Water

Submitted to
Milton Keynes Council

Submitted by
AECOM
Scott House
Alençon Link
Basingstoke
Hampshire
RG21 7PP

United Kingdom

Milton Keynes Council

Surface Water Management Plan

Final Report
April 2016

Prepared by: Penelope Pickerin
Graduate Water Consultant

Gemma Hoad
Senior Water Consultant

Amy Ruocco
Water Consultant

Checked by: Sarah Kelly
Associate Director

Approved by: Jon Robinson
Operations Director

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Scott House, Alençon Link, Basingstoke, Hampshire, RG21 7PP, United Kingdom
Telephone: 01256 310 200 Website: http://www.aecom.com

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Abbreviations

ACRONYM	DEFINITION
AEP	Annual Exceedance Probability
AMP	Asset Management Plan
AWS	Anglian Water Services
BGDB	Bedford Group of Drainage Boards
BGS	British Geological Survey
CDC	Critical Drainage Catchment
DA	Designated Area
DCLG	Government Department for Communities and Local Government
DG5	Director General 5
DRN	Detailed River Network
EA	Environment Agency
EC	European Community
ERA	Extreme Rainfall Alert
FCERM	Flood and Coastal Erosion Risk Management
FIR	Flood Investigation Report
FRM	Flood Risk Management
FRMP	Flood Risk Management Plan
FRR	Flood Risk Regulations 2009
FWMA	Flood and Water Management Act 2010
GIS	Geographic Information System
IDB	Internal Drainage Board
LFRMS	Local Flood Risk Management Strategy
LiDAR	Light Detection and Ranging
LLFA	Lead Local Flood Authority
MCM	Multi-Coloured Manual
MKC	Milton Keynes Council
MoU	Memorandums of Understanding
NPPF	National Planning Policy Framework
NRD	National Receptor Database
PPG	Planning Practice Guidance
RMA	Risk Management Authority
SFRA	Strategic Flood Risk Assessment
SLA	Service Level Agreement
SuDS	Sustainable Drainage Systems
SWMP	Surface Water Management Plan
uFMfSW	Updated Flood Map for Surface Water
WFD	Water Framework Directive

Glossary

TERM	DEFINITION
Aquifer	A source of groundwater comprising water bearing rock, sand or gravel capable of yielding significant quantities of water.
Byelaws (Environment Agency and Internal Drainage Board)	Rules and regulations enacted by the Environment Agency and Internal Drainage Boards.
Climate Change	Long term variations in global temperature and weather patterns caused by natural and human actions.
Critical Drainage Catchment	Areas of significant flood risk, characterised by the amount of surface runoff that drains into the area, the topography and hydraulic conditions of the pathway (e.g. sewer, river system), and the receptors (people, properties and infrastructure) that may be affected.
Culvert	A channel or pipe that carries water below the level of the ground.
DG5 Register	A water-company held register of properties which have experienced sewer flooding or properties which are 'at risk' of sewer flooding more frequently than once in 20 years.
Flood Defence	Infrastructure used to protect an area against flooding e.g. floodwalls and embankments. This infrastructure is designed to a specific standard of protection (design standard).
Flood Risk Management Plan	Under the Flood Risk Regulations 2009, Lead Local Flood Authorities are required to produce Flood Risk Management Plan for all Flood Risk Areas. The Flood Risk Management Plan highlights the risk and hazard of flooding from various sources and sets out how Risk Management Authorities work together to manage flood risk.
Flood Risk Regulations 2009	Transposition of the EU Floods Directive into UK law. The EU Floods Directive is a piece of European Community (EC) legislation to specifically address flood risk by prescribing a common framework for its measurement and management.
Flood and Water Management Act 2010	Part of the UK Government's response to Sir Michael Pitt's Report on the Summer 2007 floods, the aim of which is to clarify the legislative framework for managing surface water flood risk.
Fluvial Flooding	Flooding resulting from water levels exceeding the bank level of a main river or an ordinary watercourse.
Groundwater	Water that is underground. For the purposes of this study, it refers to water in the saturated zone below the water table.
Local Flood Risk	Flooding from local sources (surface water, ordinary watercourses and groundwater).
Local Flood Risk Management Strategy	A strategy completed by Lead Local Flood Authorities under the requirements of the Flood and Water Management Act 2010 to outline the risk of local flooding sources and the intended management of this flood risk.
Lead Local Flood Authority	Local Authority responsible for local flood risk management.
Local Planning Authority	A multi-agency forum, bringing together all the organisations that have a duty to cooperate under the Civil Contingencies Act, and those involved in responding to emergencies. They prepare emergency plans in a co-ordinated manner.
Main River	A watercourse shown as such on the Main River Map, and for which the Environment Agency has responsibilities and powers.
National Receptor Dataset	A collection of risk receptors produced by the Environment Agency.

TERM	DEFINITION
Ordinary Watercourse	All watercourses that are not designated main river and which are the responsibility of Local Authorities or, where they exist, internal drainage boards.
Partner	A person or organisation with responsibility for the decision or actions that need to be taken or for funding i.e. partnership funding.
Pitt Review	Comprehensive independent review of the 2007 summer floods by Sir Michael Pitt, which provided recommendations to improve flood risk management in England.
Pluvial Flooding	Another term for surface water flooding meaning flooding from water flowing over the surface of the ground which often occurs when the soil is saturated and natural drainage channels or artificial drainage systems have insufficient capacity to cope with additional flow.
Preliminary Flood Risk Assessment	A Preliminary Flood Risk Assessment comprises an assessment of floods which have taken place in the past and may occur in the future. They consider flooding from surface water runoff, groundwater and ordinary watercourses to identify areas at as significant risk of flooding.
Risk	The product of the probability and consequence of the occurrence of an event.
Risk Management Authority	Defined under the Flood and Water Management Act 2010 as the Environment Agency, Lead Local Flood Authority, internal drainage boards, district councils for areas for which there are no unitary authorities, water companies and highway authorities.
River Basin Management Plan	River Basin Management Plans encourage partnership working to achieve an enhanced water environment. These documents establish statutory objectives for river, lake, groundwater, estuarine and coastal water bodies and summarise how these water quality objectives can be achieved.
Sewer Flooding	Flooding caused by a blockage, under capacity or overflowing of a sewer or urban drainage system.
Surface Water Flooding	Flooding from water flowing over the surface of the ground which often occurs when the soil is saturated and natural drainage channels or artificial drainage systems have insufficient capacity to cope with additional flow.
Sustainable Drainage Systems (SuDS)	Methods of management practices and control structures that are designed to drain surface water in a more sustainable manner than some conventional techniques.
Water Framework Directive	The purpose of this European Directive (2000/60/EC) is to establish a framework for community action to facilitate the protection of inland surface waters (rivers and lakes), transitional waters (estuaries), coastal waters and groundwater; with the aim of ensuring all natural aquatic and terrestrial ecosystems meet ‘good status’ by 2015.

Executive Summary

This document forms the Surface Water Management Plan (SWMP) for the administrative area of Milton Keynes Council (MKC). This document is a plan which outlines the preferred surface water management strategy for Milton Keynes and includes consideration of flooding from sewers, drains, groundwater, and runoff from land, ordinary watercourses and ditches that occurs as a result of heavy rainfall. The risk of flooding from rivers and the sea has been assessed in the Milton Keynes Strategic Flood Risk Assessment (SFRA)[1].

The SWMP has been undertaken following a four phase approach:

Phase 1 – Preparation *(Identify the need for a SWMP, establish a partnership with the relevant stakeholders and clarify the scope of the SWMP).*

Phase 2 – Risk Assessment *(Select an appropriate level risk assessment and undertake an assessment in accordance).*

Phase 3 – Options *(Identify options/measures (with stakeholder engagement) which seek to alleviate the surface water flood risk within Critical Drainage Catchments.);* and,

Phase 4 – Implementation and Review *(Prepare Action Plan and implement the monitoring and review process for these actions).*

Phase 1 Preparation

Phase 1 collected and reviewed all the surface water data from key stakeholders and built partnerships between stakeholders responsible for local flood risk management. It is the role of MKC (as a Lead Local Flood Authority) to forge effective partnerships with Anglian Water Services and the Environment Agency, as well as other key stakeholders and Risk Management Authorities including the Bedford Group of Drainage Boards (BGDB), the Parks Trust (responsible in part for the management of Milton Keynes' surface water management network of balancing ponds) and Highways England.

The SWMP built on the existing partnerships established through the work undertaken for the Milton Keynes Strategic Flood Risk Assessment and Local Flood Risk Management Strategy, both of which were developed in 2015.

Phase 2 Risk Assessment

As part of Phase 2, as intermediate risk assessment was undertaken. The aim of an intermediate risk assessment is to identify sources and mechanisms of surface water flooding across the borough which will be achieved through an assessment of pluvial flooding, sewer flooding, groundwater flooding and flooding from ordinary watercourses. Subsequently the results of an intermediate risk assessment can be used to identify Critical Drainage catchments (CDCs) which represent areas or catchments of greatest risk where multiple or interlinked sources of flood risk were identified. When assessing surface water flood risks the updated Flood Map for Surface Water (uFMfSW) dataset was analysed and property counts were undertaken to determine the number of properties at risk of flooding for different rainfall across the borough. CDCs have been defined through consideration of the following:

- Surface water flood depth and extent;
- Surface water flood hazard;
- Potential impact on people, properties and critical infrastructure;
- Groundwater flood risk;
- Historical flooding events;
- Significant underground linkages;

[1] AECOM (2015) Milton Keynes Council Level 1 Strategic Flood Risk Assessment

- Cross boundary linkages[2]; and,
- Source, pathway and receptor.

For each CDC potential sources of flooding, historic incidents of flooding and surface water flood risk (in respect to number of properties potentially impacted by different rainfall events) has been identified.

The chief mechanisms for flooding in the Milton Keynes Borough can be broadly divided into the following categories:

- Natural topographic low points within fluvial floodplains of the River Great Ouse and the River Ouzel where surface water is shown to pond;
- Surface water is shown to collect behind railway embankments, e.g. in the north western part of the borough where tributaries of the River Tove flow across the route of the railway line, and in the south of the borough where tributaries of the Caldecotte Brook flow northwards. These are chiefly rural areas;
- Surface water runoff in the urban areas of Milton Keynes in particularly West Bletchley and Medbourne/ Crownhill;
- Within Central Milton Keynes, surface water flood risk is concentrated along the course of existing drains and small watercourses; and,
- Large surface water flow paths arising across unconstrained agricultural land in rural areas which flow across areas of with decreasing elevation, and in some areas steep slopes.

Within Milton Keynes, 24 CDCs have been identified. Due to the large number of potential CDCs identified, and in order to focus on the key flood risk areas, the CDCs were shortlisted based on the following:

- The frequency of historical flooding;
- The potential risk of groundwater flooding;
- The frequency of sewer flooding incidents;
- The presence of critical infrastructure at risk;
- Whether significant future development is likely which could exacerbate surface water flooding; and,
- The number of buildings and residential properties flooded at a depth greater than 150mm.

Based on the above criteria, it was agreed with stakeholders and the Council that only the most significant CDCs, 13 in total, would be assessed and taken forward into the Phase 3 Options phase. Table 1 details the shortlisted CDCs for MKC:

[2] Under the European Union (EU) Floods Directive and UK Flood Risk Regulations, LLFAs must prepare Flood Risk Management Plans (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 Anglian River Basin District FRMP which has been published for consultation by the Environment Agency and sets out the proposed measures to manage flood risk in the Anglian River Basin District from 2015 to 2021 and beyond. This document draws on existing reports and plans which have been prepared in the past.

Table 1 – Shortlisted CDCs at Greatest Risk of Surface Water Flooding in Milton Keynes

CDC Number	CDC Name	Flooded buildings 1 in 100 Annual Exceedance Probability (AEP) event
CDC15	Stony Stratford	135
CDC8	Newport Pagnell	275
CDC10	Olney	260
CDC20	West Bletchley	837
CDC4	Woburn Sands	241
CDC1	Ravenstone	42
CDC14	Bradwell Abbey	218
CDC13	Wymbush/ Two Mile	108
CDC12	Medbourne/Crownhill	266
CDC11	Brinklow	127
CDC17	Oldbrook	372
CDC19	Bradwell	315
CDC6	Downs Barn and Conniburrow	287

The other CDCs were reported for information and completeness and to highlight the potential surface water flooding issues, which although have less risk to people and property, may have more of a significant impact to relevant infrastructure stakeholders in Milton Keynes. Furthermore, additional CDCs may benefit from further works in the future and may be more likely to obtain funding due to being identified as an area of significant surface water flood risk within this SWMP.

Phase 3 Options

A range of both structural and non-structural structural measures for alleviating surface water flood risk have been identified and considered. The option identification has been undertaken for each of the 13 CDCs prioritised through the CDC prioritisation process (Section 6). Alongside this assessment, borough-wide measures (i.e. flood alleviation measures which could be implemented across the entirety of Milton Keynes Borough) have also been identified. Each option has been assessed against a range of criteria. The assessment eliminates those that are not technically, environmentally, economic and socially viable and/or those which do not meet the wider objectives of the SWMP and associated plans and programmes such as the Milton Keynes LFRMS. The remaining options are then developed and tested against their relative effectiveness, with associated costs being outlined.

It is important to recognise that flooding within Milton Keynes Borough is not confined to CDCs, and therefore, there are opportunities for generic measures to be implemented through the establishment of a policy position on topics such as new development and the inclusion of Sustainable Drainage Systems alongside sustainable land management practices achieved through partnership working with riparian owners etc.

For each of the CDCs identified, site-specific measures have been identified that could be considered to help alleviate surface water flooding. These measures were subsequently short-listed to identify a potential preferred option for each CDC alongside recommendations for further investigation where appropriate. ‘quick wins’ have also been identified.

To address local flood risk it is recommended that, the following preferred options, outlined in Table 2 are investigated for each of the CDCs.

Table 2: Preferred Options

CDC	Preferred Option: Combined Measures	Other Potential Options	Quick Wins
CDC1: Ravenstone	– Infiltration SuDS to the north of Northend Farm and the northwest of Abbey Farm. **Or** – Attenuation SuDS to the north of Northend Farm and the northwest of Abbey Farm (basins or bunded areas). – Land management practices – sustainable agricultural and rural practices *Borough-wide options which would benefit this CDC include:* – Planning policies to influence development. – Social change, education and awareness.	– N/A for this CDC.	– Ditch clearance alongside Common Street. – Improved maintenance regimes of drainage systems and ensuring resources are available to deliver this measure.
CDC4: Woburn Sands	– Attenuation SuDS at Old Park Farm and southeast of Walton High School playing field. – Watercourse clearance and increasing capacity at Cranfield Road through use of an oversized pipe. – Land management practices – sustainable agricultural and rural practices *Borough-wide options which would benefit this CDC include:* – Planning policies to influence development. – Social change, education and awareness.	– Retrofitting of rain gardens (if environmental and economic barriers can be overcome)	– Improved maintenance regimes of drainage systems and ensuring resources are available to deliver this measure. – Property level protection
CDC6: Downs Barn and Conniburrow	– Attenuation SuDS at land south of Dansteed Way including land west of Capel Drive, land west of Overstreet and land west of the Grand Union Canal, *Borough-wide options which would benefit this CDC include:*	– Green roofs (if environmental and economic barriers can be overcome) – Retrofitting of rain gardens (if environmental and economic barriers can be overcome)	– Enhanced ditch maintenance and initial clearing (land south of Dansteed Way) – Improved maintenance regimes of drainage systems and ensuring resources are

CDC	Preferred Option: Combined Measures	Other Potential Options	Quick Wins
	– Planning policies to influence development. – Social change, education and awareness.		available to deliver this measure. – Property level protection
CDC8: Newport Pagnell	– Attenuation SuDS at the playing field of Portfield Combined Schools, Newport Pagnell Youth Club Playing Field, Green Park School Playing Field and Kingfisher Park and permeable paving in their car parks; – Increased capacity of drainage systems in key locations such as the High Street. – Implementation of flood gates at Little Linford Lane *Borough-wide options which would benefit this CDC include:* – Planning policies to influence development. – Social change, education and awareness.	– Retrofitting of rain gardens (if environmental and economic barriers can be overcome)	– Improved maintenance regimes of drainage systems and ensuring resources are available to deliver this measure. – Property level protection
CDC10: Olney	– Tanked permeable paving or tanked geocellular storage could be retrofitted across the vehicle parking areas/play areas at Olney Junior and Middle School. – Increased capacity of drainage systems. *Borough-wide options which would benefit this CDC include:* – Planning policies to influence development. – Social change, education and awareness.	– Retrofitting of rain gardens (if environmental and economic barriers can be overcome) – Managing overland flows (High Street and Spring Lane) if economic challenges can be overcome.	– Improved maintenance regimes of drainage systems and ensuring resources are available to deliver this measure. – Property level protection

CDC	Preferred Option: Combined Measures	Other Potential Options	Quick Wins
CDC11: Brinklow	– Attenuation SuDS (Tanked permeable paving or tanked granular storage) retrofitted across vehicle parking areas of Brinklow industrial estate and at the Kingston Centre. – Attenuation SuDS at Monkston Primary School's playing field. – Increasing capacity of drainage systems such as those along Chippenham Drive. *Borough-wide options which would benefit this CDC include:* – Planning policies to influence development. – Social change, education and awareness	– Retrofitting of rain gardens (if environmental and economic barriers can be overcome) – Managing overland flows – Reprofiling of the commercial area of Brinklow and Kingston to redirect flows.	– Improved maintenance regimes of drainage systems and ensuring resources are available to deliver this measure. – Property level protection
CDC12: Medbourne/Crownhill	– Attenuation SuDS located at the recreation ground at Grange Farm, green space forming the Medbourne Community Sports Pavilion, Loughton Manor First School and the Green Space in between Shenley Wood and Chalkdell Drive. Tanked permeable paving or tanked geocellular storage could also be retrofitted across the vehicle parking areas of Chalkdell Drive. – Increasing capacity of drainage systems. *Borough-wide options which would benefit this CDC include:* – Planning policies to influence development. – Social change, education and awareness	– Retrofitting of rain gardens (if environmental and economic barriers can be overcome) – Managing overland flows across the residential areas to the north of Medbourne Community Sports Pavilion, southeast of Shenley Church End Recreation Ground and east of Crownhill.	– Improved maintenance regimes of drainage systems and ensuring resources are available to deliver this measure such at Shenley Church End. – Property level protection
CDC13: Wymbush/ Two Mile	– Attenuation SuDS at the Golf Course to the west of the CDC and the school playing fields adjacent to Downland. *Borough-wide options which would benefit this CDC include:* – Planning policies to influence development. – Social change, education and awareness	– Retrofitting of rain gardens (if environmental and economic barriers can be overcome)	– Clearance of the ditch which separates the two school playing fields adjacent to Downland. – Improved maintenance regimes of drainage systems and ensuring resources are available to deliver this

CDC	Preferred Option: Combined Measures	Other Potential Options	Quick Wins
			measure. – Property level protection
CDC14: Bradwell Abbey	– Attenuation SuDS at Bradwell Abbey Golf Course opposite Dalvina and Kildonan Place. Attenuation SuDS could also be implemented at the northern extent of Bradwell Abbey cricket field (next to Calvie Croft) and at the vegetated area to the south of Millers Way just north of Myrtle Bank. – Increased capacity and conveyance of drainage systems i.e. upsizing of existing surface water sewer network at White Alder. – Managing overland flows through kerb raising at White Alder. *Borough-wide options which would benefit this CDC include:* – Planning policies to influence development. – Social change, education and awareness	– Retrofitting of rain gardens (if environmental and economic barriers can be overcome)	– Improved maintenance regimes of drainage systems and ensuring resources are available to deliver this measure. – Property level protection
CDC15: Stony Stratford	– Attenuation SuDS (tanked permeable paving or tanked geocellular storage) could be retrofitted across the vehicle parking areas for the school in Stony Stratford. Attenuation basins could also be installed at the green space between the residential areas of Latimer and Millford Avenue. Permeable paving could also be implemented at the vehicle parking area at Vicarage Road. – Increased conveyance and capacity of drainage systems along the High Street and Clarence Road. *Borough-wide options which would benefit this CDC include:* – Planning policies to influence development. – Social change, education and awareness	– Retrofitting of rain gardens (if environmental and economic barriers can be overcome)	– Improved maintenance regimes of drainage systems and ensuring resources are available to deliver this measure. – Property level protection
CDC17: Oldbrook	– Attenuation SuDS (tanked permeable paving or tanked geocellular	– Retrofitting of rain gardens (if	– Improved maintenance

CDC	Preferred Option: Combined Measures	Other Potential Options	Quick Wins
	storage) could be retrofitted across the vehicle parking areas in Winterhill Retail Park; – Attenuation SuDS could also be implemented at the playing field of the Jubilee Wood Primary School. – Increasing capacity and conveyance of drainage systems throughout the residential areas surrounding Oldbrook Cricket Ground. *Borough-wide options which would benefit this CDC include:* – Planning policies to influence development. – Social change, education and awareness	environmental and economic barriers can be overcome) – Managing overland flows – reprofiling of hardstanding areas of commercial buildings in Winterhill Retail Park (if found to be technically feasible)	regimes of drainage systems and ensuring resources are available to deliver this measure. – Property level protection
CDC19: Bradwell	– Attenuation SuDS (tanked permeable paving or tanked geocellular storage) retrofitted across the vehicle parking areas of the Bradville Industrial Estate, Stantonbury School, Pepper Hill School and the industrial estate surrounding Fingle Drive. Where these areas also comprise green space i.e. Stanton School and Pepperhill School attenuation SuDS such as bunds etc. should be considered. – Increased capacity conveyance of drainage systems at the junction between Monks Way and Grafton Street. *Borough-wide options which would benefit this CDC include:* – Planning policies to influence development. – Social change, education and awareness	– Retrofitting of rain gardens (if environmental and economic barriers can be overcome)	– Improved maintenance regimes of drainage systems and ensuring resources are available to deliver this measure. – Property level protection
CDC20: West Bletchley	– Attenuation Suds - Oxley Park Academy, Howe Park wood, Green space next to the N of Snelshall West Industrial Estate, Windmill Hill Golf course, Chestnuts School (Green Space), St. Thomas Aquinas Catholic Primary School and Barleyhurst park Primary School. – Increased conveyance and capacity of drainage networks in residential areas across the CDC.	– Retrofitting of rain gardens (if environmental and economic barriers can be overcome)	– Improved maintenance regimes of drainage systems and ensuring resources are available to deliver this measure. – Property level protection

CDC	Preferred Option: Combined Measures	Other Potential Options	Quick Wins
	Borough-wide options which would benefit this CDC include: – Planning policies to influence development. – Social change, education and awareness		

Phase 4 Implementation & Review

Phase 4 establishes a long-term Action Plan for Milton Keynes. The purpose of the Action Plan is to:

- Outline the actions required to implement the preferred options identified in Phase 3;
- Identify the partners or stakeholders responsible for implementing the action;
- Provide an indication of the priority of the actions and a timescale for delivery; and,
- Outline actions that can be undertaken across the borough by MKC.

The SWMP Action Plan is a 'living' document, and as such, should be reviewed and updated regularly as part of the action plans produced by MKC for Flood Management. Reviews should consider occurrences of surface water flood events, any additional data or modelling becoming available, the outcome of investment decisions by partners and any additional major development or changes in the catchment which may affect the surface water flood risk.

1 Introduction and Aims

1.1 Introduction

AECOM has been commissioned to assist Milton Keynes Council (MKC) in the development of a surface water management strategy for the Borough of Milton Keynes through the preparation of a Surface Water Management Plan (SWMP). In this context surface water flooding describes flooding from sewers, drains, groundwater, runoff from land, ordinary watercourses and ditches that occurs as a result of heavy rainfall. The risk of flooding from rivers and the sea has been assessed in the Milton Keynes Strategic Flood Risk Assessment (SFRA)[3].

The SWMP study has been completed in consultation with the Milton Keynes Local Flood Risk Partnership to understand the causes and effects of surface water flooding and establish a starting point for a long-term action plan to manage surface water in the most cost effective way. The SWMP utilises the Environment Agency's national scale updated Flood Map for Surface Water (uFMfSW)[4] and knowledge of flooding mechanisms resulting from recent flooding events.

The outcomes from the SWMP will influence future capital investment, maintenance, public engagement and understanding, land-use planning, emergency planning and future developments. These outcomes will be supported through the delivery of the Local Flood Risk Management Strategy (LFRMS) which has the overarching aim of delivering the greatest benefit to the people, property and environment of Milton Keynes through the following objectives:

1) Ensure that drainage management is tailored to Milton Keynes unique drainage system.
2) Improve the Council's understanding of flood risk from all sources.
3) Ensure future development does not have a negative impact on flood risk and lowers the risk where possible.
4) Make best use of resources for maximum protection from flooding.
5) Help communities to become more resilient to flooding.
6) Improve communications between asset owners and build on existing partnership working.
7) Ensure emergency planning is linked to the Council's best understanding of the risks.

The Milton Keynes Local Flood Risk Partnership consists of the Risk Management Authorities that operate within the Borough, particularly Anglian Water Services (AWS), the Bedford Group of Drainage Boards (BGDB), which is a consortium of statutory Internal Drainage Boards (IDBs), including the Buckingham and River Ouzel IDB, and the Environment Agency.

The SWMP has been undertaken in four phases (Figure 1-1), based on the Defra SWMP Technical Guidance[5].

Preparation: Identify the need for a SWMP, establish a partnership with the relevant stakeholders and scope the SWMP.

