in anticipation of a property being flooded)
- Records do not distinguish between the different flood sources
- Records do not represent actual flood events

List of flooding records by settlement and year which highlights 2007 as the most significant year of flooding in the district, followed by 2008 and 2003. The location of properties claiming flood grant has also been used to geo-reference flooding in VOWH for the July 2007 floods, but the same limitations listed above apply. The number of flood investigations carried out in 2012 and 2013 by settlement has also been used.
Appendix B. Historic Flood Event Maps
Appendix C. Fluvial Flood Zone Maps
Appendix D.  Risk of Flooding from Surface Water Maps
Appendix E. Areas Susceptible to Groundwater Flooding Maps
Appendix F. Mineral Broad Area Options and associated sites Flood Risk Assessment
Appendix G.  Mineral Broad Preferred Areas and associated sites
Flood Risk Assessment
Appendix H. Waste Broad Preferred Areas and associated sites Flood Risk Assessment
About AECOM

AECOM (NYSE: ACM) is a global provider of professional technical and management support services to a broad range of markets, including transportation, facilities, environmental, energy, water and government. With approximately 100,000 employees around the world, AECOM is a leader in all of the key markets that it serves. AECOM provides a blend of global reach, local knowledge, innovation, and collaborative technical excellence in delivering solutions that enhance and sustain the world’s built, natural, and social environments. A Fortune 500 company, AECOM serves clients in more than 100 countries and has annual revenue in excess of $6 billion.

More information on AECOM and its services can be found at www.aecom.com.

Scott House
Alençon Link
Basingstoke
Hampshire
RG21 7PP
United Kingdom
+44 1256 310200