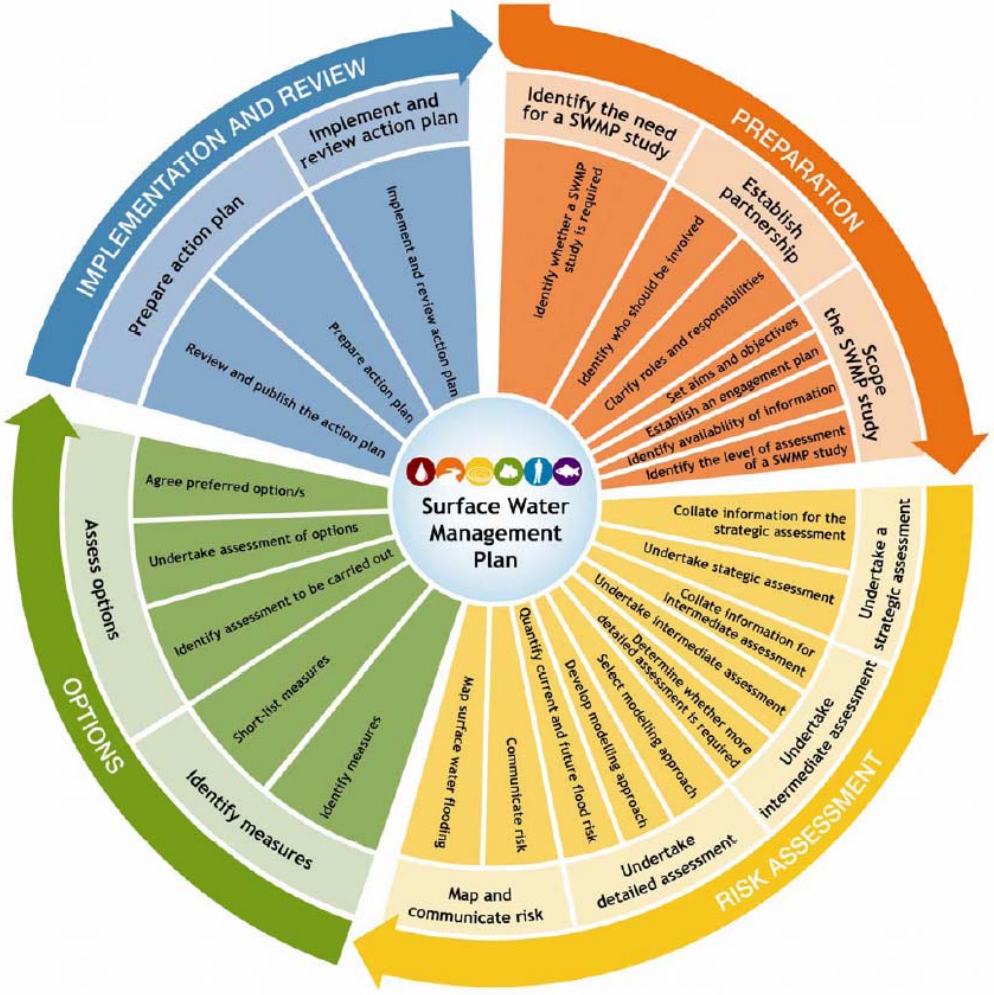
Risk Assessment: Select an appropriate level risk assessment and complete it.

Options: Identify options/measures (with stakeholder engagement) which seek to alleviate the surface water flood risk within Critical Drainage Catchments.

Implementation and Review: Prepare an Action Plan and implement the monitoring and review process for these actions.

[3] AECOM (2015) Milton Keynes Council Level 1Strategic Flood Risk Assessment
[4] Environment Agency (December 2013), updated Flood Map for Surface Water. Available online at: http://watermaps.environment-agency.gov.uk/wiyby/wiyby.aspx?&topic=ufmfsw#x=357683&y=355134&scale=2
[5] Defra (March 2010) Surface Water Management Plan Technical Guidance. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69342/pb13546-swmp-guidance-100319.pdf

Figure 1-1 SWMP Phases (based on Defra SWMP Technical Guidance, March 2010)



1.2 Study Area

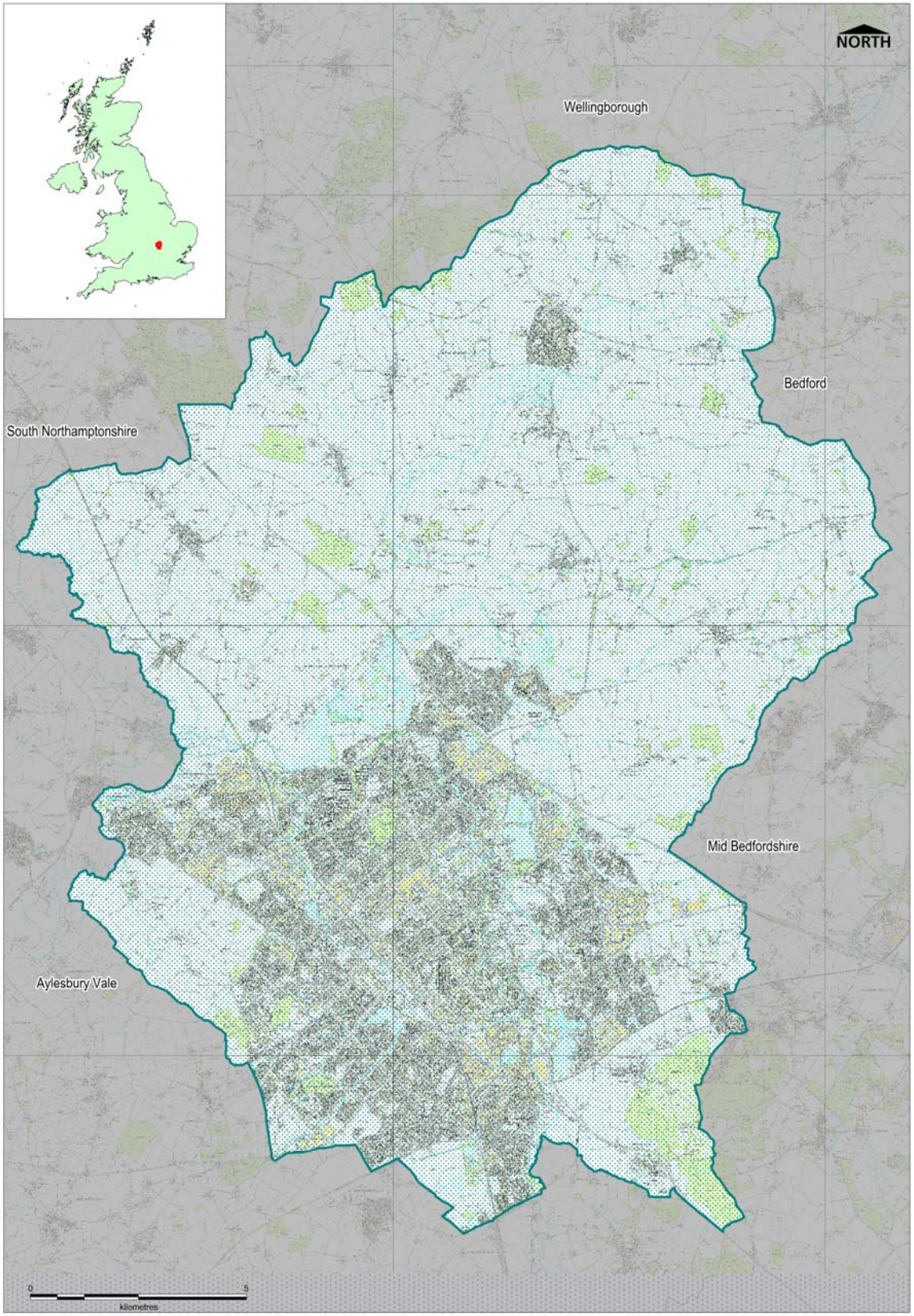
Milton Keynes was founded in 1967 and is predominantly a rural area located between London and Birmingham. Milton Keynes Borough is bordered by the regions of Aylesbury Vale, South Bedfordshire, Central Bedfordshire, Bedford and South Northamptonshire and spans 31,000 hectares. Milton Keyes has a population of 255,700 (2013)[6], the majority of which live in the rapidly expanding urban environment.

MKC formed in 1997. MKC is a Lead Local Flood Authority (LLFA) and has a number of duties in relation to local flood risk management for its administrative area under the Flood and Water Management Act 2010 (FWMA)[7] and the Flood Risk Regulations 2009 (FRR)[8]. Further details of these can be found in the LFRMS.

Figure 1-2 shows the Milton Keynes administrative area which makes up the study area for this SWMP

[6] Milton Keynes Council (2013) Population Statistics. http://www.milton-keynes.gov.uk/your-council-and-elections/statistics/population-statistics
[7] HMSO (2010) The Flood and Water Management Act 2010 http://www.legislation.gov.uk/ukpga/2010/29/contents
[8] HMSO (2009) The Flood Risk Regulations http://www.legislation.gov.uk/uksi/2009/3042/contents/made

Figure 1-2 Milton Keynes Council Administrative Area and SWMP Study Area



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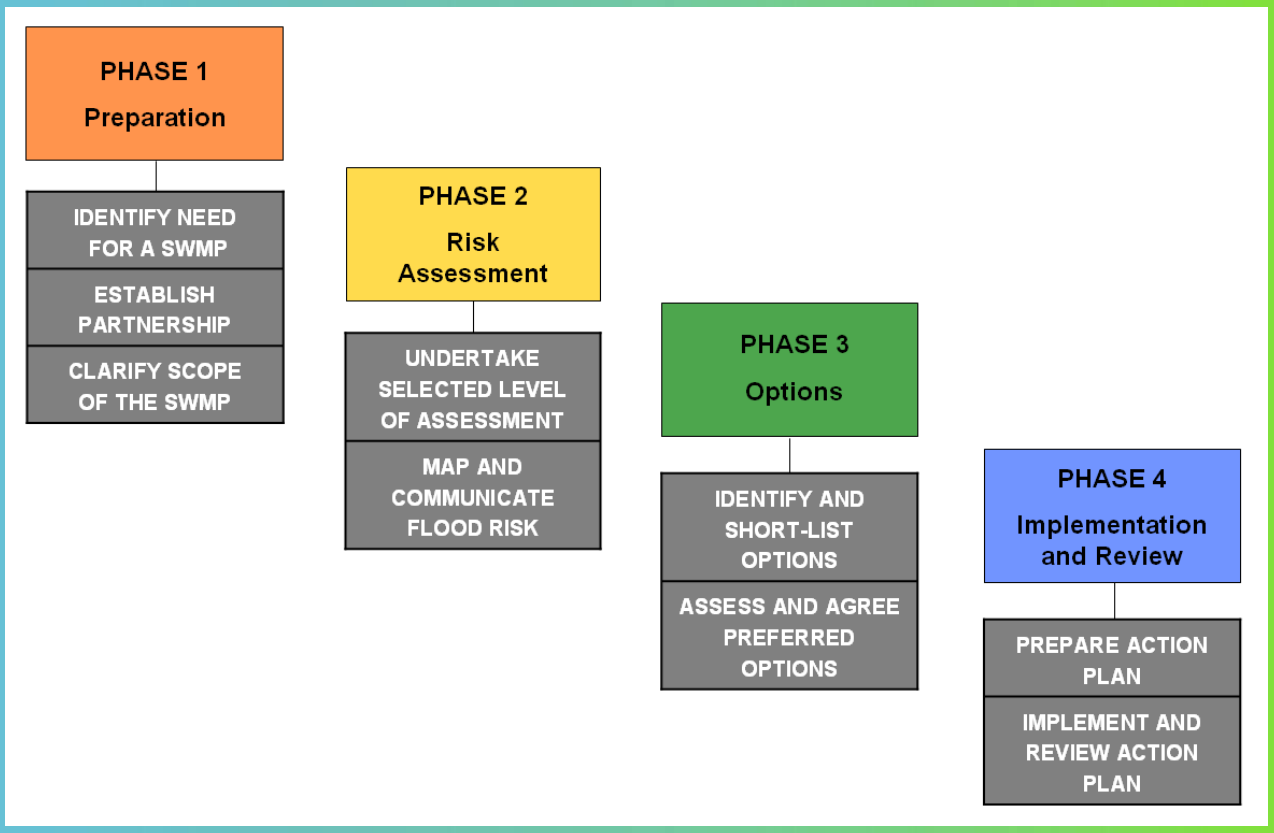
Phase 1: Preparation



2 Preparation

2.1 Preparation – Introduction

The purpose of the preparation phase is to identify whether a SWMP is required, and if so, which organisations will facilitate the delivery of the plan. Roles and responsibilities of each organisation will also be determined during the preparation phase. Subsequently the scope of the plan can be defined along with the following:

- Setting aims and objectives;
- Establishing an engagement plan;
- Identifying all available information; and,
- Identifying the level of assessment required for the SWMP study.

2.2 Partnership

In order for the SWMP and more general future flood risk management across the Milton Keynes Borough to be successful, it is essential that relevant partners and stakeholders, who share the responsibility for necessary decisions and actions, work collaboratively to understand existing and future surface water flood risk in the Borough.

The FWMA and FRR, enacted by Government in response to the recommendations of The Pitt Review - Learning Lessons from the 2007 Floods[9], gave unitary and county councils, as Lead Local Flood Authorities (LLFAs), responsibilities for leading and co-ordinating the management of local flood risk. As the LLFA, Milton Keynes Council is responsible for leading local flood risk management, including establishing effective partnerships within their local authority as well as with the Risk Management Authorities (RMAs) such as the Environment Agency, AWS, the Bedford Group of Drainage Boards and external stakeholders such as the Parks Trust. Ideally these working arrangements should be formalised to ensure clear lines of communication, mutual co-operation and management through the provision of Service Level Agreements (SLA) or Memorandums of Understanding (MoU). Further details of the RMA roles and responsibilities are provided within the Local Flood Risk Management Strategy (LFRMS).

The MKC SWMP study establishes a number of essential partners, and will seek to incorporate additional partners and stakeholders as they are identified throughout the SWMP study.

The Development Plans team co-ordinate the flood and water risk management programme as part of a joint working multi-departmental group with the responsibility for flood risk management within the following departments:

- **Development Plans** – responsible for the Strategic Flood Risk Assessment (SFRA) and the Local Plan;
- **Emergency Planning** – responsible for the Multi-Agency Flood Plan;
- **Transport/Highways/Drainage** – responsible for the gully and road drainage network
- **Sustainability** - responsible for the Sustainability Action Plan.

2.2.1 Milton Keynes Council Flood Risk Partnership Group (Strategic Flood Group)

MKC is working closely with neighbouring Boroughs to forge partnerships with respect to local flood risk management. The Council is part of an officer led Anglian Regional LLFA group and Tri-Partnership LLFA Group, which incorporates MKC, Bedford Borough Council and Central Bedfordshire Council as well as representatives from the Environment Agency, AWS and the Bedford Group of Drainage Boards.

Measure 7.3 of the Milton Keynes LFRMS is to 'Ensure findings from ongoing studies and the SWMP are communicated with Emergency Planning'. Milton Keynes Council will formalise an internal flood group to create a more efficient group between officers of different departments, focussing on the LLFA responsibilities, such as flood investigations and emergency planning. This will improve the effective communication between the different internal departments and allow

[9] Cabinet Office (2008) Sir Michael Pitt Report 'Learning lessons learned from the 2007 floods' http://webarchive.nationalarchives.gov.uk/20100807034701/http://archive.cabinetoffice.gov.uk/pittreview/_/media/assets/www.cabinetoffice.gov.uk/flooding_review/pitt_review_full%20pdf.pdf

a more joined up approach to flood risk studies in the Borough. The outputs of these studies, along with the SWMP, will be used to inform emergency planning in Milton Keynes. This measure will facilitate a community focus and partnership working alongside a catchment based approach.

2.2.2 Benefits of Collaborative Working

A number of benefits will arise from the collaborative working between members of the internal Council flood risk group and the Strategic Flood Group, including:

- Greater understanding of urban drainage by a range of organisations;
- A shared understanding of flood risk between the Council, AWS, Environment Agency, the Bedford Group of Drainage Boards and the Parks Trust;
- Efficiency savings for 'essential partners' though achieving outcomes;
- Appraisal of surface water drainage options;
- Greater certainty for developers concerning appropriate drainage;
- Quicker, more certain decisions on development and infrastructure provision; and,
- Overall reduction in flood risk within the Milton Keynes Borough (primarily driven through Phases 3 and 4 of the SWMP and dependent upon available funding).

2.2.3 Stakeholder Engagement

As part of the preparation of the Milton Keynes LFRMS, SFRA and SWMP, the following stakeholder organisations and authorities have been engaged:

- Environment Agency (EA);
- Anglian Water Services (AWS);
- Bedford Group of Drainage Boards (BGDB); and,
- The Parks Trust.

2.3 Data Collection

Table 2-1 provides a summary of the main data sources held by partner organisations used in the preparation of the SWMP.

Table 2-1 Data Sources

Data Supplier	Dataset	Description
Milton Keynes Council	Ordnance Survey 1:10,000 Mapping and Mastermap	Ordnance Survey Mapping for the Milton Keynes area for the 1:10,000 scale and Mastermap dataset.
	Green belt (GIS layer)	A GIS layer of the green belt area within Milton Keynes.
	Historic records of flooding (GIS layer)	Records of historic flooding within MKC's administrative area.
	Administrative Boundaries (GIS layer)	A GIS layer of MKC's administrative boundary
	Aquifer Designation Map (Bedrock Geology) (From EA Geostore)	A GIS layer of the bedrock geology of the Milton Keynes area, as shown in Appendix A.1a.
	Aquifer Designation Map (Superficial Deposits) (From EA Geostore)	A GIS layer of the superficial geology of the Milton Keynes area, as shown in Appendix A.1b.
	Detailed River Network (From EA Geostore)	A GIS layer of the Detailed River Network of Milton Keynes including Main Rivers and Ordinary Watercourses, Culverted watercourses etc.
	Historic Flood Map (From EA Geostore)	Attributed spatial flood extent data for flooding from all sources.
	Groundwater Vulnerability (From EA Geostore)	A GIS layer of groundwater vulnerability within the Milton Keynes area.

Data Supplier	Dataset	Description
	National Receptor Database (From EA Geostore)	A nationally consistent dataset of social, economic, environmental and cultural receptors including residential properties, schools, hospitals, transport infrastructure and electricity substations.
	Recorded Flood Outlines (GIS layer) (From EA Geostore)	A GIS layer of flood extents from historic flood events.
	Source Protection Zones (GIS layer) (From EA Geostore)	A GIS layer of Source Protection Zones within Milton Keynes.
	Updated Flood Map for Surface Water (complex) (From EA Geostore)	A GIS layer of the updated flood map for surface water produced by the Environment Agency in 2013.
	Statutory Main Rivers (GIS layer) (From EA Geostore)	A GIS layer of statutory main rivers within the Milton Keynes area.
Environment Agency	Areas Benefiting from Defences (GIS layer)	A GIS layer of the areas within Milton Keynes which benefit from the flood defences.
	Historic records of flooding from all sources (GIS layer)	Records of historic flooding within MKC's administrative area.
	LiDAR Data	A GIS layer of Milton Keynes topography collected through light detection and ranging techniques. Appendix A.2 shows the LiDAR data for the study area.
Anglian Water Services	Sewer Flooding Records	Records of sewer flooding which has occurred within AWS' sewer network throughout Milton Keynes.
	Sewer Network in GIS	A GIS layer of AWS' sewer network assets.
	Information regarding combined and surface water system interactions	Information provided by AWS relating to the interactions between combined and surface water sewers within the Milton Keynes are.
	Any locations or particular assets that are susceptible to flooding in the Milton Keynes study area	Information provided by AWS which lists particular assets and locations which may be susceptible to sewer flooding within Milton Keynes.
Bedford Group of Drainage Boards	Asset Location Data (GIS layer)	A GIS layer provided by the Bedford Group of Internal Drainage Boards relating to the location of Bedford Group of Drainage Boards assets in association with ordinary watercourses.
	Historic Records of Flooding (GIS layer)	A GIS layer of historic records of flooding associated with ordinary watercourses managed by the Bedford Group of Drainage Boards.
	Bedford Group of Drainage Boards Area (GIS layer)	A GIS layer of the administrative area of the Bedford Group of Drainage Boards within Milton Keynes.
Parks Trust	Records of Flooding (GIS layer)	A GIS layer of recorded floods within areas the Parks Trust's area of management.
	Details of SuDS	Information provided by the Parks Trust relating to Sustainable Drainage Systems (SuDS) within the areas they manage within Milton Keynes.
Highways England	Historic and recent records of flooding (GIS layer)	A GIS layer provided by the Highways England relating to historic incidents of highways flooding.
	Any locations or particular assets that are susceptible to flooding in the Milton Keynes study area	Information provided by the Highways England which lists particular assets and locations which may be susceptible to sewer flooding within Milton Keynes.
Canal & River Trust (from EA Geostore)	Aqueduct Data	GIS layers relating to the Canal network and assets within Milton Keynes as provided by the Canal & River Trust.
	Canal Centreline Data	
	Bridges Data	
	Lakes. Ponds and Fisheries Data	
	Locks Data	
	Outfall/Discharge Point Data	
	Reservoirs Data	
	Wharves Data	

Data Supplier	Dataset	Description
	Canal network Junction Points Data	
	Docks Data	
	Embankments Data	

2.4 Scope for Milton Keynes SWMP

The purpose of **Phase 2 (Risk Assessment)** is to develop the understanding of surface water flood risk across Milton Keynes Borough and subsequently communicate that risk to the relevant partners and stakeholders. This includes:

- Reviewing the data collated in Phase 1;
- Analysing the uFMfSW dataset, published by the Environment Agency in December 2013, to identify the mechanisms of surface water flooding and enable an intermediate level risk assessment of surface water flood risk in the Borough;
- Quantifying the risks from surface water flooding through the identification of overland flow paths and areas of surface water ponding leading to the delineation of Critical Drainage Catchments (CDCs) and an assessment of properties and infrastructure at risk;
- Prioritisation of CDCs based on historical flooding, flood risk and future development to determine those to be taken forward to Phase 3 of the SWMP; and,
- Mapping the results of surface water flood risk and communicate the risk of flooding to relevant stakeholders within the Milton Keynes Borough Local Flood Risk Partnership.

The purpose of **Phase 3 (Options)** is to identify and assess flood alleviation options and measures that can be put forward. This includes:

- Identifying potential options for surface water management across Milton Keynes Borough, both specific to the individual CDCs prioritised under Phase 2 and across the borough;
- Undertaking a detailed assessment of short-listed options for each CDC; and
- Undertaking a high-level assessment of the costs and benefits of short-listed options.

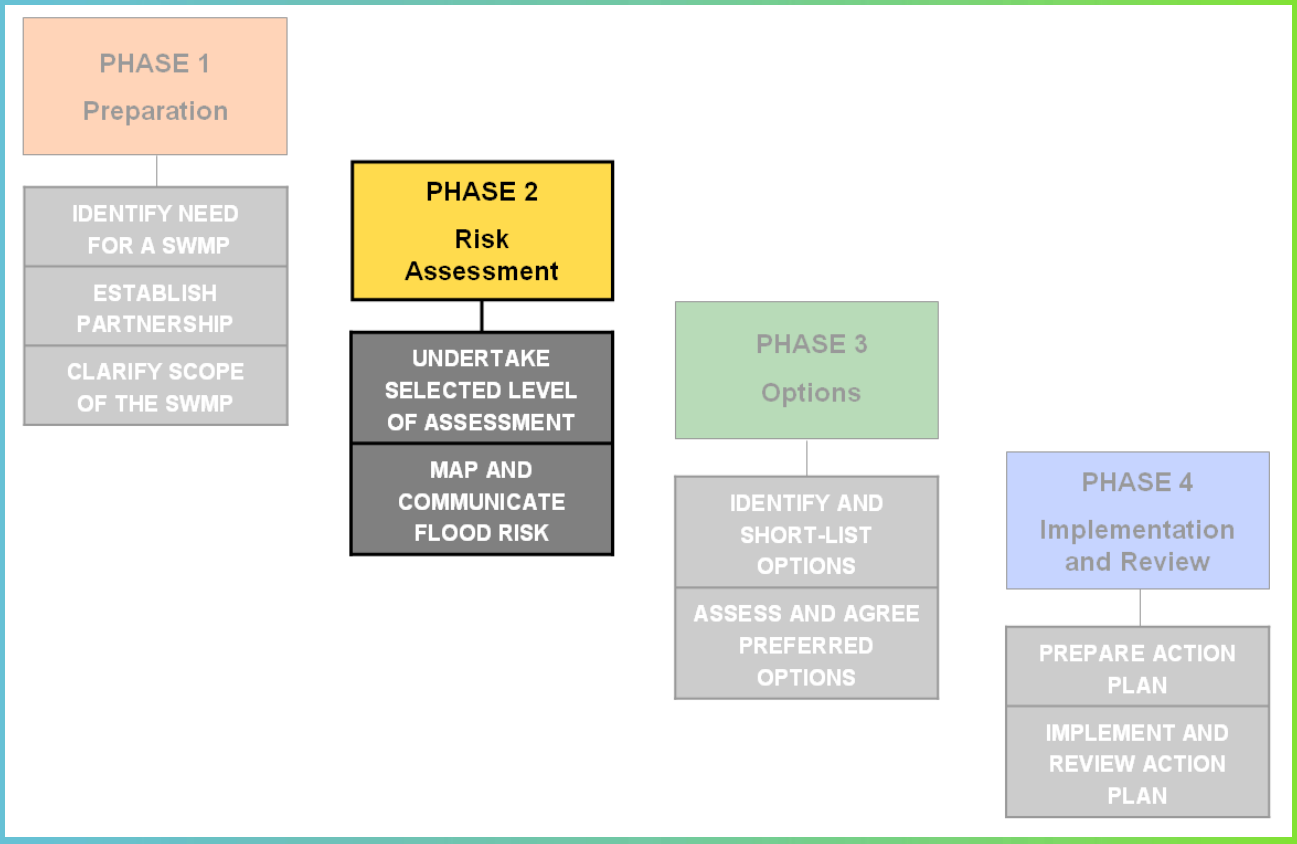
The purpose of **Phase 4 (Implementation and Review)** is to prepare the SWMP Action Plan and provide a strategy on how it will be implemented and reviewed.

2.5 Phase 1 Summary

Phase 1 of the SWMP has:

- Engaged key stakeholders including the Environment Agency, AWS and Bedford Group of Drainage Boards to discuss and agree on local flood risk management within the Milton Keynes Borough in the future;
- Collected and reviewed flood risk data and knowledge from key stakeholders and partner organisations; and,
- Set out the objectives and governance for the Phase 2 – Risk Assessment, Phase 3 – Options Assessment, and Phase 4 – Action Plan phases of the Milton Keynes SWMP.

Phase 2: Risk Assessment



3 Strategic and Intermediate Risk Assessment

3.1 Introduction

The purpose of Phase 2 of the Milton Keynes SWMP is to undertake an intermediate risk assessment, in line with the SWMP Technical Guidance[5], to identify, assess and prioritise the risk of surface water flooding in catchments across Milton Keynes Borough.

The aim of an intermediate risk assessment is to identify sources and mechanisms of surface water flooding across the borough which will be achieved through an assessment of pluvial flooding, sewer flooding, groundwater flooding and flooding from ordinary watercourses. Subsequently the results of an intermediate risk assessment can be used to identify Critical Drainage catchments (CDCs). The nature and degree of flood risk within each CDC has been assessed to determine those at greatest risk and which should therefore be prioritised and recommended for mitigation works.

Using the uFMfSW will provide an overview of the spatial distribution of pluvial flood risk across the borough. However, there are limitations associated with the uFMfSW, such as considering a smaller number of events (than may have been considered through more detailed modelling) which do not include climate change. A site visit was undertaken in May 2015 which comprised 'ground-truthing' of the uFMfSW.

Upon identifying CDCs, Milton Keynes Council should undertake a more tailored risk assessment inclusive of more detailed surface water modelling stage as part of their ongoing flood and water management efforts, as identified within the associated SWMP Action Plan.

3.2 Sources of Flooding

The SWMP has considered flooding from each of the following sources:

- **Surface water runoff;** runoff as a result of high intensity rainfall when water is ponding or flowing over the ground surface before it enters the underground drainage network or watercourse, or cannot enter it because the network is full to capacity, thus causing flooding (known as pluvial flooding);

- **Sewer flooding**[10]; flooding which occurs when the capacity of the underground network system is exceeded, resulting in flooding inside and outside of buildings. Normal discharge of sewers and drains through outfalls may be impeded by high water levels in receiving waters[11] as a result of wet weather or high tidal conditions;

- **Flooding from small open channels and culverted urban watercourses**[12]; and

- Localised flooding resulting from emerging **groundwater** sources.

The risk of flooding from rivers and the sea has been assessed in the Milton Keynes Strategic Flood Risk Assessment (SFRA)[13].

The interaction of multiple flood sources is a common occurrence. For example, surface water and sewer flooding is known to be exacerbated by high river and tide levels and high groundwater levels. Where these interactions have been identified, either through historical flooding incidents, local knowledge or flood risk datasets, these have been identified and discussed within this report.

[10] Consideration of sewer flooding in 'dry weather' resulting from blockage, collapse or pumping station mechanical failure is excluded from SWMPs as this is for the sole concern of the sewage undertaker.
[11] Interactions with larger rivers and tidal waters can be important mechanisms controlling surface water flooding.
[12] These watercourses will frequently be ordinary watercourses (with responsibility for managing the risk with LLFAs) but may also be designated main river (with responsibility for managing the risk with the Environment Agency). Riparian owners will be responsible for managing those sections of watercourse that lie within or border their properties.
[13] URS (2015) Milton Keynes Council Strategic Flood Risk Assessment Level 1, April 2015

3.3 Surface Water

3.3.1 Flood Mechanism

Surface water or pluvial flooding usually occurs during very intense rainfall which causes water to flow over the surface of the ground and create deep pools or puddles of water in low lying areas. This type of flooding is most common in urban areas where water is unable to enter the ground because of tarmac or other impermeable surfaces. It can also be exacerbated in rural areas when the soil is saturated and natural drainage channels or artificial drainage systems have insufficient capacity to cope with the intense rainfall.

3.3.2 Historical Flood Records

Historical flood records relating to surface water have been collated from the Environment Agency and Highways England. No records were available from MKC at the time of the SWMP.

Appendix A.3 shows there to be five incidents of historic surface water flooding in the administrative area of Milton Keynes, largely concentrated in Newport Pagnell with one incident in Stoke Goldington and another in Lavendon. All of these instances of surface water flooding are reported to have occurred as a result of drainage system capacity exceedance resulting in sewer surcharge as shown in Table 3-2. It should be noted that a large number of anecdotal flood records are held by MKC. However, as specific locations are not always recorded they have not been mapped.

There is a history of surface water flooding in Stoke Goldington as a result of surface water runoff flowing over agricultural land. Following severe flooding events on the 4th June and 2nd July 2007 a Flood Investigation Report (2008)[14] was published which assessed the cause of flooding and potential mitigation measures associated with the flooding events. . The Report found that Stoke Goldington is affected by overland run off due to its location in a natural topographic hollow, and the local geology. The village is situated on relatively impermeable Upper Lias Clay whereas higher land to the north and west of the village is generally situated upon boulder clay and limestone respectively. The clay soils act as impermeable surfaces when saturated, or baked, leading to a high percentage of runoff, which flows towards the village due to the slope of the fields. The limestone geology to the west can retain significant volumes of rainfall. During an extended period of heavy rainfall this water can be released as natural springs on the local hillsides at the interface of the limestone and clay geology, and contribute to flooding.

As part of the Milton Keynes Level 1 SFRA, Highways England provided information relating to incidents of flooding and standing water on their network from their command and control system (Table 3-). Appendix A.3 shows that Highways Flooding is typically found in the south of Milton Keynes near Bradwell Abbey and Fenny Stratford.

3.3.3 Updated Flood Map for Surface Water

In December 2013, the Environment Agency published the uFMfSW[15] dataset. This national dataset maps the risk of flooding from surface water and represents the best available surface water flood risk information for Milton Keynes Borough. The uFMfSW identifies the risk of surface water flooding at a strategic scale, utilising up to date datasets and modelling techniques to provide a useful means whereby surface water flood risk extents can be identified. The surface water flood risk is banded based on the following:

- **High Risk** – at risk of flooding for a rainfall event with a 1 in 30 (3.3% Annual Exceedance Probability (AEP)) probability of occurrence in any given year,
- **Medium Risk** – at risk of flooding for a rainfall event with a 1 in 100 (1% AEP) probability of occurrence in any given year, and,
- **Low Risk** – at risk of flooding for a rainfall event with a 1 in 1000 (0.1% AEP) probability of occurrence in any given year.

An assessment of the risk of surface water flooding to properties across the Milton Keynes Borough has been undertaken using the uFMfSW dataset, Ordnance Survey MasterMap, the National Receptor Database (NRD) and the Multi-Coloured Manual (MCM) as outlined below.

1. The MasterMap dataset has been used to determine which buildings lie within the High, Medium and Low Risk surface water flood extents utilising a threshold value of 150mm,
2. The 'flooded' buildings have then been cross referenced against the NRD to determine which buildings are classed as properties, as opposed to garages or outbuildings.

[14] WSP (2008). Flood Investigation Report: 4th June and 2nd July 2007, Milton Keynes.
[15] Flood Risk from Surface Water maps, also known as the updated Flood Map for Surface Water (uFMfSW) dataset, available at http://watermaps.environment-agency.gov.uk/wiyby/wiyby.aspx?topic=ufmfsw#x=357683&y=355134&scale=2. accessed April 2015

3. The 'flooded' properties have then been further cross referenced against the MCM to determine what type of property they are, e.g. residential, shop, hospital, factory, doctor's surgery etc.
4. Finally, the properties have been classified based on their vulnerability, based on the Flood Risk Vulnerability Classification[16] set out in the National Planning Policy Framework (NPPF)[17] and the Planning Practice Guidance[18] (PPG) to summarise the number and vulnerability of properties at risk of surface water flooding across Milton Keynes Borough.

Flood Risk Vulnerability Classifications are as follows:

- **Essential Infrastructure** e.g. Sewage Treatment Works, Electricity Infrastructure.
- **Highly Vulnerable** e.g. Fire and Ambulance Services.
- **More Vulnerable** e.g. Educational facilities, Hospital and Residential Homes.
- **Less Vulnerable** e.g. Commercial Properties.
- **Water Compatible** e.g. Docks, Marinas and Wharves.

Section 5 provides a summary of the Phase 2 Risk Assessment and outlines the risk of surface water flooding to existing properties and infrastructure.

3.4 Groundwater

3.4.1 Flood Mechanism

Groundwater flooding occurs as a result of a rising water table from the underlying aquifer or from water flowing from springs. This tends to occur after long periods of sustained heavy rainfall and can be random in both location and time of flooding, often lasting longer than a river or surface water flood. High groundwater levels may not always lead to widespread groundwater flooding; but has the potential to exacerbate the risk of;

- Surface water flooding by saturating the soil and reducing the amount of rainfall the ground can accept;
- River flooding by increasing the base flow in rivers; and,
- Sewer flooding through the interaction between groundwater and underground sewer networks.

3.4.2 Historical Flood Records

Groundwater flooding has not been widely reported within Milton Keynes Borough. However, Environment Agency groundwater flood records shown in Appendix A.3 highlight incidents of groundwater flooding in Ravenstone, Newport Pagnell, Olney and Stony Stratford. Table 3-2 provides further detail regarding these incidents.

3.4.3 Flood Risk

Groundwater flood risk has been mapped using the British Geological Survey's (BGS) Susceptibility to Groundwater Flooding dataset (Appendix A.4).

As shown by the BGS Susceptibility to Groundwater Flooding mapping, in the north of the borough, where the underlying geology is predominantly the Kellaways Formation and Oxford Clay Formation (Figure A.1a) there is a limited potential for groundwater flooding to occur. The bedrock geology of the central and southern parts of Milton Keynes is predominantly Oxford Clay which is relatively impermeable. As a result of this, areas which sit directly on the clay are not considered to be at risk from groundwater flooding. Along and adjacent to the watercourses throughout the Milton Keynes Borough, there is an increased potential for groundwater flooding to occur due to the higher permeability of the River Terrace Deposits and Alluvium (Figure A.1b) and the associated high groundwater levels in adjacent areas.

Based on the above, and the relatively sparse groundwater flooding records, it has been concluded that whilst the risk of localised groundwater flooding remains, it is considered to be of low risk across the Borough.

[16] http://planningguidance.planningportal.gov.uk/blog/guidance/flood-risk-and-coastal-change/flood-zone-and-flood-risk-tables/table-2-flood-risk-vulnerability-classification/ accessed March 2015.
[17] Communities and Local Government (2012) National Planning Policy Framework, Department for Communities and Local Government: London.
[18] http://planningguidance.planningportal.gov.uk/ accessed March 2016.

3.5 Ordinary Watercourses/Land Drainage

3.5.1 Flood Mechanism

Flooding as a result of ordinary watercourses can occur from small open channels, culverted watercourses and other land drainage assets (i.e. drainage ditches). In addition to these flooding mechanisms, there are also a series of artificial drainage channels across the urban area of Milton Keynes as a result of development.

Flooding from ordinary watercourses/land drainage usually occurs as a result of, and in combination with, surface water, sewer and fluvial flooding, with factors including;

- Insufficient capacity in the drainage channel;
- Maintenance and conveyance (e.g. blockages, bankside vegetation, aquatic vegetation and siltation);
- Large volumes of surface water entering the drainage channel; and/or
- High water levels downstream (e.g. main river or public sewer).

Flooding from main rivers or the sea is the responsibility of the Environment Agency and is outside the scope for the SWMP. The risk from main rivers[19] and the sea is outlined in the Milton Keynes Level 1 SFRA[20] and shown in Figure A6.a. Main Rivers in the borough include:

- The Great Ouse;
- The River Ouzel;
- Water Eaton Brook;
- Tongwell Brook; and,
- The River Tove.

3.5.2 Historical Flood Risk

Appendix A.5 shows the main rivers and ordinary watercourses that are located within the Milton Keynes. There are also numerous SuDS features across the study area, some of which are shown on the figure. Table 3-1 lists and provides further detail on the ordinary watercourses within Milton Keynes.

[19] Main rivers are watercourses shown on the statutory main river maps held by the Environment Agency, the Department of Environment, Food and Rural Affairs (in England) and the Welsh Assembly Government (in Wales). They can include any structure or appliance for controlling or regulating the flow of water into, in or out of the channel.
[20] AECOM (2015) 'Milton Keynes Council Level 1 Strategic Flood Risk Assessment'

Table 3-1 Ordinary Watercourses within Milton Keynes

Watercourse (name or location if un-named)	Risk Management Authority	Description
Loughton Brook	Bedford Group of Drainage Boards	Loughton Brook flows northeast from the Salden area towards Tattenhoe Park and then parallel to the A421 before flowing northwest parallel to the A5. The confluence of the Loughton Brook with the Great Ouse is at New Bradwell. The Loughton Brook catchment is almost entirely within the Designated Area (DA) of Milton Keynes. Loughton Brook, downstream of Fulmer Street is in a Drainage District and the Bedford Group of Drainage Boards exercise its permissive powers to carry out works for flood defence purposes. Upstream of Fulmer Street the watercourse is under the jurisdiction of MKC. The Parks Trust manages the public open space and manages watercourses in the linear parks. AWS own the balancing ponds within the catchment.
Broughton Brook	Bedford Group of Drainage Boards	Broughton Brook is a tributary of the River Ouzel on the eastern side of Milton Keynes, and is within the Bedford Group of Drainage Boards area. AWS own the balancing ponds within the catchment.
Chicheley Brook	MKC	Chicheley Brook drains the area surrounding the village of Chicheley in the east of the Borough, and flows west to join the Great Ouse immediately to the north of Newport Pagnell. It is under the jurisdiction of MKC.
Springhill Brook	MKC	Springhill Brook flows east through Neath Hill in the northern part of Milton Keynes town. It then becomes culverted for approximately 1.5km before joining the Tongwell Brook adjacent to Tongwell Lake. It is under the jurisdiction of MKC.
Calverton Brook	Bedford Group of Drainage Boards	Calverton Brook is a tributary of the Great Ouse which flows through the village of Lower Weald on the western side of Milton Keynes within the Bedford Group of Drainage Boards area.
Caldecotte Brook	Bedford Group of Drainage Boards	Caldecotte Brook is a tributary of the River Ouzel. It flows west from Woburn Sands through the east side of Milton Keynes into Caldecotte Lake via twin culverts owned by MKC and into a box culver public storm sewer. It is within the Bedford Group of Drainage Boards area.
Shenley Brook	MKC	Shenley Brook comprises a number of culverted and non-culverted sections and flows through Shenley Brook End.

3.5.3 Historic Flooding

Flooding from ordinary watercourses is mainly experienced in central areas of the borough and to the south of the borough, particularly to the south west. Examples of historic flooding incidents related to ordinary watercourses, as detailed in the Milton Keynes' Level 1 SFRA, are included within Table 3-2.

It is likely that the occurrence of flooding originating from ordinary watercourses is under represented in the borough, for instance flood incidents in unoccupied open spaces or on private land are unlikely to have been reported and some of the incidents attributed to surface water flooding may also be associated with ordinary watercourses or land drainage.

3.6 Sewer Flooding

3.6.1 Flood Mechanism

Sewer flooding generally results in localised short term flooding. During heavy rainfall flooding from the sewer system may occur if;

- The amount of rainfall exceeds the capacity of the sewer system / drainage system;
- The system becomes blocked by debris or sediment; and/or
- High water levels in receiving watercourses cause water to back up in the sewer system and overflow.

Sewers are typically designed to cope for a storm period up to the 3.3% AEP (1 in 30 year storm event)[21]. Therefore, storm events with a probability of greater than 1 in 30 years would be expected to result in surcharging of some of the sewer system, which could result in localised flooding. In areas where surface water and foul drainage are drained via combined sewer systems, sewer flooding events can often be more frequent, although the scale of consequence is generally small.

Separate surface water and foul sewer systems are common throughout Milton Keynes, with the exception of parts of Wolverton and Western Underwood which are served partially by combined sewer systems. In these areas, sewer flood risk and surface water flood risk are closely related due to the significant volumes of surface water entering the combined sewer system during storm events.

3.6.2 Historic Records of Flooding

Records of sewer flooding have been provided by AWS. AWS is required to record all instances of internal flooding of properties where they reported to the water company. These are categorised on their cause, either hydraulic overloading of the sewers (the sewer pipe is too small or at too shallow a gradient) or other causes (blocked or collapsed sewers, pumping station failure, etc.). In addition they are required to maintain a register of properties which are at risk of internal flooding due to hydraulic overloading and this is usually known as the DG5 at risk register.

The DG5 (Director General 5) Register is 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 due to hydraulic overload. Properties flooded in severe weather (rare events) are recorded by AWS but do not go on to the register. Table 3-2 details the DG5 sewer records for Milton Keynes Borough.

3.7 Historical flooding Data

Table 3-2 lists all available historical flooding data by source.

Table 3-2 Milton Keynes Historical Flooding Data

Date	Description	Location	Data Source
Surface Water			
05 Jul 2006	Flooding on Main Carriageway – Incident Support Unit called.	A5 Carriageway	Highways England
06 Jul 2006	Flooding on Slip Road Carriageway - Incident Support Unit called.	A5 Carriageway	Highways England
06 Nov 2006	Underpass flooding beneath the Main Carriageway due to blocked ditch.	A5 Carriageway	Highways England
01 Dec 2006	Flooding Main Carriageway across L1/2 n/b, c.res. And L1/2 s/b - Cut grips.	A5 Carriageway	Highways England
20 Jul 2007	Standing water on the Main Carriageway.	A5 Carriageway	Highways England
20 Jul 2007	Standing water on the Main Carriageway.	A5 Carriageway	Highways England
22 Feb 2010	Runoff from offside verge across Slip Road due to a blockage in the drainage system.	A5 Carriageway	Highways England
Sept. 1992	Flooding from surface water drain surcharge.	John Street, Newport Pagnell	Environment Agency
Sept. 1992	Flooding from surface water drain surcharge.	Caldecote St, Newport Pagnell	Environment Agency
Sept. 1992	Flooding from surface water drain surcharge.	Priory St, Newport Pagnell	Environment Agency
July 2007	Pluvial. Excess surface water runoff. Drainage system overwhelmed. Source: Review of Summer 2007 Floods - Anglian Region.	Stoke Goldington	Environment Agency
Aug. 2008	Pluvial. Drainage system capacity exceeded. Source: Bedford Parish File.	Lavendon	Environment Agency
Groundwater			
Jun.1969	Well overflow due to high water table. Source: Bedford Parish	War Memorial,	Environment

[21] WRc Sewers for Adoption 7th Edition

Date	Description	Location	Data Source
	File.	Olney	Agency
Apr.1976	High water table. Source: Bedford Parish File.	Weston Road, Ravenstone	Environment Agency
Apr. 1998	Water entered through the ground. Wrack marks in garden.	High Street, Stony Stratford	Environment Agency
Feb. 2003	Flooded basement due to high groundwater level. Source: GWCL Team Records.	Mill Street, Newport Pagnell	Environment Agency
***Ordinary Watercourses**:* Information on historical flooding was gathered during the preparation of the 2008 SFRA from Environment Agency flood outlines and measured flood levels, published reports and a review of the local newspaper.			
1998 & 1947 (Great Ouse) and 1968 (Loughton Brook)	The Environment Agency flood event outlines only show flooding to gardens and grounds, not buildings, for these events	New Bradwell	See above
Aug 1980	Flooded due to an obstruction or blockage of a culvert. The local newspaper reports flood damage to Long Meadow School but does not give a date.	Shenley Brook End	See above
November 2004 and November 2007.	The local newspaper reports flooding to Wadesmill Lane, under the v10 road bridge. It reports that a local resident claims that the street floods once or twice a year. The newspaper attributes the flooding to the brook next to the community centre	Walton Park	See above
Unknown	The newspaper reports flooding to Bourton Low in Walnut Tree due to blockage to a culvert on Caldecotte Brook. *Since the flooding, improvements have been made to the Caldecotte Brook and the trash screen outfall.*	Bourton Low in Walnut Tree	See above
Unknown	The newspaper reports flooding to a garden in Ellesborough Grove.	Two Mile Ash	See above
August 1980	The Environment Agency flood outline reports that the channel capacity of the ordinary watercourse was exceeded.	Ravenstone	See above
August 1980	The Environment Agency flood outline reports that the channel capacity of the ordinary watercourse was exceeded.	Lavendon	See above
June 2007	There were two severe flooding events on 4th June and the 2nd July 2007. Following these events MKC commissioned WSP to produce a report into the cause of the flooding and potential mitigation measures, the second stage of which was completed in January 2008. The study found that Stoke Goldington had a long history of flooding with previous events in the 1880s, 1968, 1973, 1980, 1984 and 2002. Hydraulic analysis showed that the flooding was due to a combination of surface run off from higher ground and insufficient capacity in open channels and culverts. There are recorded flood levels in Orchard Way, High Street, Maltings Close and Ram Alley.	Stoke Goldington	See above
1973 and 2007	Environment Agency point measurements record 150mm of flooding to a property in 1973. The local newspaper reports flooding to the road in July 2007.	Tathall End	See above
August 2004	The local newspaper reports flooding due to a blocked culvert in August 2004.	Woburn Sands	See above
1998	Flooded in Easter 1998 from Calverton Brook, due to insufficient culvert capacity.	Lower Weald	See above
1981	N/A	Broughton Brook	Bedford Group of Drainage Boards
Unknown	Flooding of houses and Public Park as a result of heavy rainfall.	Walnut Tree	Bedford Group of

Date	Description	Location	Data Source
			Drainage Boards
Unknown	Flooding of low lying properties during heavy rainfall.	Lower Weald	Bedford Group of Drainage Boards
Unknown	Water behind properties on Lakes Lane.	Newport Pagnell	Bedford Group of Drainage Boards
Unknown	Leaks in defences at Lakes Lane	Newport Pagnell	Bedford Group of Drainage Boards
DG5 Sewer Records			
Unknown	1 property – internal flooding	Postcode: MK2 2	AWS
Unknown	1 property – internal flooding	Postcode: MK11 1	AWS
Unknown	1 property – external flooding	Postcode: MK16 0	AWS
Unknown	1 property – external flooding	Postcode: MK3 6	AWS
Unknown	1 property – external flooding	Postcode: MK17 8	AWS
Unknown	1 property – external flooding	Postcode: MK16 0	AWS
Unknown	1 property – external flooding	Postcode: MK1 1	AWS

4 Identification of Critical Drainage Catchments

4.1 Overview

The intermediate assessment was used to identify areas where the flood risk is considered to be most severe; these areas have been identified as Critical Drainage Catchments (CDCs). The definition of a CDC in this context has been agreed as:

'a discrete geographic area (usually a hydrological catchment) where multiple or interlinked sources of flood risk cause flooding during a severe rainfall event thereby affecting people, property or local infrastructure.'

The CDC comprises the upstream 'contributing' catchment, the influencing drainage catchments, surface water catchments and, where appropriate, a downstream area if this can have an influence on the CDC. In spatially defining the CDC the following have been taken into account:

- **Surface Water flood depth and extent** – areas shown within the uFMfSW as predicted deep or extensive levels of surface water flooding;
- **Surface Water flood hazard** – areas shown within the uFMfSW as predicted high hazard as a result of flooding (hazards is defined as a function of flood depth and velocity);
- **Potential impact on people, properties and critical infrastructure** – including residential properties, commercial properties, main roads (access to hospitals or evacuation routes), rail routes, rail stations, hospitals and schools;
- **Groundwater flood risk** – based on the BGS Susceptibility to Groundwater Flooding dataset identifying areas most susceptible to groundwater flooding;
- **Historical flooding events** – based on information from various RMAs;
- **Significant underground linkages** – including underpasses, tunnels, large diameter pipelines (surface water, sewer or combined) or culverted rivers;
- **Cross boundary linkages** – CDCs have not been curtailed by political or administrative boundaries; and,
- **Source, pathway and receptor** – the source, pathway and receptor of the main flooding mechanisms.

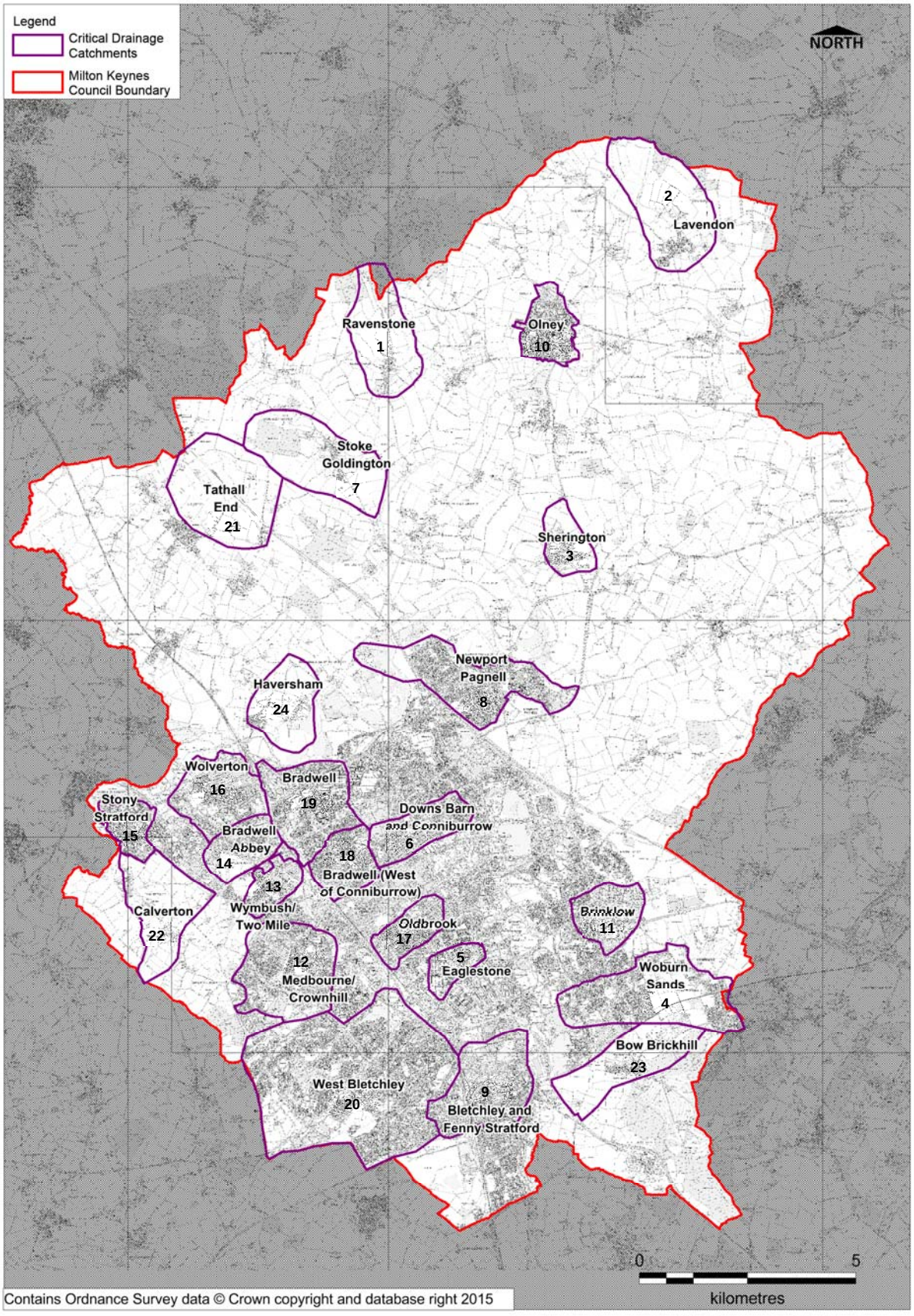
Within Milton Keynes Borough, 24 CDCs have been identified, as illustrated in Figure 4-1. Each of these CDCs were visited during a site visit in May 2015 to determine flood mechanisms, identify opportunities for flood mitigation, review local vulnerability to flooding and to assess the potential local impacts of flooding.

Further details on each of the CDCs are included in the subsequent sections and overview maps of each individual CDC can be found in Appendix B.1-24. Table 4-1 identifies the ID number for each CDC.

Table 4-1: Milton Keynes CDCs

CDC ID	CDC Name
CDC1	Ravenstone
CDC2	Lavendon
CDC3	Sherrington
CDC4	Woburn Sands
CDC5	Eaglestone
CDC6	Downs Barn and Conniburrow
CDC7	Stoke Goldington
CDC8	Newport Pagnell
CDC9	Bletchley and Fenny Stratford
CDC10	Olney
CDC11	Brinklow
CDC12	Medbourne/Crownhill
CDC13	Wymbush/ Two Mile
CDC14	Bradwell Abbey
CDC15	Stony Stratford
CDC16	Wolverton
CDC17	Oldbrook
CDC18	Bradwell (west of Conniburrow)
CDC19	Bradwell
CDC20	West Bletchley
CDC21	Tathall End
CDC22	Calverton
CDC23	Bow Brickhill
CDC24	Haversham

Figure 4-1 Critical Drainage Catchments within Milton Keynes Borough



CDC1: Ravenstone

Ward	Olney
Flood Source	Surface water, ordinary watercourses and groundwater.
Description	Ravenstone is a small village located at the northern boundary of the borough. Elevations decline from ~100mAOD at the valley ridge to ~65mAOD across the fluvial floodplain, resulting in surface water flow paths flowing from north to south. Surface water ponding is likely to arise in topographical depressions and has the potential to affect residential properties and to a greater extent local farmland. A number of ordinary watercourses are present in the CDC including a number of drains and springs which may combine with pluvial sources and result in flooding. Whilst surface water flooding is largely constrained to roads, properties located near Common Street are likely to experience an increased risk of surface water flooding relative to surrounding areas. Agricultural land use may also be affected by surface water, in particularly Abbey and Northend Farm. There is a historical record of groundwater flooding along with the potential for groundwater flooding to occur at the surface according to the BGS groundwater dataset.
Historical Flooding	The Environment Agency holds 1 record of groundwater flooding from April 1976 which is reported to have occurred as a result of a high water table.
Surface Water Flood Risk	**Summary of properties at risk of surface water flooding in Ravenstone:** – 8 residential and 19 non-residential properties are at high risk (3.33% AEP). – 12 residential and 30 non-residential properties are at medium risk (1% AEP). – 27 residential and 49 non-residential properties are at low risk (0.1% AEP). **Risk to critical infrastructure in Ravenstone:** – No critical infrastructure shown to be at risk.

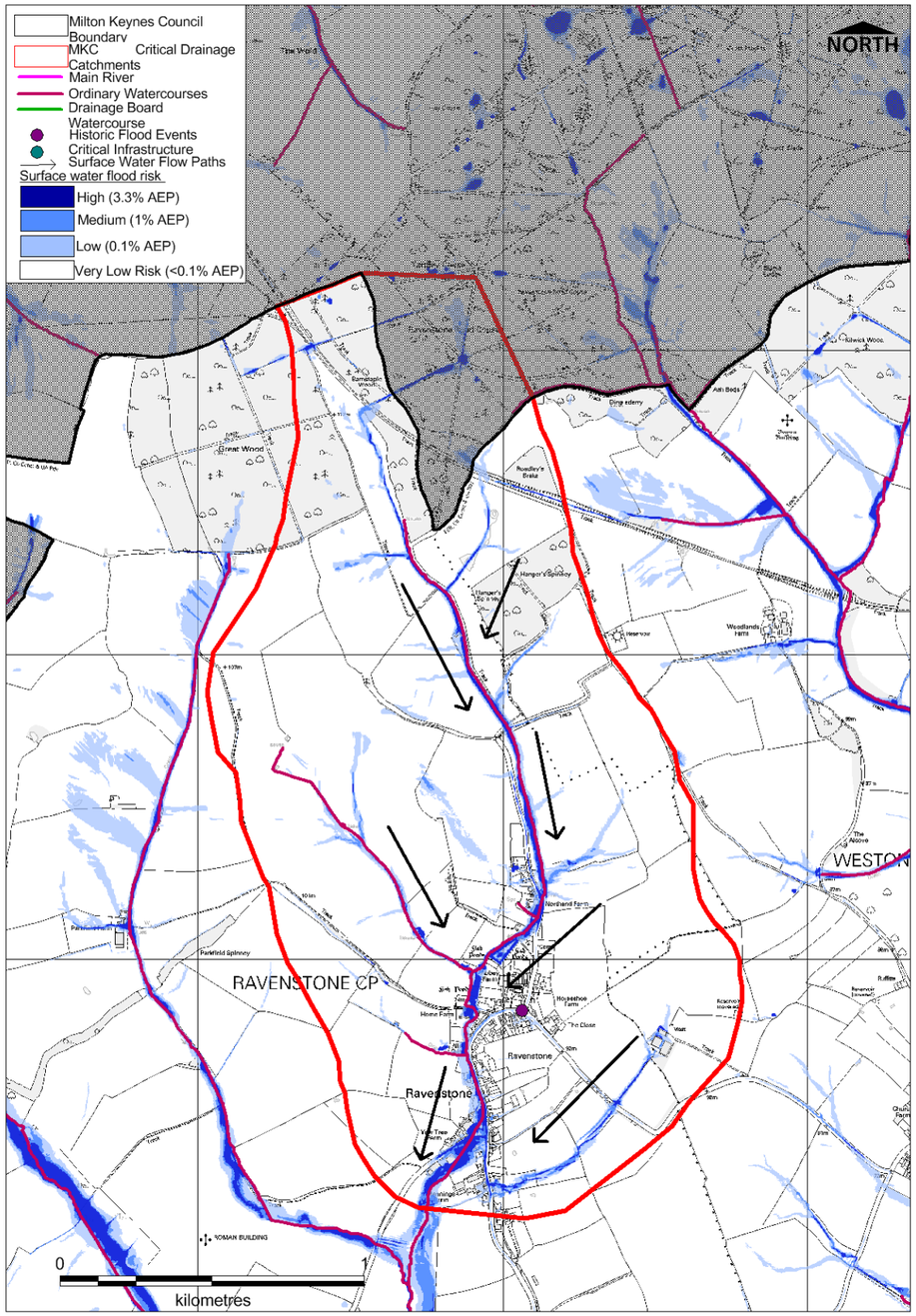


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Figure 4-2 Ravenstone Surface Water Flood Risk

CDC2: Lavendon

Ward	Olney
Flood Source	Surface water, ordinary watercourses and groundwater.
Description	Lavendon is a small village located at the northern extent of the borough with elevations ranging from ~95mAOD at the top of the valley to ~65mAOD along the fluvial floodplain. There is an extensive surface water flow path flowing from north to south Lavendon in conjunction with a number of smaller surface water flow paths flowing from higher to lower elevations. Consequently, surface water ponding is apparent across the valley floor. The uFMfSW identifies central Lavendon (comprising Northampton Road, Rectory Orchard, High Street and Olney Road) as an area which may be at high risk of surface water flooding. A number of culverted and non-culverted watercourses are present within the area (under the jurisdiction of MKC) which may combine with pluvial sources and result in flooding. The BGS groundwater dataset suggests that there is the potential for groundwater flooding to occur at the surface.
Historical Flooding	The Environment Agency holds 1 record of surface water flooding from April 1980 which is reported to have occurred as a result of the drainage system exceeding capacity.
Surface Water Flood Risk	**Summary of properties at risk of surface water flooding in Lavendon:** – 38 residential and 16 non-residential properties are at high risk (3.3% AEP). – 55 residential and 20 non-residential properties are at medium risk (1% AEP). – 111 residential and 41 non-residential properties are at low risk (0.1% AEP). **Risk to critical infrastructure in Lavendon:** – 2 educational facilities are at low risk (0.1% AEP).

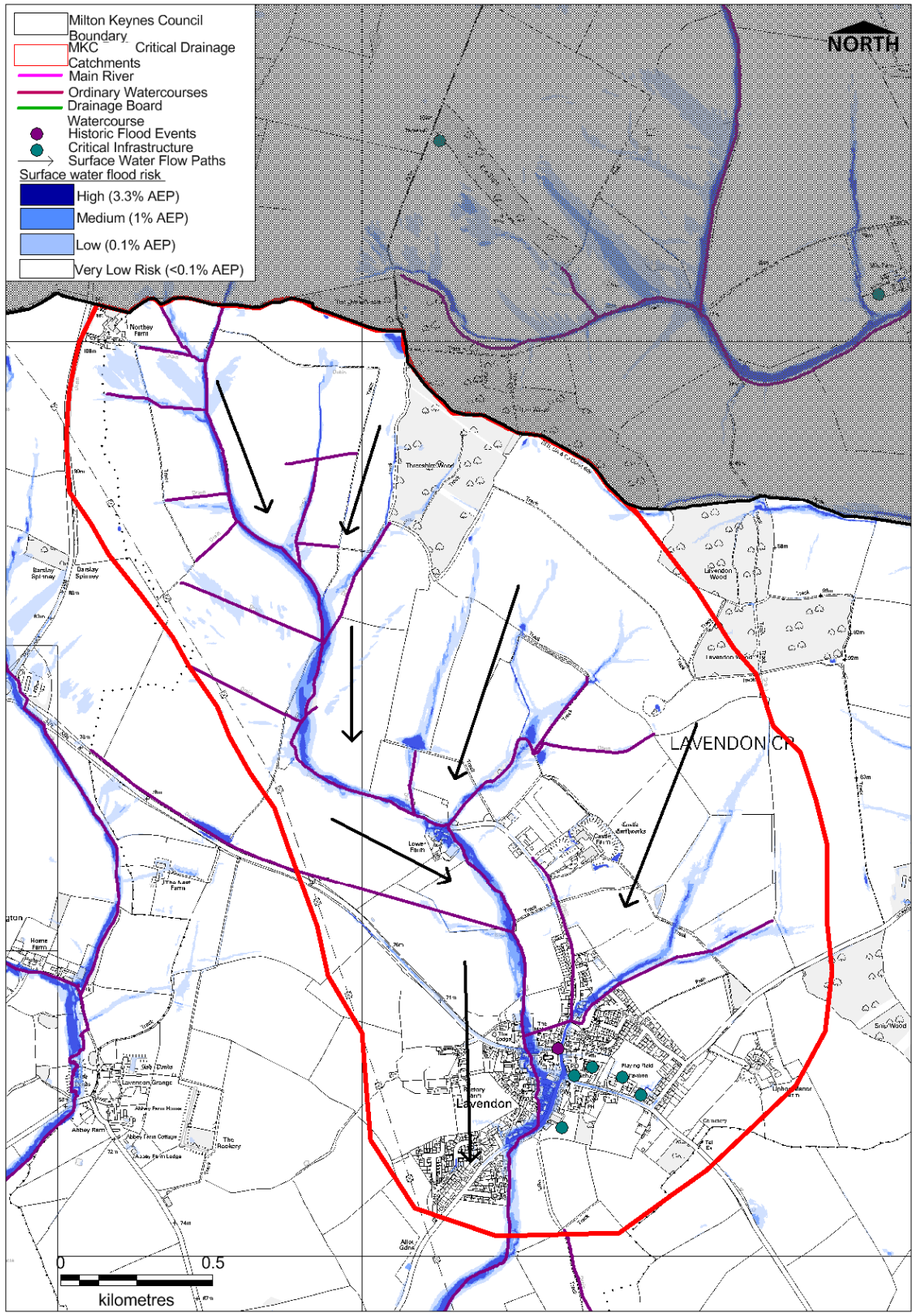

Figure 4-3 Lavendon Surface Water Flood Risk

CDC3: Sherington

Wards	Sherington
Flood Source	Surface water, ordinary watercourses and groundwater.
Description	Sherington is a village in the north of the borough. Elevations decline from ~90mAOD in the east to ~65mAOD in the west. Consequently, there are a number of extensive surface water flow paths which flow from east to west in line with this decline in elevation. Typically surface water flood risk in Sherington is constrained to highways, however there are residential areas which may also be at risk of surface water flooding such as Ley's View, a cul-de-sac located off the High Street near Water Lane. Whilst the area may not be affected by a 3.3% AEP event, the area may be significantly affected by a 0.1% AEP event. The CDC also has an ordinary watercourses running through it which may combine with pluvial sources and exacerbate flooding. The BGS groundwater dataset suggests that there is the potential for groundwater flooding to occur at the surface.
Historical Flooding	There are historical records of flooding within this CDC. Subsequently Anglian Water have installed a new storm water drainage system to relieve flooding in village, particularly in Water Lane.
Surface Water Flood Risk	**Summary of properties at risk of surface water flooding in Sherington:** – 10 residential and 9 non-residential properties are at high risk (3.33% AEP). – 25 residential and 21 non-residential properties are at medium risk (1% AEP). – 71 residential and 34 non-residential properties are at low risk (0.1% AEP). **Risk to critical infrastructure in Sherington:** – 1 educational facility and 1 electricity substation are at low risk (0.1% AEP).

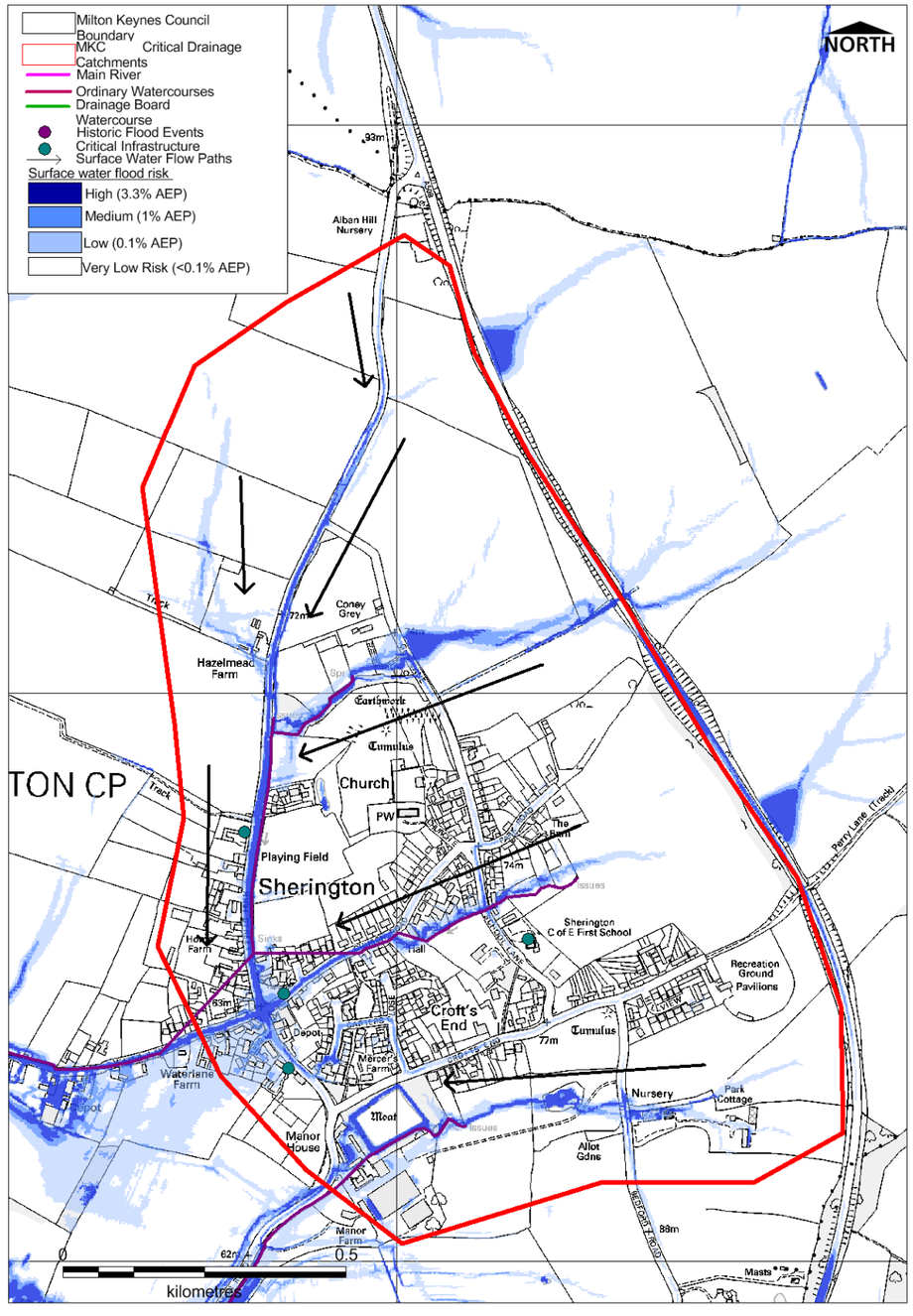

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Figure 4-4 Sherington Surface Water Flood Risk

CDC4: Woburn Sands	
Wards	Walton Park, Danesborough and Walton Park.
Flood Source	Surface water, ordinary watercourses, groundwater and sewer.
Description	Woburn Sands is located in the south-eastern extent of the borough. There is a distinct surface water flow path to the east of the CDC whilst surface water flood risk in the west of the CDC is less well defined and generally constrained to the highway network. Despite surface water flood risk generally being constrained to roads, there are some residential areas which are could be affected by surface water flooding, particularly during a 0.1% AEP event. Areas which may be at risk include: – Cul-de-sacs to the southeast of Lichfield Down; – Quilter Meadow; and, – Britten Grove. Other areas which may be affected include agricultural areas such as Old Park Farm. There are a number of historic flooding incidents. Whilst these incidents are related to fluvial flooding and sewer flooding, these sources may combine with pluvial sources to exacerbate flooding. In addition, the BGS groundwater dataset suggests that there is the potential for groundwater flooding to occur at the surface of the land.
Historical Flooding	– Fluvial flooding of properties and public park as a result of heavy rain (recorded by Bedford Group of Drainage Boards) – One instance of sewer flooding of an external property occurring in Woburn Sands (MK17 8).
Surface Water Flood Risk	**Summary of properties at risk of surface water flooding in Woburn Sands:** – 52 residential and 19 non-residential properties are at high risk (3.33% AEP). – 194 residential and 47 non-residential properties are at medium risk (1% AEP). – 769 residential and 223 non-residential properties are at low risk (0.1% AEP). **Risk to critical infrastructure in Woburn Sands:** – 3 educational facilities and 1 electricity substation are at low risk (0.1% AEP).

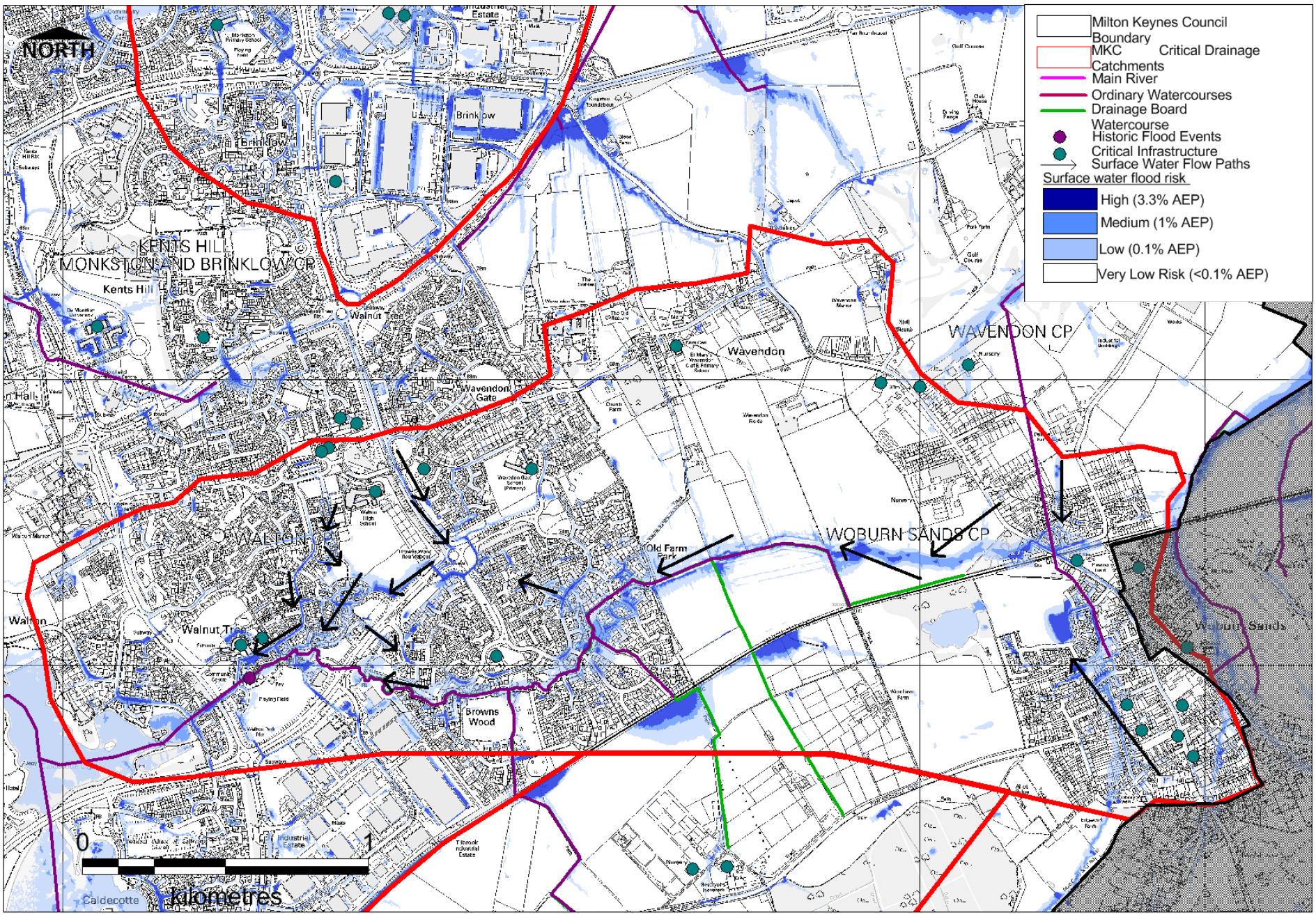

Figure 4-5 Woburn Sands Surface Water Flood Risk

CDC5: Eaglestone

Wards	Woughton and Middleton.
Flood Source	Surface water, ordinary watercourses and groundwater.
Description	Eaglestone is located in the south of the borough. The elevation in the CDC ranges from ~100mAOD in the west and declines to ~70mAOD in the east. The surface water flow paths are less defined in the west of the CDC with the majority of surface water flowing from west to east in line with the decline in elevation. Surface water is predicted to pond to the east of the hospital which is shown to be at risk of surface water flooding from the 3.3% AEP event. In addition to the hospital, the uFMfSW suggests that ponding near the B4034 is likely and that residential areas nearby may be affected. There are no historical incidents of flooding in the area. However, there are a number of other watercourses managed by MKC which may contribute to flood incidents cumulatively alongside pluvial sources of flooding. In addition, the BGS groundwater dataset suggests that there is the potential for groundwater flooding to occur at the surface of the land.
Historical Flooding	None
Surface Water Flood Risk	**Summary of properties at risk of surface water flooding in Eaglestone:** – 25 residential and 27 non-residential properties are at high risk (3.33% AEP). – 46 residential and 45 non-residential properties are at medium risk (1% AEP). – 148 residential and 89 non-residential properties are at low risk (0.1% AEP). **Risk to critical infrastructure in Eaglestone:** – 1 emergency service, 1 hospital, 1 educational facility and 1 surgery/ healthcare centre are at high risk (3.3% AEP).

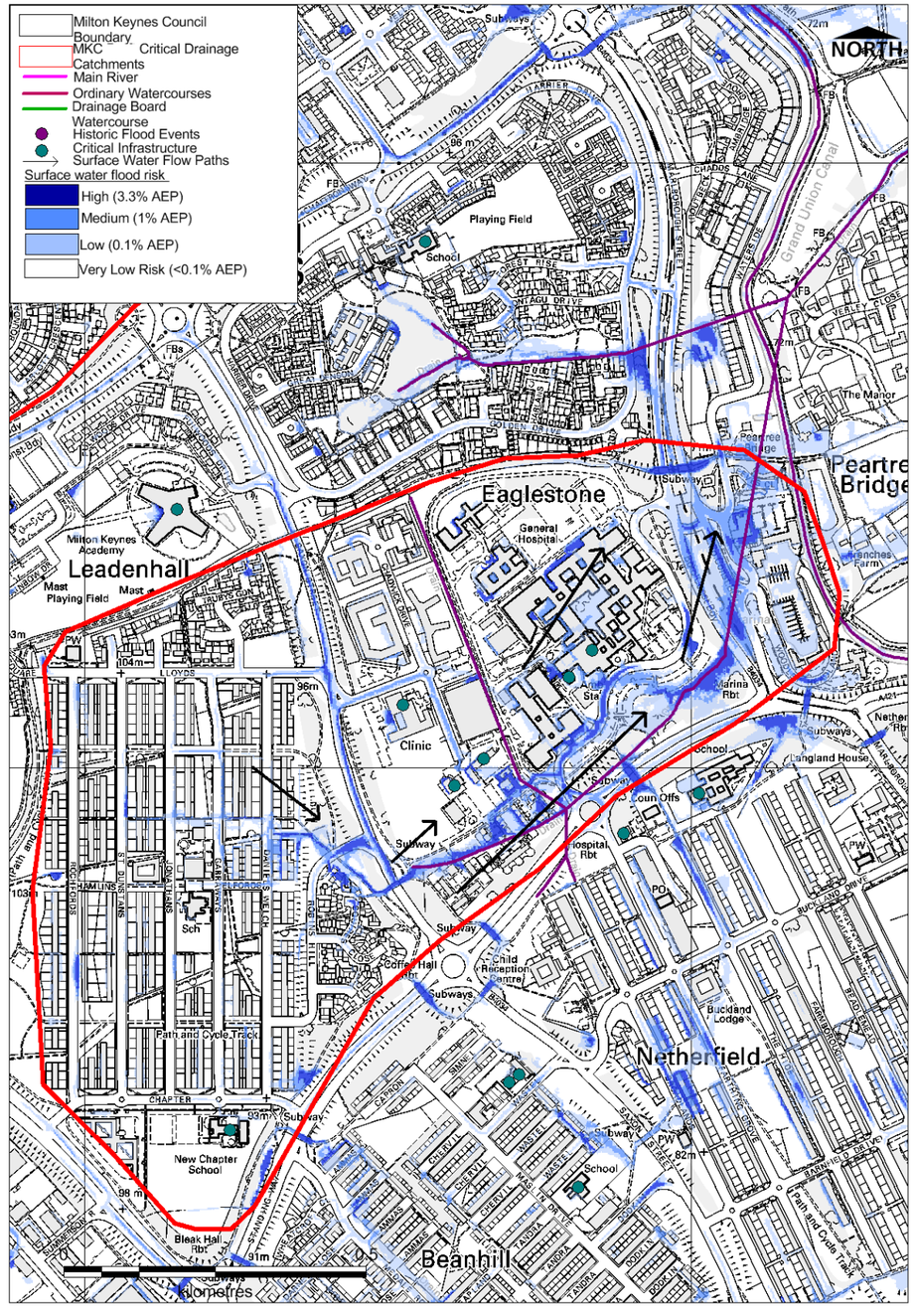

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Figure 4-6 Eaglestone Surface Water Flood Risk

CDC6: Downs Barn and Conniburrow

Wards	Statonbury, Bradwell and Linford South.
Flood Source	Surface water and groundwater.
Description	Downs Barn and Conniburrow are located in the south of the borough to the south of Springhill Brook. Elevations range from ~100mAOD in the east to ~70mAOD in the west which results in surface water flow in this direction. Surface water flow paths are poorly defined and are largely constrained to highways. However, the uFMfSW shows that there are some areas at higher risk of surface water flooding including Southwood Primary School, Mickleton and Haythorp Close. There are two small watercourses in the area which are both culverted in part. Whilst there are no historic incidents of flooding across Downs Barn and Conniburrow, surface water runoff may combine with other sources and exacerbate flooding. In addition, the BGS groundwater dataset suggests that there is the potential for groundwater flooding to occur at the surface of the land.
Historical Flooding	None
Surface Water Flood Risk	**Summary of properties at risk of surface water flooding in Downs Barn and Conniburrow:** – 88 residential and 14 non-residential properties are at high risk (3.33% AEP). – 260 residential and 27 non-residential properties are at medium risk (1% AEP). – 677 residential and 62 non-residential properties are at low risk (0.1% AEP). **Risk to critical infrastructure in Downs Barn and Conniburrow:** – 1 educational facility is at high risk (3.3% AEP).

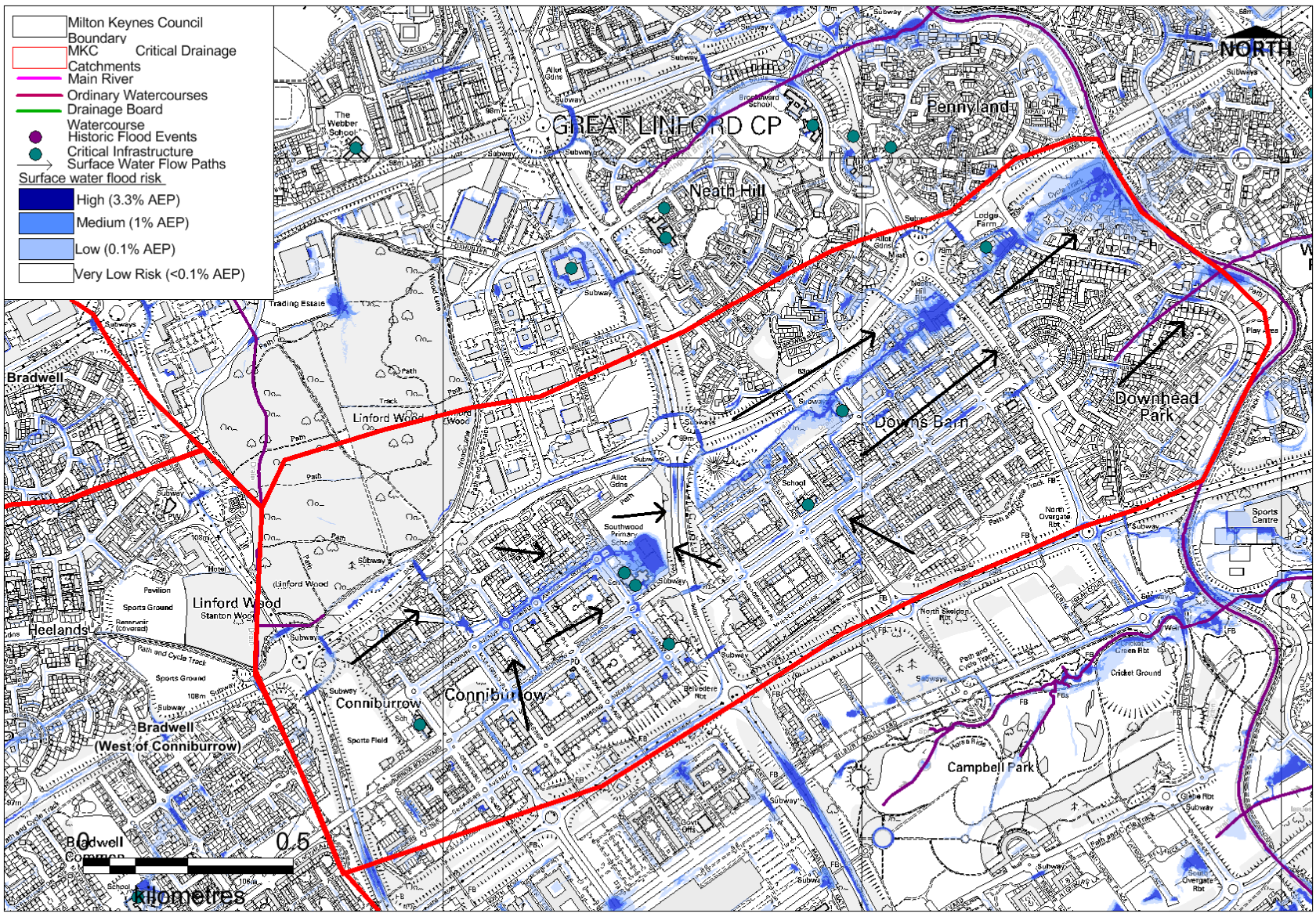

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Figure 4-7 Downs Barn and Conniburrow Surface Water Flood Risk

CDC7: Stoke Goldington	
Wards	Sherington
Flood Source	Surface water, ordinary watercourses and groundwater.
Description	Stoke Goldington is located in the northwest of the borough. LiDAR data is missing for a portion of this CDC and therefore elevations are approximate. Elevations decline from ~100mAOD in the west to ~60mAOD in the east. There are a number of well-defined surface water flow paths which follow the Hollow Brook and join the River Great Ouse. The uFMfSW shows surface water flowing across the residential area of Stoke Goldington and identifies Orchard Way and the High Street as at high risk of surface water flooding. Malting Close is another residential area shown to be at moderate to low surface water flood risk. There are a number of watercourses within the CDC which drain to the Great Ouse. There are 14 historic events of fluvial flooding associated with these watercourses. In addition, the BGS groundwater dataset suggests that there is the potential for groundwater flooding to occur at the surface of the land. In addition to these events, a historic incident of surface water flooding is recorded as a result of surface water overwhelming the drainage network which may suggest Stoke Goldington has sewer capacity issues.
Historical Flooding	– 14 records of fluvial flooding in August 1980. – One record of surface water flooding in July 1997 reported as occurring due to excess surface water runoff overwhelming the drainage system.
Surface Water Flood Risk	**Summary of properties at risk of surface water flooding in Stoke Goldington:** – 30 residential and 19 non-residential properties are at high risk (3.33% AEP). – 42 residential and 22 non-residential properties are at medium risk (1% AEP). – 74 residential and 33 non-residential properties are at low risk (0.1% AEP). **Risk to critical infrastructure in Stoke Goldington:** – No critical infrastructure shown to be at risk.

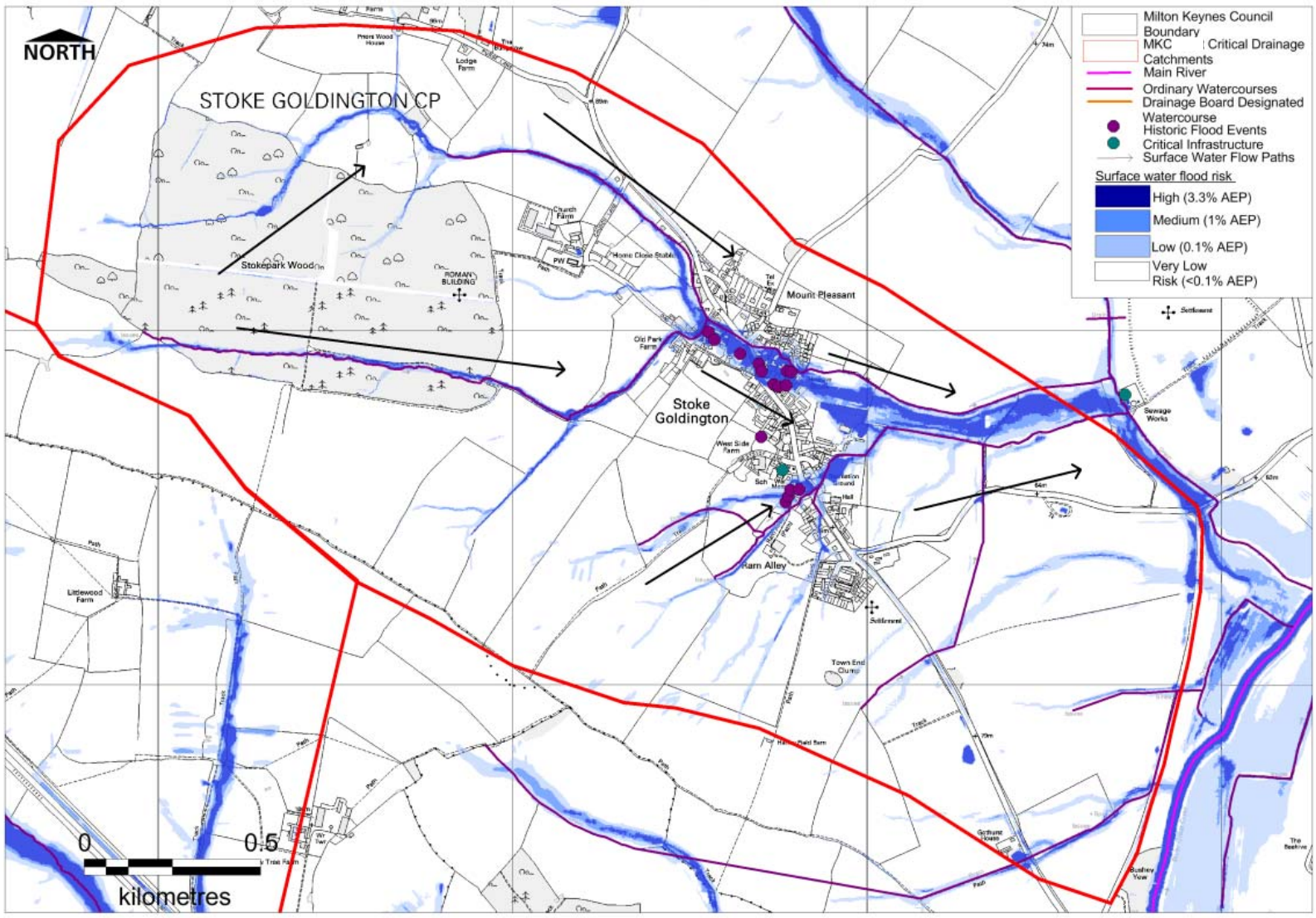

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Figure 4-8 Stoke Goldington Surface Water Flood Risk

CDC8: Newport Pagnell	
Wards	Newport Pagnell South and Newport Pagnell North.
Flood Source	Surface water, fluvial, ordinary watercourses, groundwater and sewer.
Description	Newport Pagnell is located centrally within the borough and is a relatively flat area with elevations declining from ~70mAOD in the west to ~60mAOD in the south and east. Consequently, the topography of the area is not a major contributor to surface water flooding in this area. However, there is the potential that overland flows originating from other catchments (such as Crawley and Chicheley) in the north-east of the borough may culminate in this relatively low-lying area. Typically, surface water flood risk is constrained to highways such as Caldecotte Street and Priory Street which are shown to have historic surface water flood records. However, there are residential areas including Lakes Lane and Wolverton Road which are shown to have been at risk of surface water flooding. Lakes Lane (which has experienced historical fluvial flooding) is shown to be at risk, especially for the 0.1% AEP event which may result in flooding of gardens. Along Wolverton Road, properties are shown to be at risk from the 3.3% AEP event. Newport Pagnell acts as a confluence for a number of watercourses (River Great Ouse, Tongwell Brook, Chicheley Brook and the River Ouzel) and consequently there are a number of historical fluvial flood records. These watercourses may combine with pluvial sources and exacerbate flooding. In addition, the BGS groundwater dataset suggests that there is the potential for groundwater flooding to occur at the surface of the land.
Historical Flooding	– One incident of external sewer flooding in south Newport Pagnell (MK16 0) – Two fluvial flood incidents in Lakes Lane (including one in January 2003) – Three surface water flood events occurring in September 1992 reported to have occurred se to a surface water drain surcharging. – One incident of groundwater flooding in February 2003 reported to result in a basement flooding due to high groundwater levels. – Seven fluvial flood incidents dating back to 23rd September 1992.
Surface Water Flood Risk	**Summary of properties at risk of surface water flooding in Newport Pagnell:** – 52 residential and 17 non-residential properties are at high risk (3.33% AEP). – 217 residential and 58 non-residential properties are at medium risk (1% AEP). – 1070 residential and 138 non-residential properties are at low risk (0.1% AEP). **Risk to critical infrastructure in Newport Pagnell:** – 1 emergency service is at low risk (0.1%). – 2 educational facilities are at medium risk (1% AEP) – 2 surgeries/healthcare centres are at medium risk (1% AEP) – 1 electricity substation is at low risk (0.1% AEP).

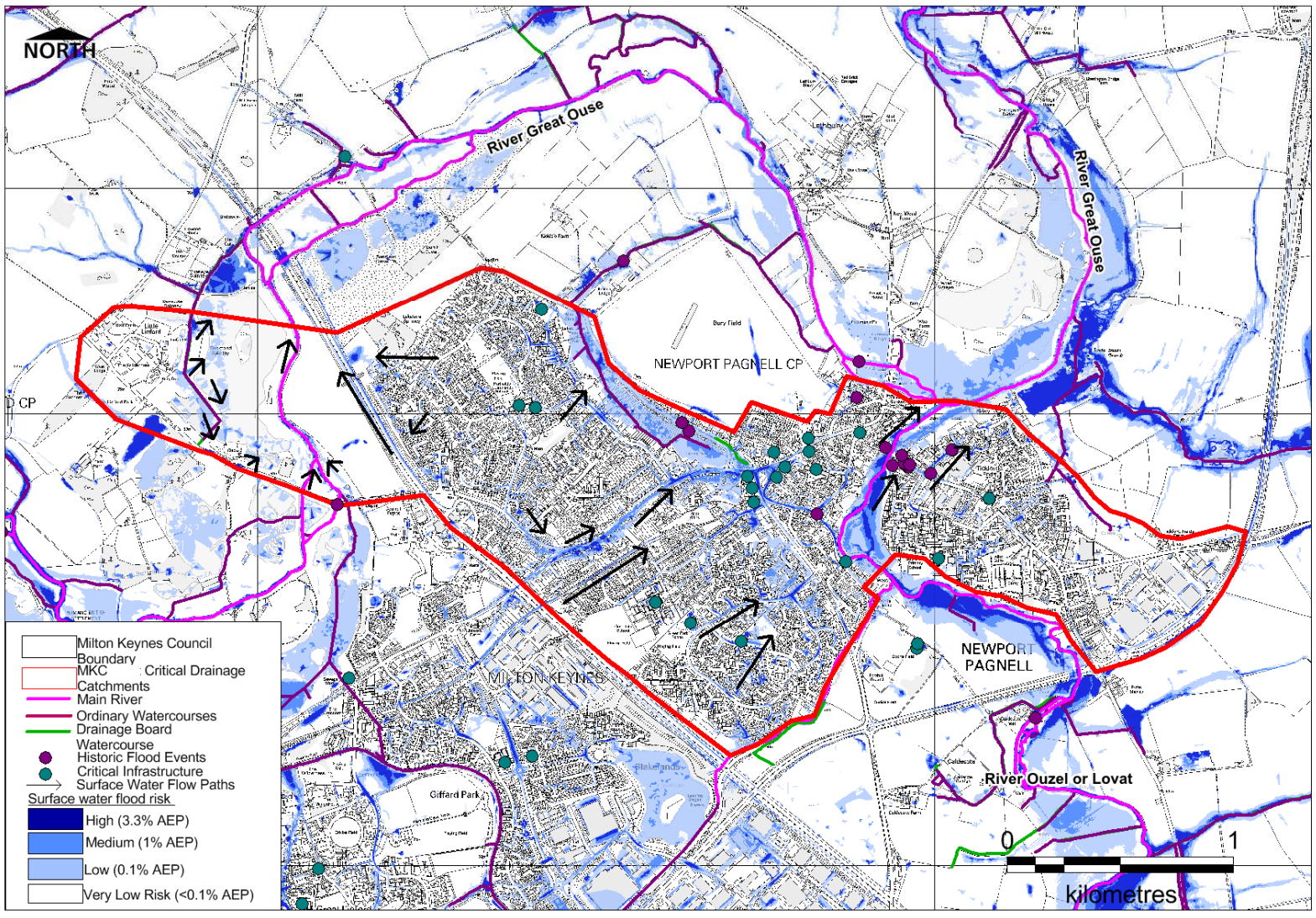

Figure 4-9 Newport Pagnell Surface Water Flood Risk

CDC9: Bletchley and Fenny Stratford

Wards	Bletchley and Fenny Stratford
Flood Source	Surface water, groundwater and sewer.
Description	Bletchley and Fenny Stratford are located in the south of the borough. Surface water flows path do not typically follow the decline in elevation from ~100mAOD in the south west to ~70mAOD in the north east due to the railway which restricts surface water flows causing ponding behind railway embankments, Consequently strong surface water flow paths are not apparent within this CDC. Surface water runoff is largely constrained to highways (many of which are shown to be at high risk) and drains to the Great Ouse located along the north eastern boundary of the CDC. The uFMfSW shows a large area of commercial land including Ward Road/Bond Avenue to be at a low risk (0.1% AEP) of surface water flooding. There are a number of recorded sewer flooding incidents in the area which may suggest a sewer capacity issue within this area. In addition, the BGS groundwater dataset suggests that there is the potential for groundwater flooding to occur at the surface of the land.
Historical Flooding	– One incident of internal sewer flooding (MK2 2) – One incident of external sewer flooding (MK1 1)
Surface Water Flood Risk	**Summary of properties at risk of surface water flooding in Bletchley and Fenny Stratford:** – 20 residential and 52 non-residential properties are at high risk (3.33% AEP). – 64 residential and 153 non-residential properties are at medium risk (1% AEP). – 341 residential and 384 non-residential properties are at low risk (0.1% AEP). **Risk to critical infrastructure in Bletchley and Fenny Stratford:** – 1 emergency service is at high risk (3.3% AEP). – 2 educational facilities are at high risk (3.3% AEP). – 1 surgery/healthcare centre is at medium risk (1% AEP). – 2 electricity substations are at medium risk (1% AEP).

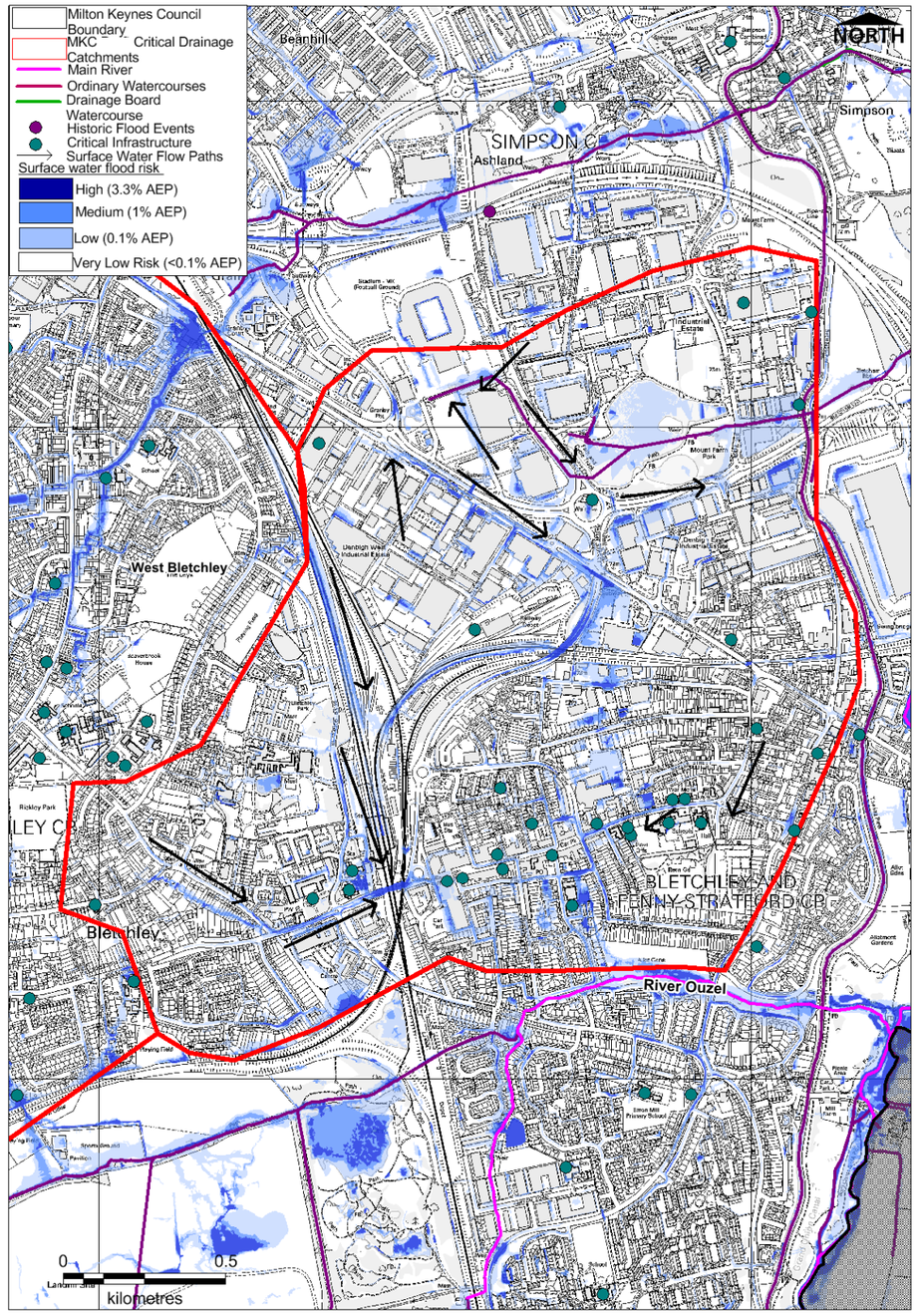

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Figure 4-10 Bletchley and Fenny Stratford Surface Water Flood Risk

CDC10: Olney	
Wards	Olney
Flood Source	Surface water and groundwater.
Description	Olney is a town in the north of the borough, close to the northern boundary of the MKC's administrative area. The area declines in elevation from west to east from ~80mAOD to ~50mAOD with the eastern extent of Olney being relatively flat. Whilst the potential for surface water flooding is widespread in Olney, flooding is predicted to be constrained within highways and there are a limited number of defined surface water flow paths. However, there are a large number of historical flooding incidents in this area. Whilst these incidents relate to groundwater, sewer and fluvial flooding, such sources of flooding may combine with surface water to exacerbate flooding. In addition, the BGS groundwater dataset suggests that there is the potential for groundwater flooding to occur at the surface of the land. The fluvial flood records are related to the Great Ouse which borders Olney to the south and the east.
Historical Flooding	– One Groundwater flood incident in June 1969 where it was reported that a well overflowed due to a high water table. – Three fluvial flood records: • March 1947 - Bowling Green was reported to be submerged; • April 1998 - Water was reported in close proximity to a property; and, • April 1998 – Flooded grounds.
Surface Water Flood Risk	**Summary of properties at risk of surface water flooding in Olney:** – 71 residential and 31 non-residential properties are at high risk (3.33% AEP). – 199 residential and 61 non-residential properties are at medium risk (1% AEP). – 586 residential and 162 non-residential properties are at low risk (0.1% AEP). **Risk to critical infrastructure in Olney:** – 1 educational facility is at high risk (3.3% AEP). – 2 surgeries/healthcare centres are at low risk 0.1% AEP). – 1 sewage treatment works is at low risk (3.3% AEP). – 1 electricity substation is at low risk (0.1% AEP).

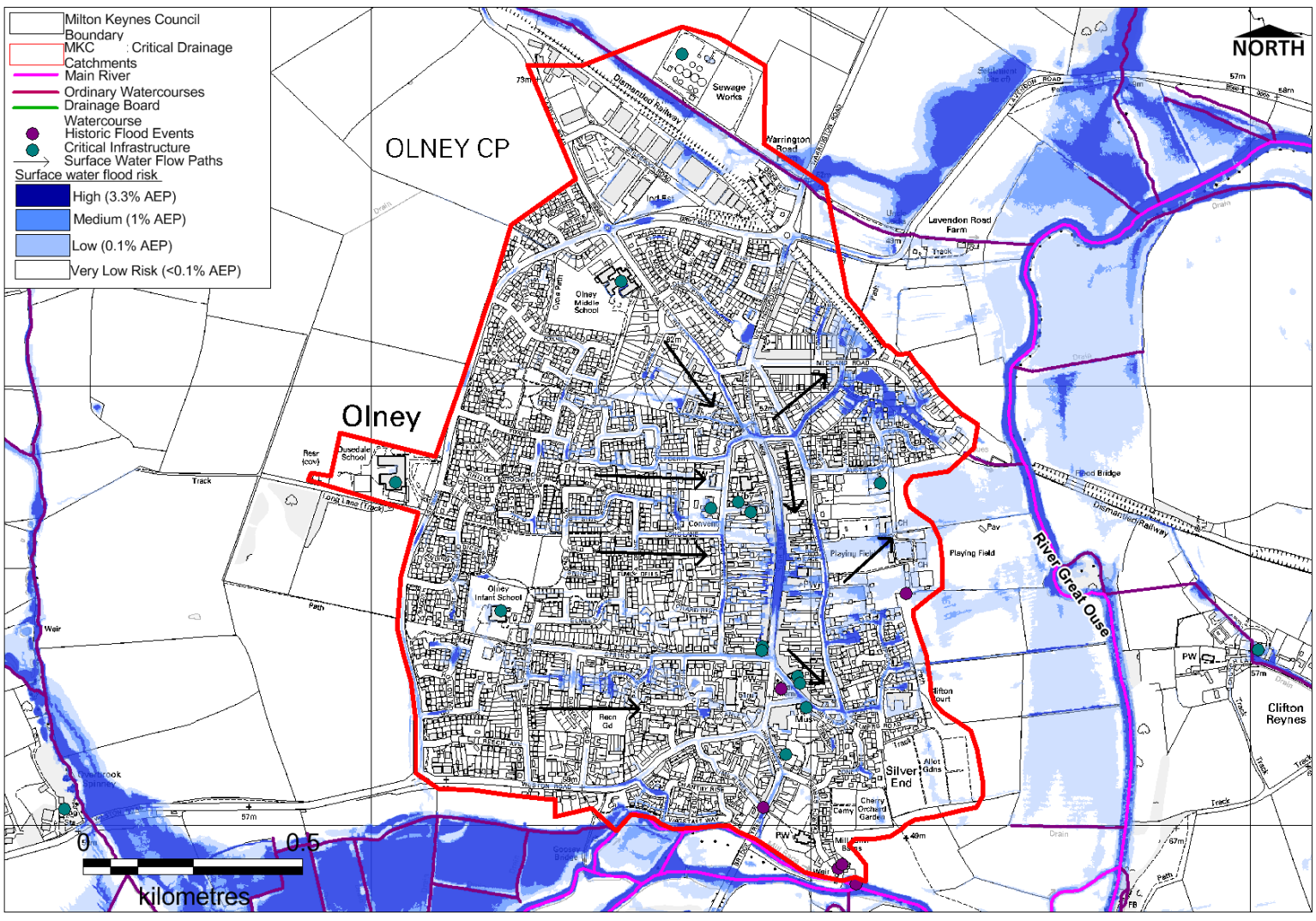

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Figure 4-11 Olney Surface Water Flood Risk

CDC11: Brinklow

Wards	Walton Park and Middleton
Flood Source	Surface water
Description	Brinklow is located in the southeast of the borough. The CDC is relatively flat yet there is a gradual decline in elevation to the north. This CDC is bordered by Broughton Brook (a Bedford Group of Drainage Boards watercourse) to the north of the CDC and a smaller, partially culverted watercourse to the east. Surface water flow paths are poorly defined and are largely confined to the highway network. Despite this, the uFMfSW identifies a number of areas which may be affected by surface water flooding, including: – The residential area of Chetwode Avenue (low risk); – Grey Friars Court commercial area (low risk); and, – Etheridge Avenue (medium risk). There is one historic incident of external sewer flooding which may indicate sewer capacity issues in the area.
Historical Flooding	– One incident of external sewer flooding (MK17 8).
Surface Water Flood Risk	**Summary of properties at risk of surface water flooding in Brinklow:** – 6 residential and 33 non-residential properties are at high risk (3.33% AEP). – 68 residential and 59 non-residential properties are at medium risk (1% AEP). – 342 residential and 133 non-residential properties are at low risk (0.1% AEP). **Risk to critical infrastructure in Brinklow:** – 1 educational facility is at medium risk (1% AEP). – 1 electricity substation is at high risk (3.3% AEP).

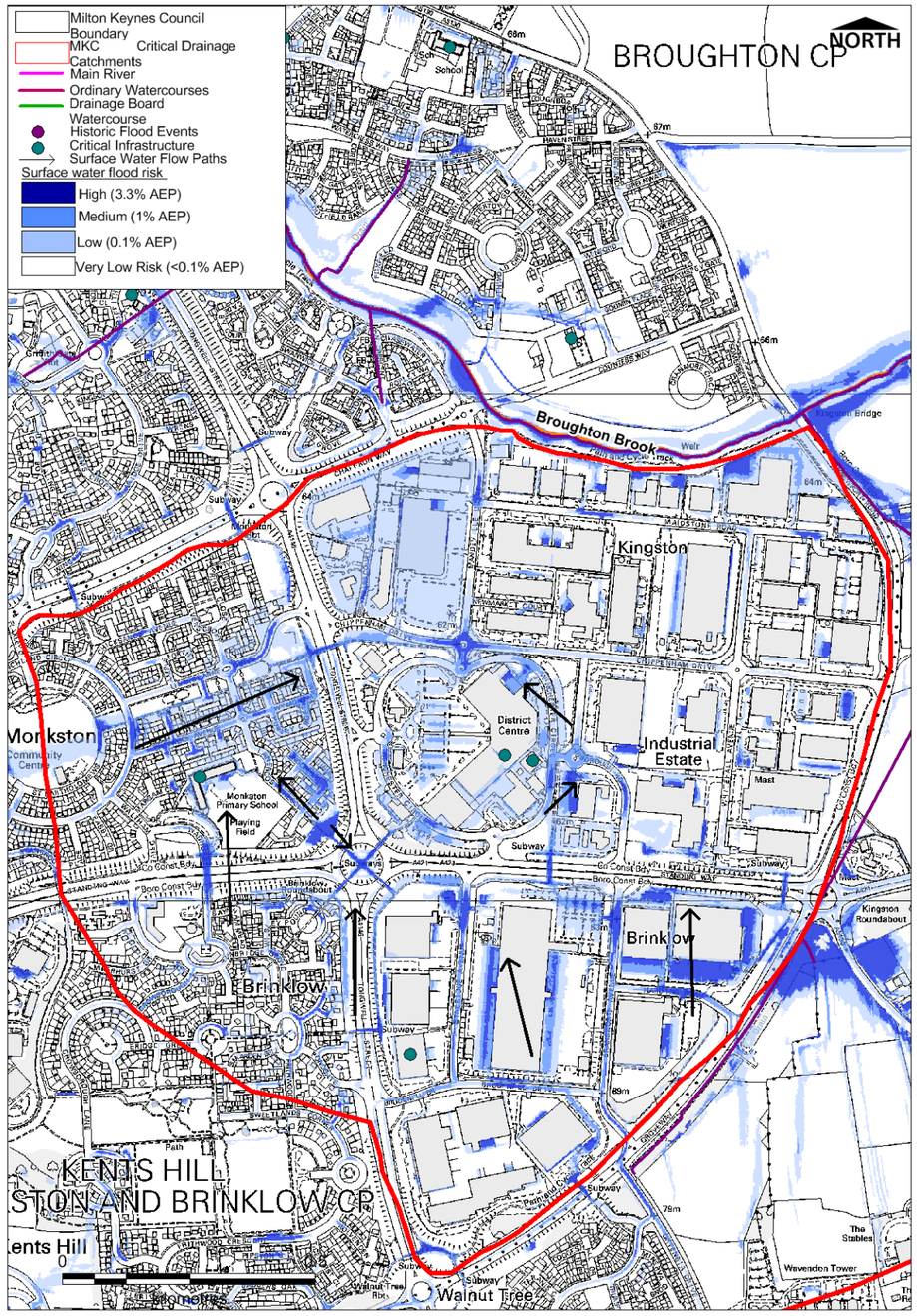

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Figure 4-12 Brinklow Surface Water Flood

CDC12: Medbourne/Crownhill	
Wards	Loughton Park and Furzton Park.
Flood Source	Surface water, ordinary watercourses and groundwater.
Description	Medbourne and Crownhill CDC is located in the southeast of the borough and declines in elevation from ~110mAOD in the southwest to ~75mAOD in the northeast. There are a number of defined surface water flow paths within the CDC in addition to smaller areas of surface water ponding which is typically constrained to the highway network. Surface water generally drains to Loughton Brook (a Bedford Group of Drainage Boards watercourse). In addition to Loughton Brook there are a number of partially culverted watercourses in the CDC. The uFMfSW shows that there are a number of residential areas potentially at risk of surface water flooding, many of which are shown to be at high risk (3.3% AEP). Residential areas which may be at risk include: – Edmund Court; – Dorsey Close; and, – Haddow Greenhill Close. In addition, the BGS groundwater dataset suggests that there is the potential for groundwater flooding to occur at the surface of the land.
Historical Flooding	There is a historical record of flooding in Holyrood Great Holm wherein water came from watercourse next to crematorium and flooded through red way underpass.
Surface Water Flood Risk	**Summary of properties at risk of surface water flooding in Medbourne/Crownhill:** – 118 residential and 39 non-residential properties are at high risk (3.33% AEP). – 193 residential and 73 non-residential properties are at medium risk (1% AEP). – 604 residential and 171 non-residential properties are at low risk (0.1% AEP). **Risk to critical infrastructure in Medbourne/Crownhill:** – 1 emergency service is at high risk (3.3% AEP). – 2 educational facilities are at high risk (3.3% AEP). – 2 surgeries/healthcare centres are at high risk (3.3% AEP). – 1 electricity substation is at high risk (3.3% AEP).

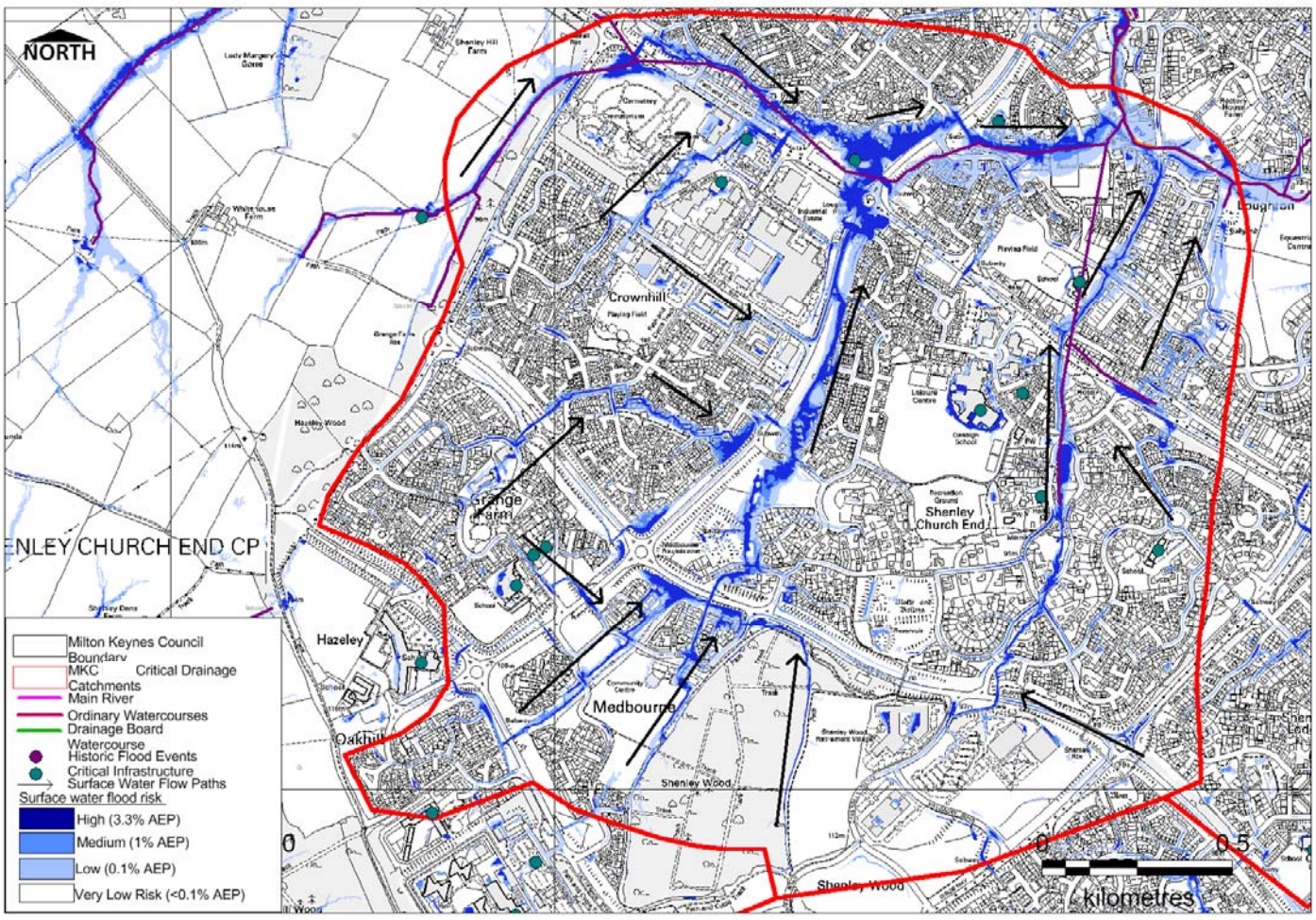

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Figure 4-13 Medbourne/Crownhill Surface Water Flood Risk

CDC13: Wymbush/ Two Mile Ash

Wards	Stony Stratford
Flood Source	Surface water and groundwater.
Description	Wymbush and Two Mile are located in the southwest of the Borough. Elevations decline from ~95mAOD in the southwest to ~70mAOD in the northeast. There are two small watercourses at the western and eastern extent of the CDC boundary and surface water drains to the Bedford Group of Drainage Boards managed watercourses on the eastern boundary of the CDC. Surface water flow paths are poorly defined within the CDC and are largely constrained to highway networks. Highways England holds data relating to a historical incident of carriageway flooding (6th July 2006). A number of large residential areas may be at high risk of surface water flooding, including Great Monks Street. Some commercial areas, including Garamonde Drive are shown to be at a high risk of surface water flooding, whilst other commercial areas, including Alston Drive, are shown to be at a low risk of surface water flooding. The BGS groundwater dataset suggests that there is the potential for groundwater flooding to occur at the surface of the land.
Historical Flooding	– One incident of flooding of the A5 carriageway on the 6th July 2006.
Surface Water Flood Risk	**Summary of properties at risk of surface water flooding in Wymbush/ Two Mile Ash:** – 52 residential and 14 non-residential properties are at high risk (3.33% AEP). – 80 residential and 28 non-residential properties are at medium risk (1% AEP). – 191 residential and 88 non-residential properties are at low risk (0.1% AEP). **Risk to critical infrastructure in Wymbush/Two Mile Ash:** – 5 commercial / industrial premises are at high risk (3.33% AEP). – 2 educational facilities are at medium risk (1% AEP).

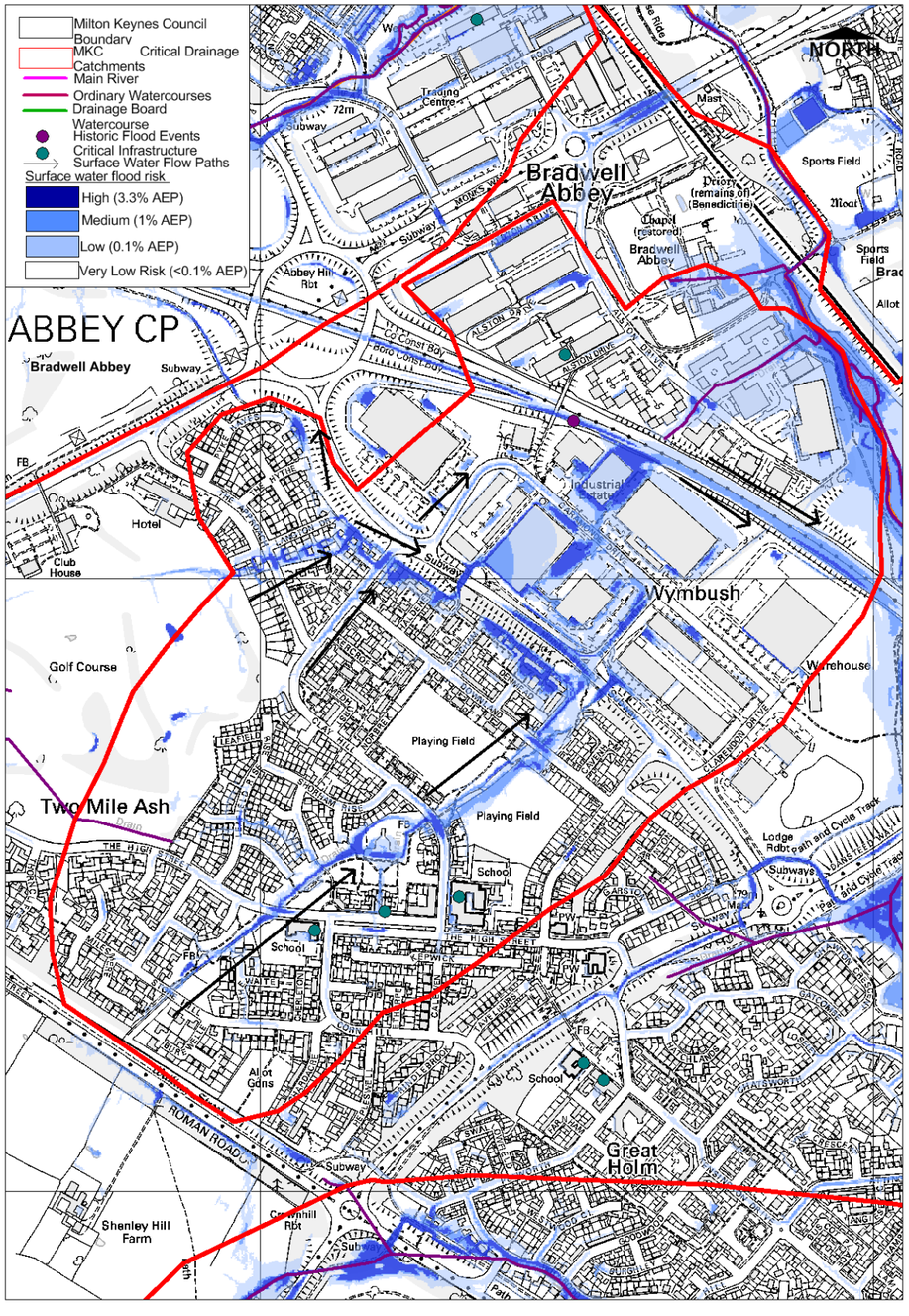

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Figure 4-14 Wymbush/ Two Mile Ash Surface Water Flood Risk

CDC14: Bradwell Abbey	
Wards	Stony Stratford and Wolverton
Flood Source	Surface water, ordinary watercourses and groundwater.
Description	Medbourne and Crownhill CDC is located in the southeast of the borough and declines in elevation from ~110mAOD in the southwest to ~75mAOD in the northeast. There are a number of defined surface water flow paths within the CDC in addition to smaller areas of surface water ponding which is typically constrained to the highway network. Surface water generally drains to Loughton Brook (a Bedford Group of Drainage Boards watercourse). Low intrusion maintenance is carried out by the IDB on this watercourse. In addition to Loughton Brook there are a number of partially culverted watercourses in the CDC. The uFMfSW shows that there are a number of residential areas potentially at risk of surface water flooding, many of which are shown to be at high risk (3.3% AEP). Residential areas which may be at risk include: – Edmund Court; – Dorsey Close; and, – Haddow Greenhill Close. In addition, the BGS groundwater dataset suggests that there is the potential for groundwater flooding to occur at the surface of the land.
Historical Flooding	None
Surface Water Flood Risk	**Summary of properties at risk of surface water flooding in Medbourne/Crownhill:** – 118 residential and 39 non-residential properties are at high risk (3.33% AEP). – 193 residential and 73 non-residential properties are at medium risk (1% AEP). – 604 residential and 171 non-residential properties are at low risk (0.1% AEP). **Risk to critical infrastructure in Medbourne/Crownhill:** – 1 emergency service is at high risk (3.3% AEP). – 2 educational facilities are at high risk (3.3% AEP). – 2 surgeries/healthcare centres are at high risk (3.3% AEP). – 1 electricity substation is at high risk (3.3% AEP).

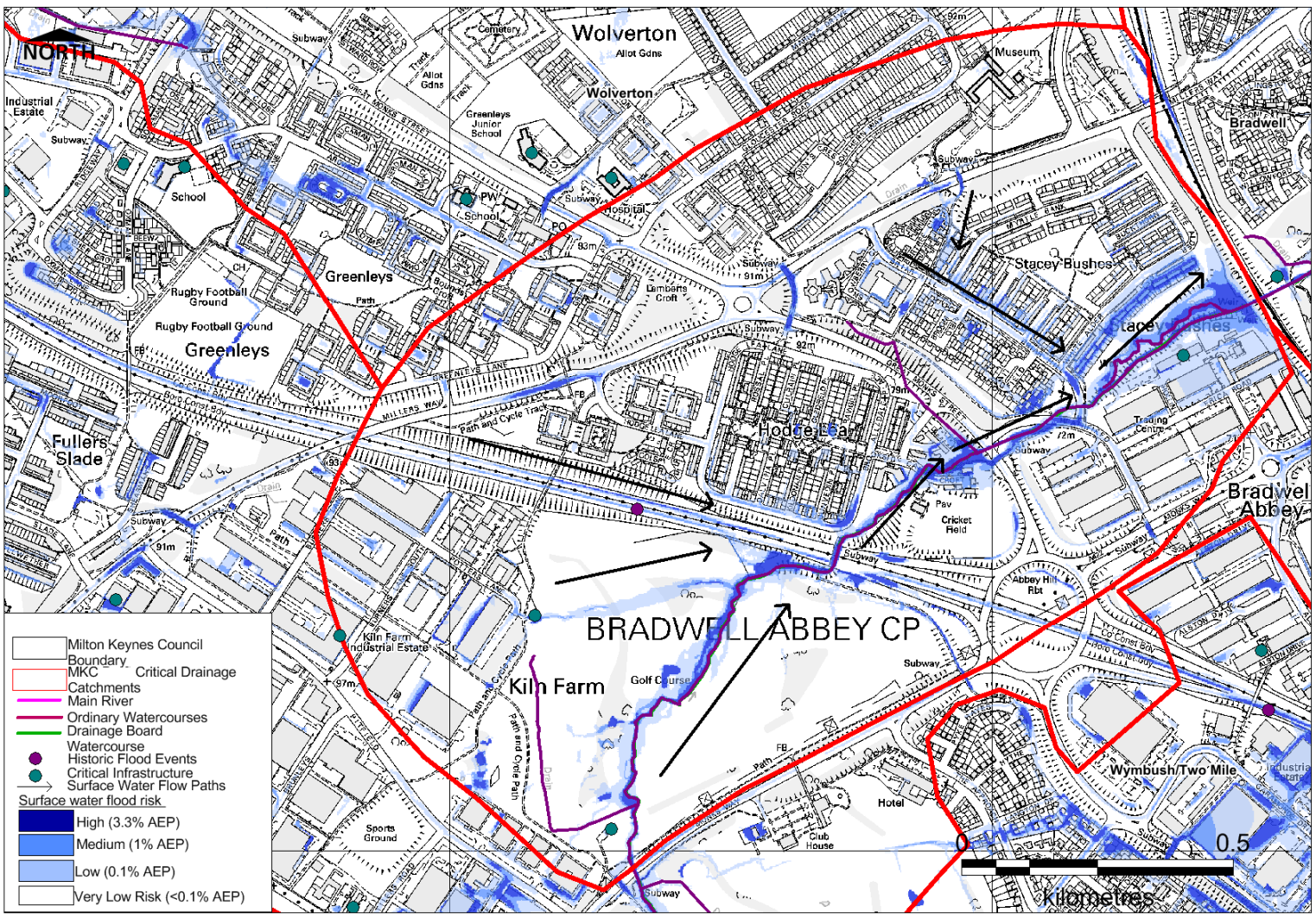

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Figure 4-15 Bradwell Abbey Surface Water Flood Risk

CDC15: Stony Stratford

Wards	Stony Stratford.
Flood Source	Surface water, fluvial, groundwater and sewer.
Description	Stony Stratford is a town located at the western extent of the borough which declines in elevation from ~90mAOD to ~65mAOD from the southeast to northwest. The majority of historic records of flooding in this area are attributed to fluvial flooding relating to the Great Ouse which is located to the north and west of the CDC. Other flood records relating to groundwater and highways flooding are also recorded in the area. The BGS groundwater dataset suggests that there is the potential for groundwater flooding to occur at the surface of the land. The uFMfSW identifies a number of areas which are at risk of surface water flooding. Typically flood risk is constrained to highway routes; however there are also residential areas which may be at risk such as The Limes and Park Road. Multiple residential properties may to be at risk in this area, some of which will be affected by a 3.3% AEP event. Calverton Road Cemetery, which borders properties on Park Road, is also shown to be at risk of surface water flooding for the 1% and 0.1% AEP event.
Historical Flooding	– One internal incident of sewer flooding (MK11 1) – One groundwater flooding incident in April 1998. – Seven fluvial flood records – six on 21st July 2007 and one on April 1998. – One highway flooding incident on 20th July 2007 reported as standing water on the carriageway – One record of fluvial flooding at Stony Stratford Mill which was reported as being associated with the River Great Ouse.
Surface Water Flood Risk	**Summary of properties at risk of surface water flooding in Stony Stratford:** – 34 residential and 4 non-residential properties are at high risk (3.33% AEP). – 119 residential and 16 non-residential properties are at medium risk (1% AEP). – 408 residential and 82 non-residential properties are at low risk (0.1% AEP). **Risk to critical infrastructure in Stony Stratford:** – No critical infrastructure shown to be at risk.

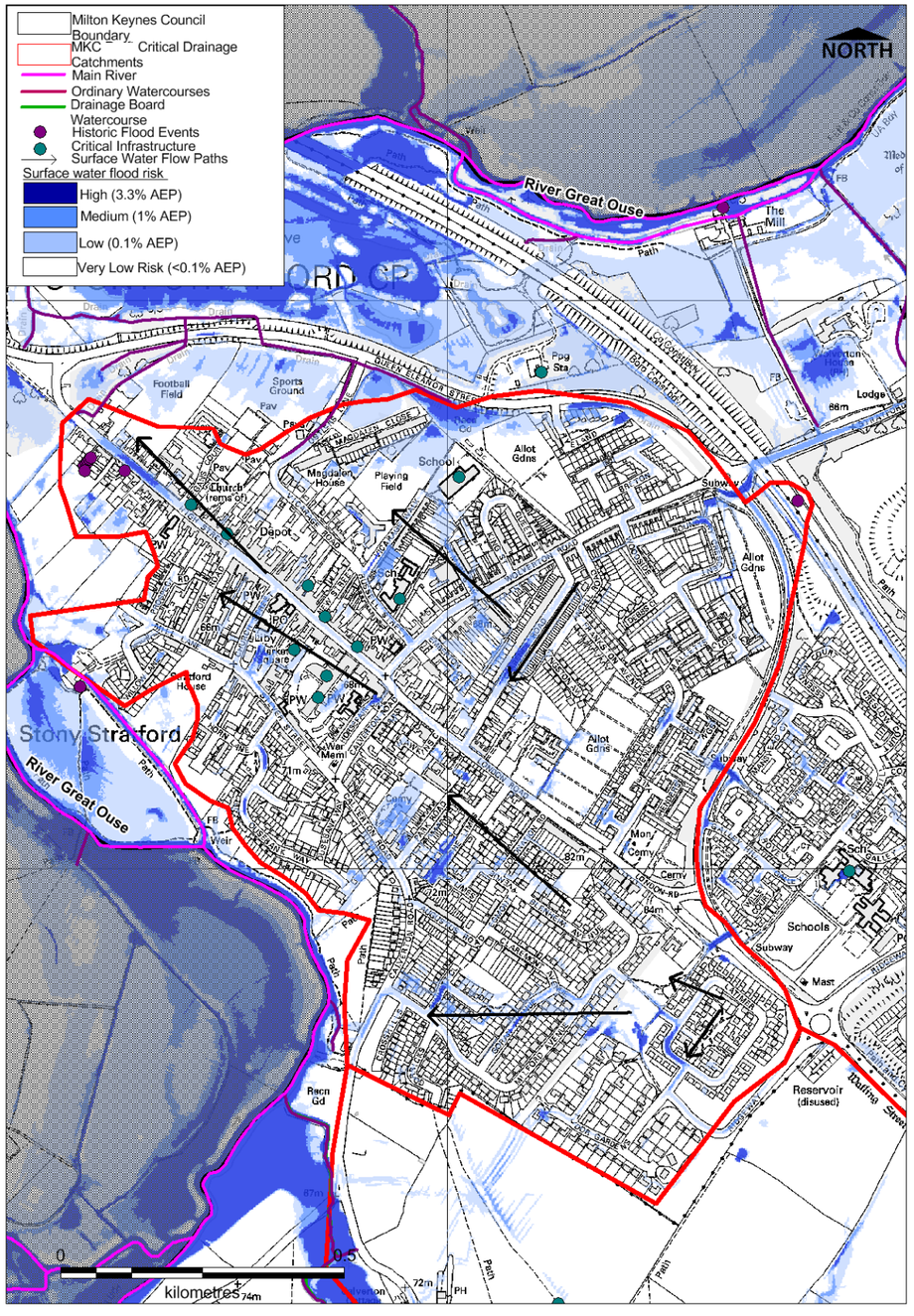

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Figure 4-16 Stony Stratford Surface Water Flood Risk

CDC16: Wolverton	
Wards	Wolverton
Flood Source	Surface water and groundwater.
Description	Wolverton is located towards the western extent of MKC's administrative boundary. Elevations decline from ~90mAOD in the south to ~65m AOD in the north. The surface water flow paths are poorly defined with the majority of surface water flooding being constrained to highway networks (many of which are shown to be at high risk). Surface water ponding is predicted to occur in the CDC between Stratford Road and Old Wolverton Road. There are a number of watercourses in the area including the Grand Union Canal and a small drain of the Great Ouse. The majority of surface water runoff drains to the River Great Ouse which is to the north of the CDC. The BGS groundwater dataset suggests that there is the potential for groundwater flooding to occur at the surface of the land.
Historical Flooding	There is a historical record of flooding in Stratford Road outside of the Craufurd Arms Public House. In response to this Anglian Water have installed a flood relief storm water carrier drain.
Surface Water Flood Risk	**Summary of properties at risk of surface water flooding in Wolverton:** – 21 residential and 24 non-residential properties are at high risk (3.33% AEP). – 86 residential and 56 non-residential properties are at medium risk (1% AEP). – 389 residential and 175 non-residential properties are at low risk (0.1% AEP). **Risk to critical infrastructure in Wolverton:** – 2 educational facilities are at high risk (3.3% AEP). – 1 surgery/healthcare centre is at moderate risk (1% AEP). – 1 electricity substation is at high risk (3.3% AEP).

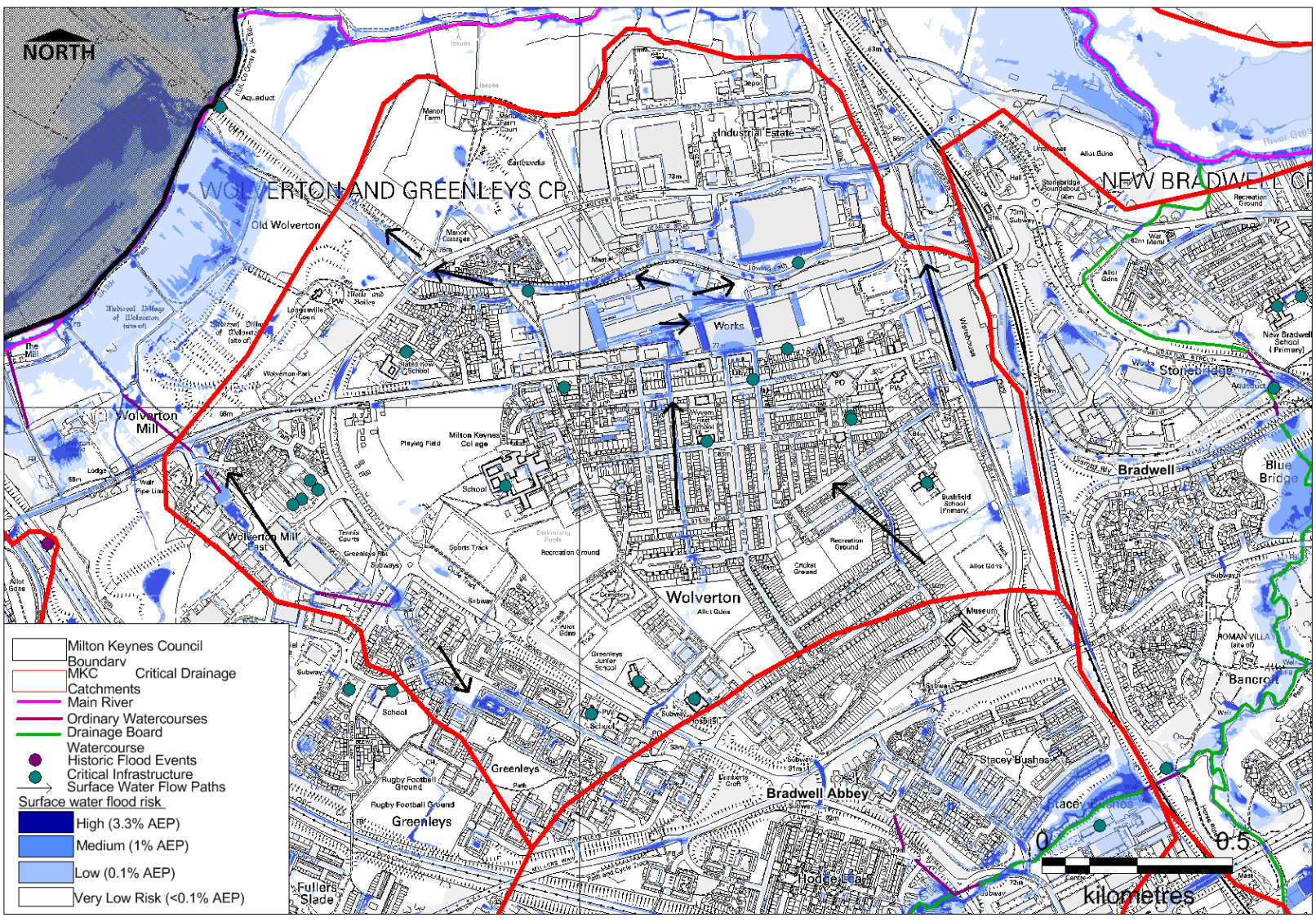

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Figure 4-17 Wolverton Surface Water Flood Risk

CDC17: Oldbrook

Wards	Campbell Park
Flood Source	Surface water and groundwater.
Description	The Milton Keynes Oldbrook CDC is located in the south of the borough. Elevations decline from ~100mAOD in the northeast to ~80mAOD in the southwest. Surface water flow paths are poorly defined and are mainly confined to highway networks. Surface water tends to pond to the western extent of the CDC and is constrained behind the railway embankment. The uFMfSW identifies a number of areas which may be at risk of surface water flooding, including: – Hutton Avenue; – Shackleton Place; – Boycott Avenue; – Milburn Avenue; – Wardle Place; – Douglas Place; – Grace avenue; – Snowdon Drive; and, – Cairngorm Gate. There are no watercourses within the area. The BGS groundwater dataset suggests that there is the potential for groundwater flooding to occur at the surface of the land.
Historical Flooding	None
Surface Water Flood Risk	**Summary of properties at risk of surface water flooding in Oldbrook:** – 149 residential and 10 non-residential properties are at high risk (3.33% AEP). – 339 residential and 33 non-residential properties are at medium risk (1% AEP). – 714 residential and 78 non-residential properties are at low risk (0.1% AEP). **Risk to critical infrastructure in Oldbrook:** – 1 educational facility is at high risk (3.3% AEP).

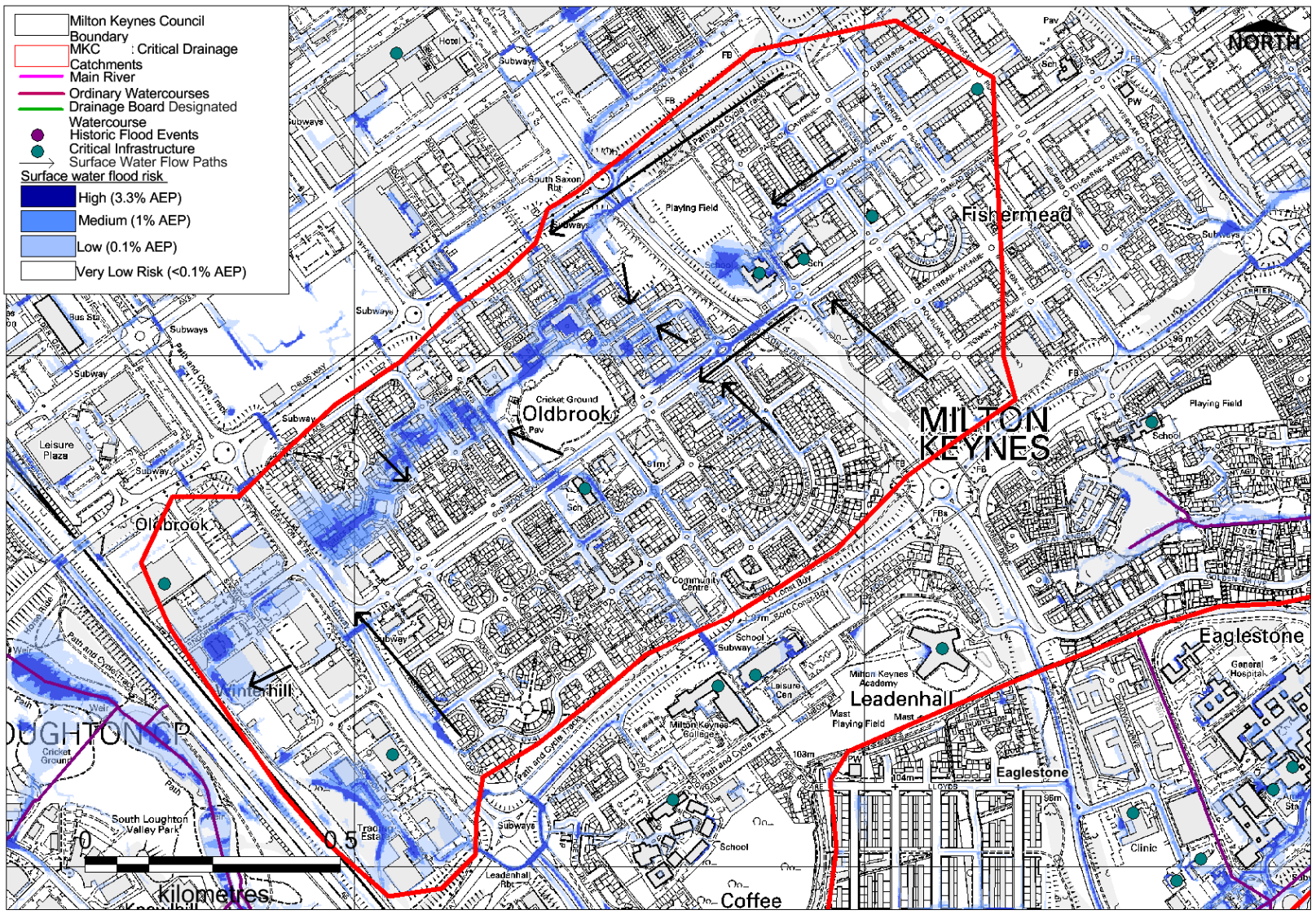

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Figure 4-18 Oldbrook Surface Water Flood Risk

CDC18: Bradwell (west of Conniburrow)	
Wards	Statonbury and Bradwell.
Flood Source	Surface water and groundwater.
Description	Bradwell (West of Conniburrow) is located in the south of the borough and declines in elevation from ~100mAOD in the east to ~80mAOD in the west. There is one watercourse within the CDC which is a small drain and a tributary of the larger Bedford Group of Drainage Boards watercourse to the east of the CDC. Surface water drains to these two watercourses. Surface water flow paths are poorly defined within this CDC and surface water runoff is generally confined to highway networks. Despite this there are a number of areas which may experience surface water ponding such as Coleshill Place and the school near Bradwell Common. The BGS groundwater dataset suggests that there is the potential for groundwater flooding to occur at the surface of the land.
Historical Flooding	None
Surface Water Flood Risk	**Summary of properties at risk of surface water flooding in Bradwell (West of Conniburrow):** – 44 residential and 24 non-residential properties are at high risk (3.33% AEP). – 105 residential and 56 non-residential properties are at medium risk (1% AEP). – 310 residential and 175 non-residential properties are at low risk (0.1% AEP). **Risk to critical infrastructure in Bradwell (West of Conniburrow):** – 1 educational facility is shown to be at high risk (3.3% AEP).

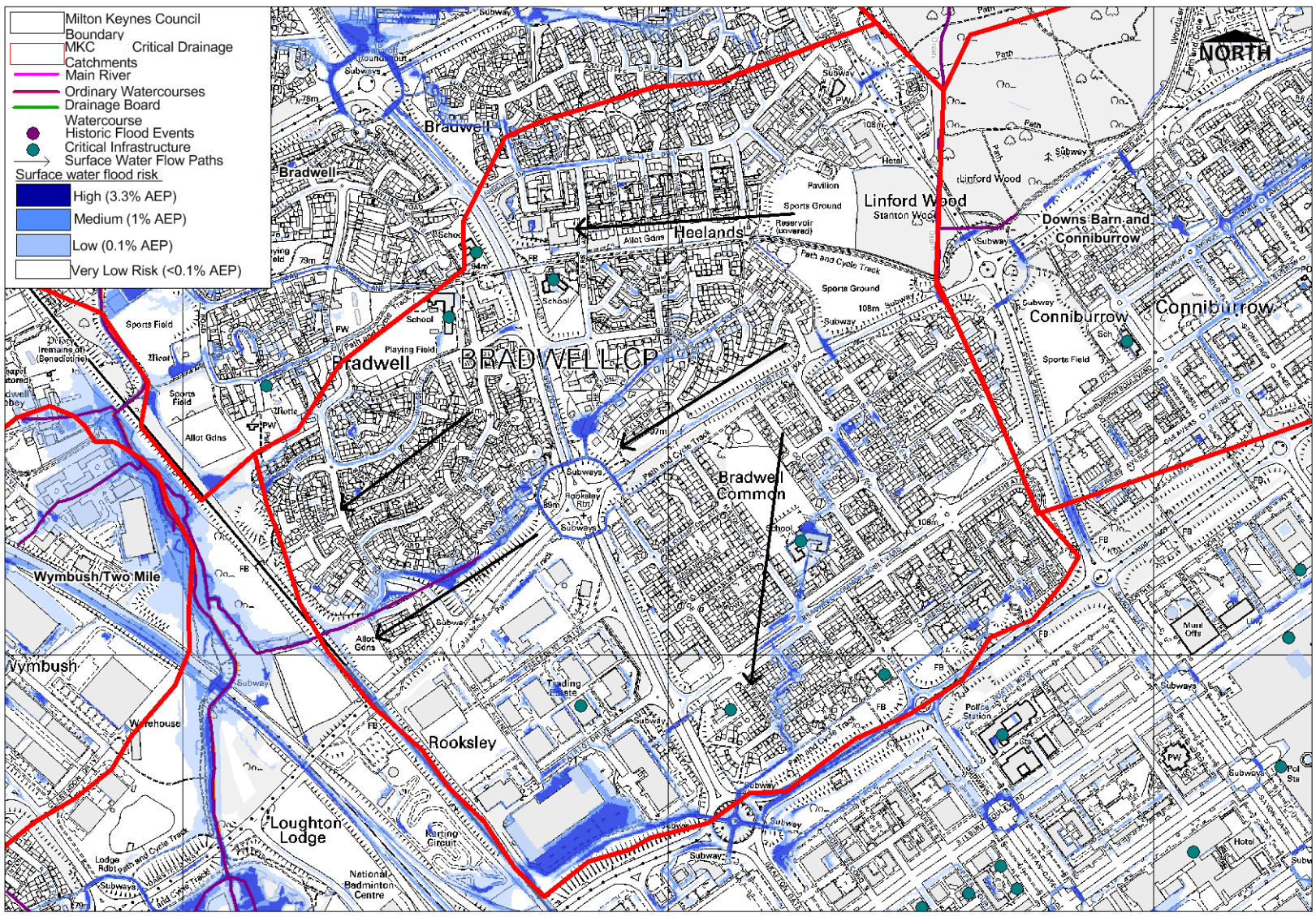

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Figure 4-19 Bradwell (West of Conniburrow) Surface Water Flood Risk

CDC19: Bradwell	
Wards	Statonbury and Bradwell.
Flood Source	Surface water and groundwater.
Description	Bradwell (West of Conniburrow) is located in the south of the borough and declines in elevation from ~100mAOD in the east to ~80mAOD in the west. There is one watercourse within the CDC which is a small drain and a tributary of the larger Bedford Group of Drainage Boards watercourse to the east of the CDC. Surface water drains to these two watercourses. Surface water flow paths are poorly defined within this CDC and surface water runoff is generally confined to highway networks. Despite this there are a number of areas which may experience surface water ponding such as Coleshill Place and the school near Bradwell Common. The BGS groundwater dataset suggests that there is the potential for groundwater flooding to occur at the surface of the land.
Historical Flooding	None
Surface Water Flood Risk	**Summary of properties at risk of surface water flooding in Bradwell (West of Conniburrow):** – 44 residential and 24 non-residential properties are at high risk (3.33% AEP). – 105 residential and 56 non-residential properties are at medium risk (1% AEP). – 310 residential and 175 non-residential properties are at low risk (0.1% AEP). **Risk to critical infrastructure in Bradwell (West of Conniburrow):** – 1 educational facility is shown to be at high risk (3.3% AEP).

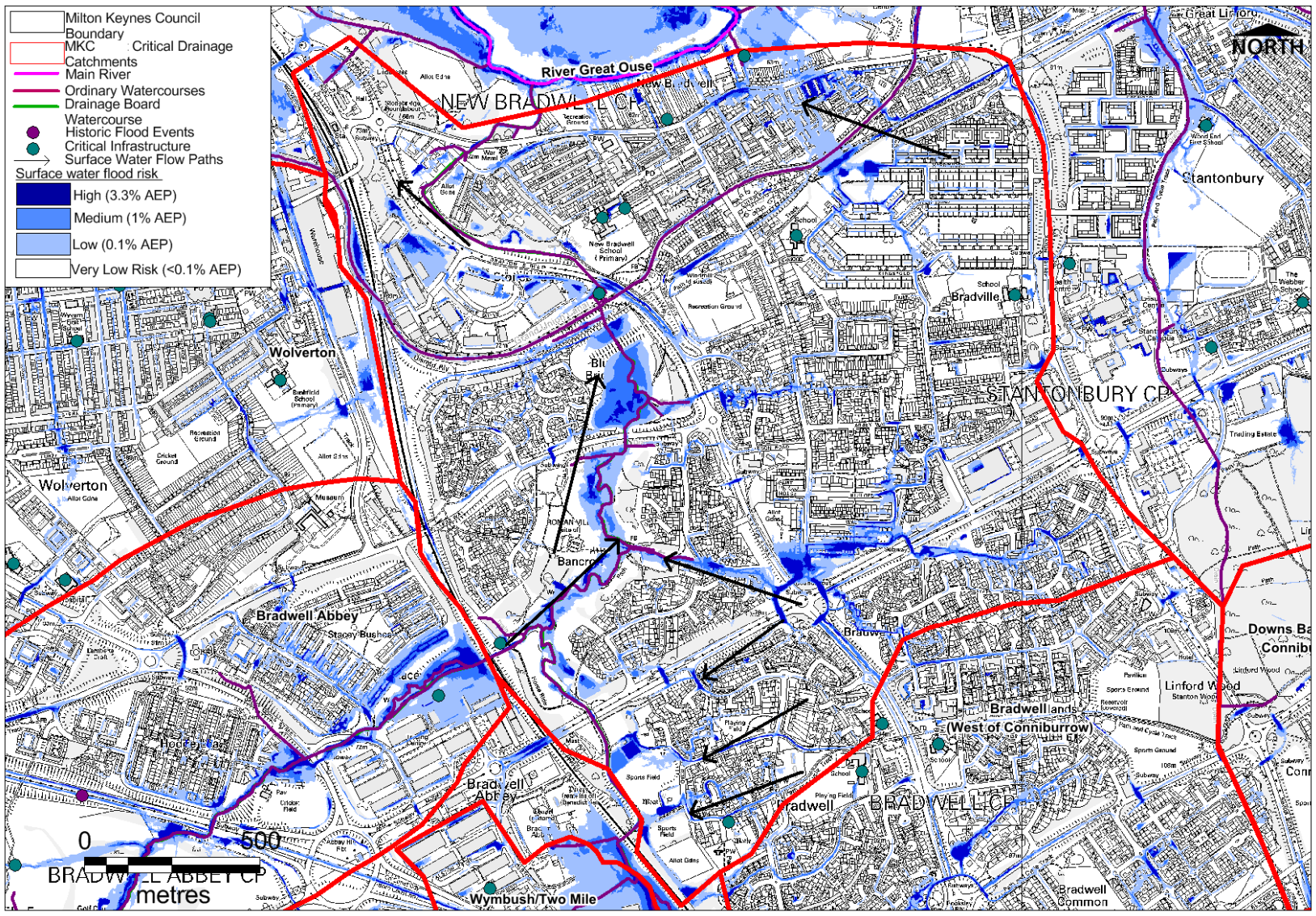

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Figure 4-20 Bradwell Surface Water Flood Risk

CDC20: West Bletchley	
Wards	Loughton Park, Furzton, Emerson Valley, Denbigh, Whaddon and Bletchley and Fenny Stratford.
Flood Source	Surface water, sewer, ordinary watercourses and groundwater.
Description	West Bletchley is a large CDC in the south of the borough which has relatively high elevations ranging from ~120mAOD to ~80mAOD in the river valleys. This CDC has three well defined surface water flow paths which are constrained to the river valley floodplains and drain to Furzton Lake. In addition to Furzton Lake there are a number of watercourses within the area including Loughton Brook and a number of other smaller watercourses. These watercourses may combine with pluvial sources to exacerbate flooding. There are a number of residential areas in West Bletchley which may be affected by surface water flooding, many of which are identified as being at high risk by the uFMfSW, including: – Sunningdale Way; – Severn Way; – Nottingham Grove; – Berwick Drive; – The residential area between Calluna Drive and Melrose Avenue; – Morebath Grove; – Bletchley Road; and, – Wolfescote Road. In addition, the BGS groundwater dataset suggests that there is the potential for groundwater flooding to occur at the surface of the land.
Historical Flooding	– One external incident of sewer flooding (MK3 6)
Surface Water Flood Risk	**Summary of properties at risk of surface water flooding in West Bletchley:** – 299 residential and 65 non-residential properties are at high risk (3.33% AEP). – 717 residential and 120 non-residential properties are at medium risk (1% AEP). – 2377 residential and 304 non-residential properties are at low risk (0.1% AEP). – **Risk to critical infrastructure in West Bletchley:** – 2 emergency services are shown to be at low risk (0.1% AEP) – 8 educational facilities are shown to be at high risk (3.3% AEP) – 1 surgery/healthcare centre is shown to be at high risk (3.3% AEP) – 1 sewage treatment works is shown to be at medium risk (1% AEP); – 1 electricity substation is shown to be at medium risk (1% AEP).

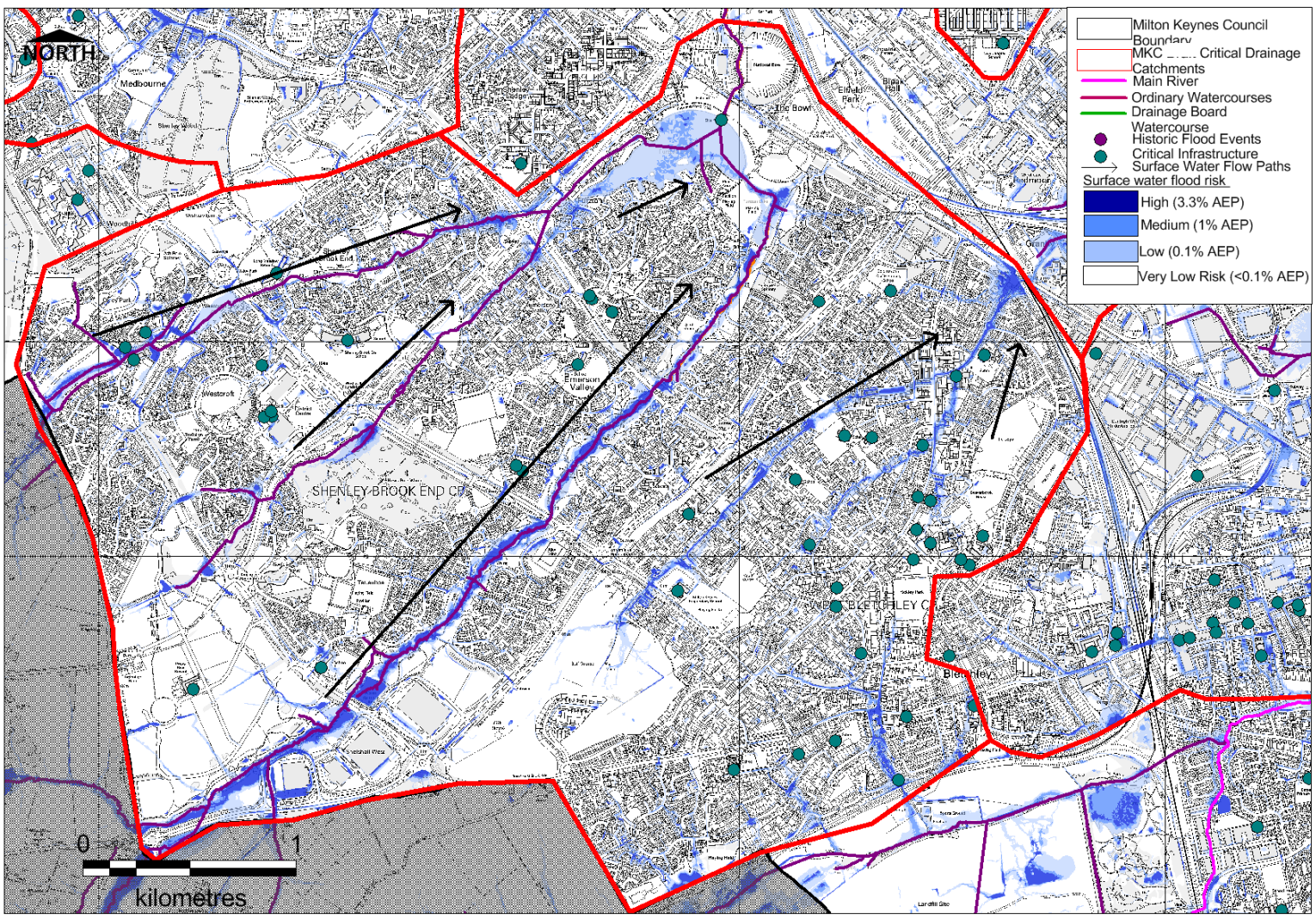

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Figure 4-21 West BletchleySurface Water Flood Risk

CDC21: Tathall End

Ward	Danesborough
Flood Source	Surface water, ordinary watercourses and fluvial flooding.
Description	Tathall End is a rural area, located to the north of the borough in close proximity to Stoke Goldington. The direction of surface water flows are generally in a south-easterly direction, following the floodplain of the ordinary watercourses within this CDC. As surface water flows are generally confined to floodplains they are typically well-defined. There is only one incident of historic flooding within this CDC related to fluvial flooding in 1973 in Tathall End village. There are very few residential areas within the CDC which limits the risk of surface water flooding. Tathall End village is shown to be at the highest risk of surface water flooding.
Historical Flooding	– One record of fluvial flooding in 1973.
Surface Water Flood Risk	**Summary of properties at risk of surface water flooding in Tathall End:** – 6 residential and 7 non-residential properties are at high risk (3.33% AEP). – 8 residential and 11 non-residential properties are at medium risk (1% AEP). – 20 residential and 18 non-residential properties are at low risk (0.1% AEP). **Risk to critical infrastructure in Tathall End:** – No critical infrastructure shown to be at risk.

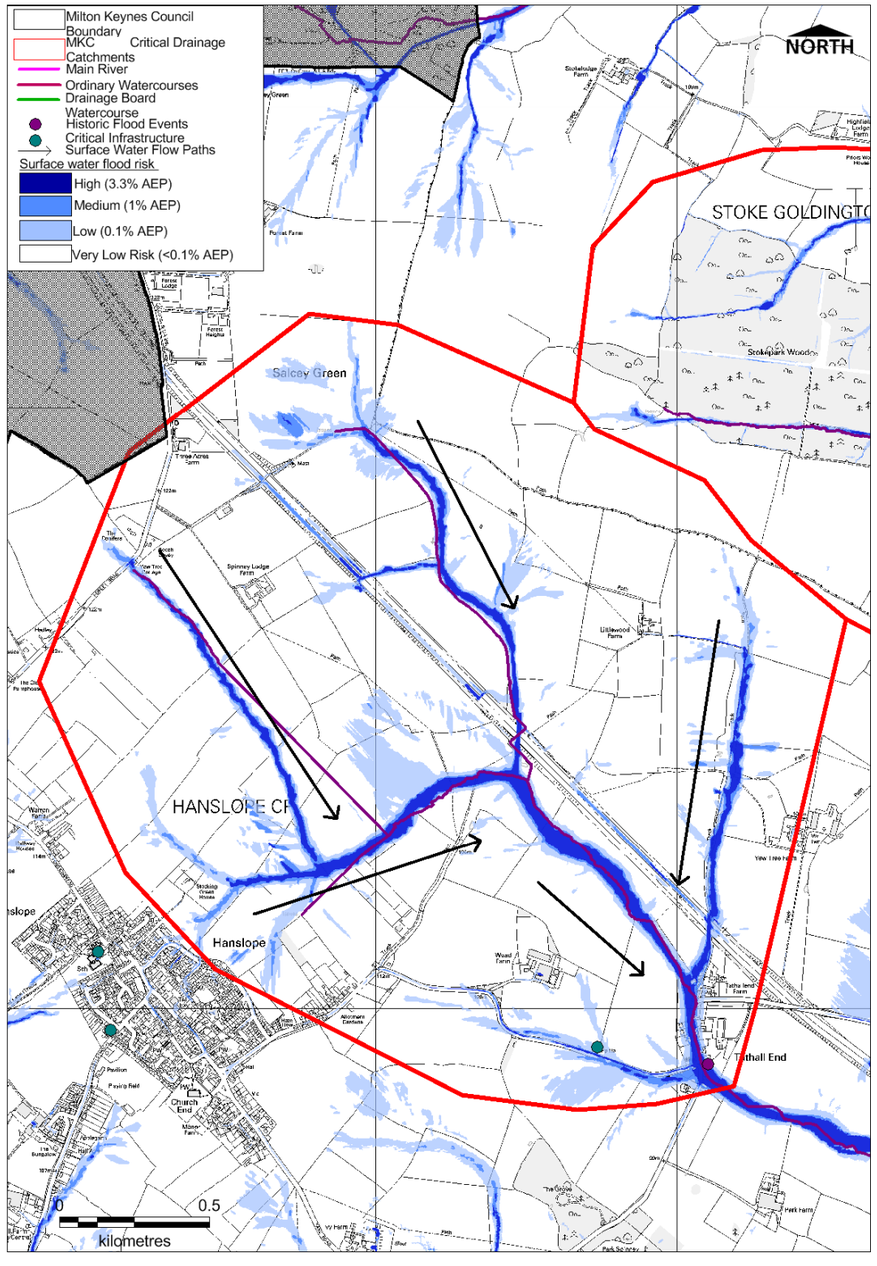

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Figure 4-22 Tathall End Surface Water Flood Risk

CDC22: Calverton

Wards	Stony Stratford
Flood Source	Surface water and ordinary watercourses.
Description	Calverton is a rural area located near the western extent of the borough and is bordered to the west by a tributary of the Great Ouse which is managed by the Bedford Group of Drainage Boards. At Lower Weald there is a confluence between this watercourse and another watercourse which flows from east to west to the north of the CDC. The topography of the area is varied with elevations of ~100mAOD in the east, declining to ~70mAOD in the west. Consequently, surface water ponding occurs in areas such as Lower Weald as a result of surface water flow paths following the decline in elevation. Surface water flow paths are largely constrained to the floodplains of the ordinary watercourses previously mentioned. This therefore limits the potential for surface water flooding to both residential areas and critical infrastructure. The residential area of Lower Weald is shown to be at greatest risk of surface water flooding within the CDC, along with farmland.
Historical Flooding	– One incident of flooding to low-lying houses located at Lower Weald, reportedly due to heavy rainfall.
Surface Water Flood Risk	**Summary of properties at risk of surface water flooding in Calverton:** – 11 residential and 5 non-residential properties are at high risk (3.33% AEP). – 11 residential and 7 non-residential properties are at medium risk (1% AEP). – 15 residential and 15 non-residential properties are at low risk (0.1% AEP). **Risk to critical infrastructure in Calverton:** – No critical infrastructure shown to be at risk.

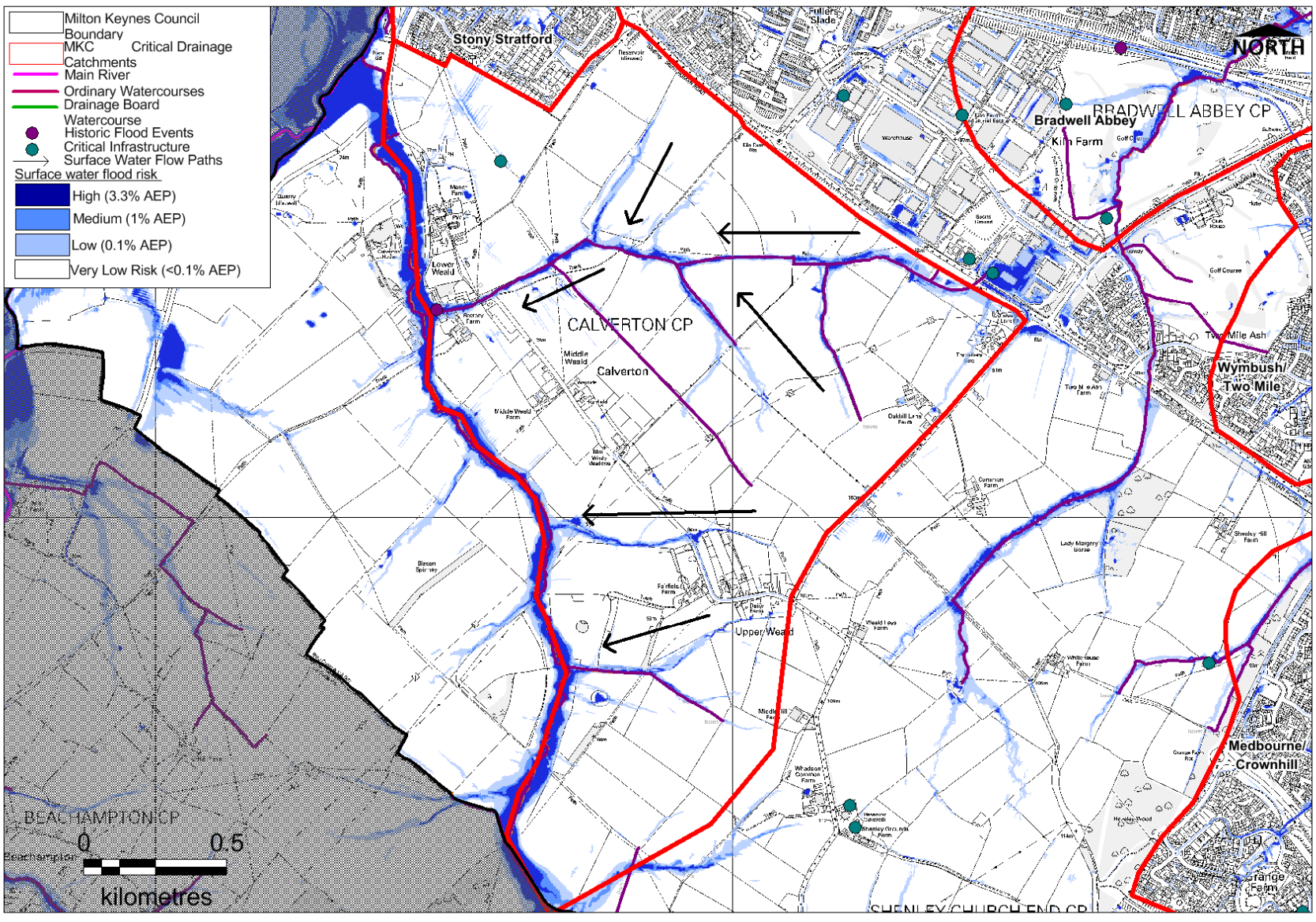

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Figure 4-23 CalvertonSurface Water Flood Risk

CDC23: Bow Brickhill	
Wards	Danesborough
Flood Source	Surface water and ordinary watercourses.
Description	Bow Brickhill is a rural area located towards the eastern extent of the borough, in close proximity to Woburn Sands. This CDC comprises a step decline in elevation from ~155mAOD in the south-east of the CDC to ~65mAOD to the west of the CDC. Consequently, surface water generally flows from east to west which is predicted to result in surface water ponding in areas near Fenny Stratford. Ponding is may also occur behind the railway embankment which constrains surface water flows. Across this CDC, there are very few residential areas which are shown to be at risk of surface water flooding. Whilst there are no incidents of historic flooding within the CDC, Highways England hold a record of highways flooding near Cross Roads Farm where an underpass reportedly flooded in 2006 due to a blocked ditch. Cross Roads Farm is located on the boundary of the CDC at the north-western extent. There are a number of watercourses within the area, some of which are managed by the Bedford Group of Drainage Boards.
Historical Flooding	None
Surface Water Flood Risk	**Summary of properties at risk of surface water flooding in Bow Brickhill:** – 14 residential and 5 non-residential properties are at high risk (3.33% AEP). – 26 residential and 7 non-residential properties are at medium risk (1% AEP). – 45 residential and 14 non-residential properties are at low risk (0.1% AEP). **Risk to critical infrastructure in Bow Brickhill:** – 1 educational facility is shown to be at low risk of surface water flood risk (0.1%AEP).

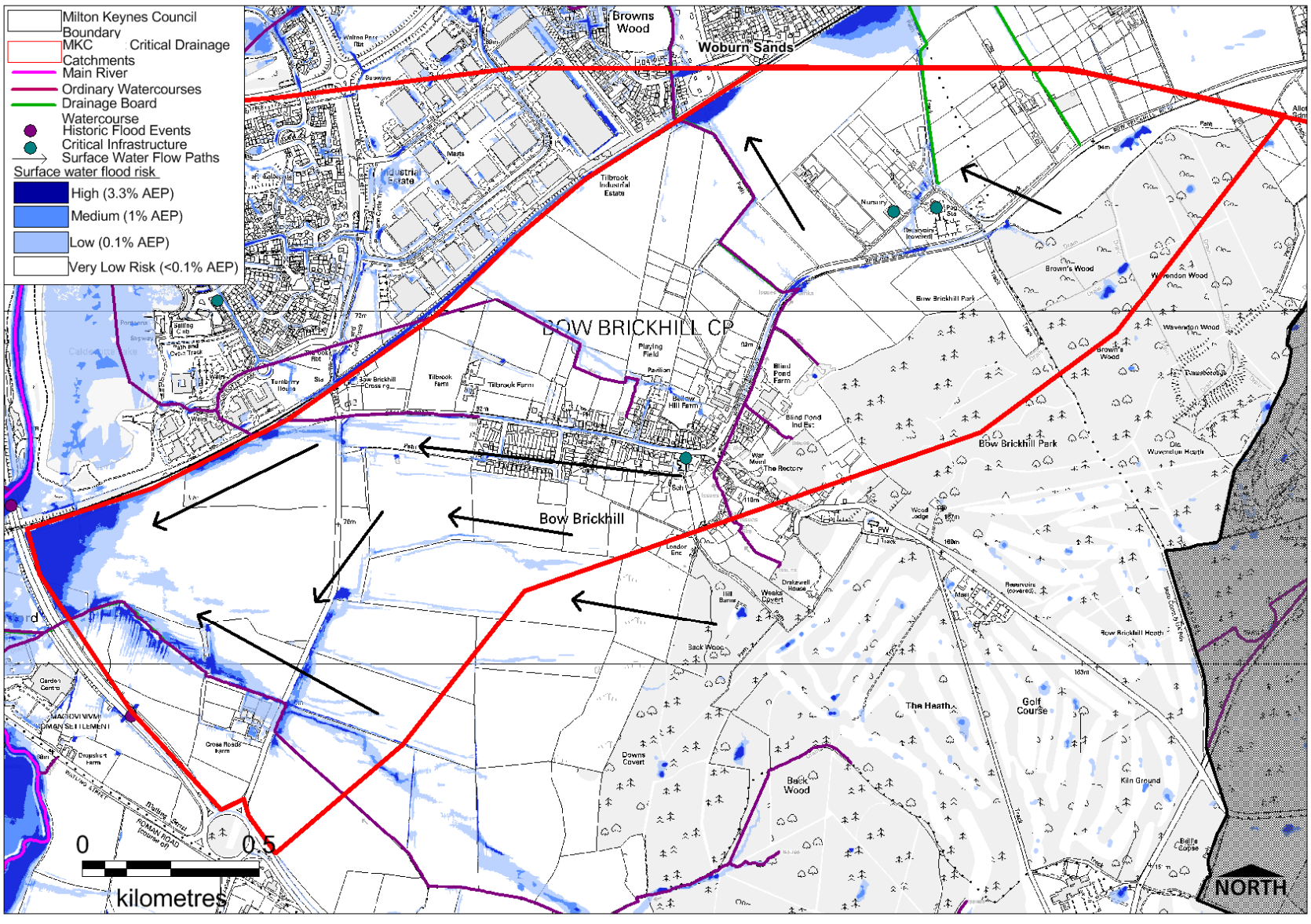

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Figure 4-24 Bow BrickhillSurface Water Flood Risk

CDC24: Haversham

Wards	Hanslope Park
Flood Source	Surface water and ordinary watercourses.
Description	Haversham is a sparsely populated rural area located centrally within the borough, to the south-west of Newport Pagnell. The topography of the area is characterised by a steep decline in elevation from ~100mAOD in the north and west of the CDC declining to ~60mAOD in the east and south. Consequently, surface water flow paths typically flow from the north to the south of the CDC, resulting in an increased risk of surface water flooding in areas including the High Street. In addition to the surface water flood risk in the east of the CDC, the residential area of Wolverton Road (to the west of the CDC) may also be at a high risk of surface water flooding, though surface water flows are largely constrained to highways in this area. There are three watercourses within this CDC, two of which are managed by the Bedford Group of Drainage Boards and one which forms a short tributary of the River Ouse.
Historical Flooding	None
Surface Water Flood Risk	**Summary of properties at risk of surface water flooding in Haversham:** – 14 residential and 5 non-residential properties are at high risk (3.33% AEP). – 26 residential and 7 non-residential properties are at medium risk (1% AEP). – 45 residential and 14 non-residential properties are at low risk (0.1% AEP). **Risk to critical infrastructure in Haversham:** – 1 surgery/healthcare centre is at a low risk (0.1% AEP).

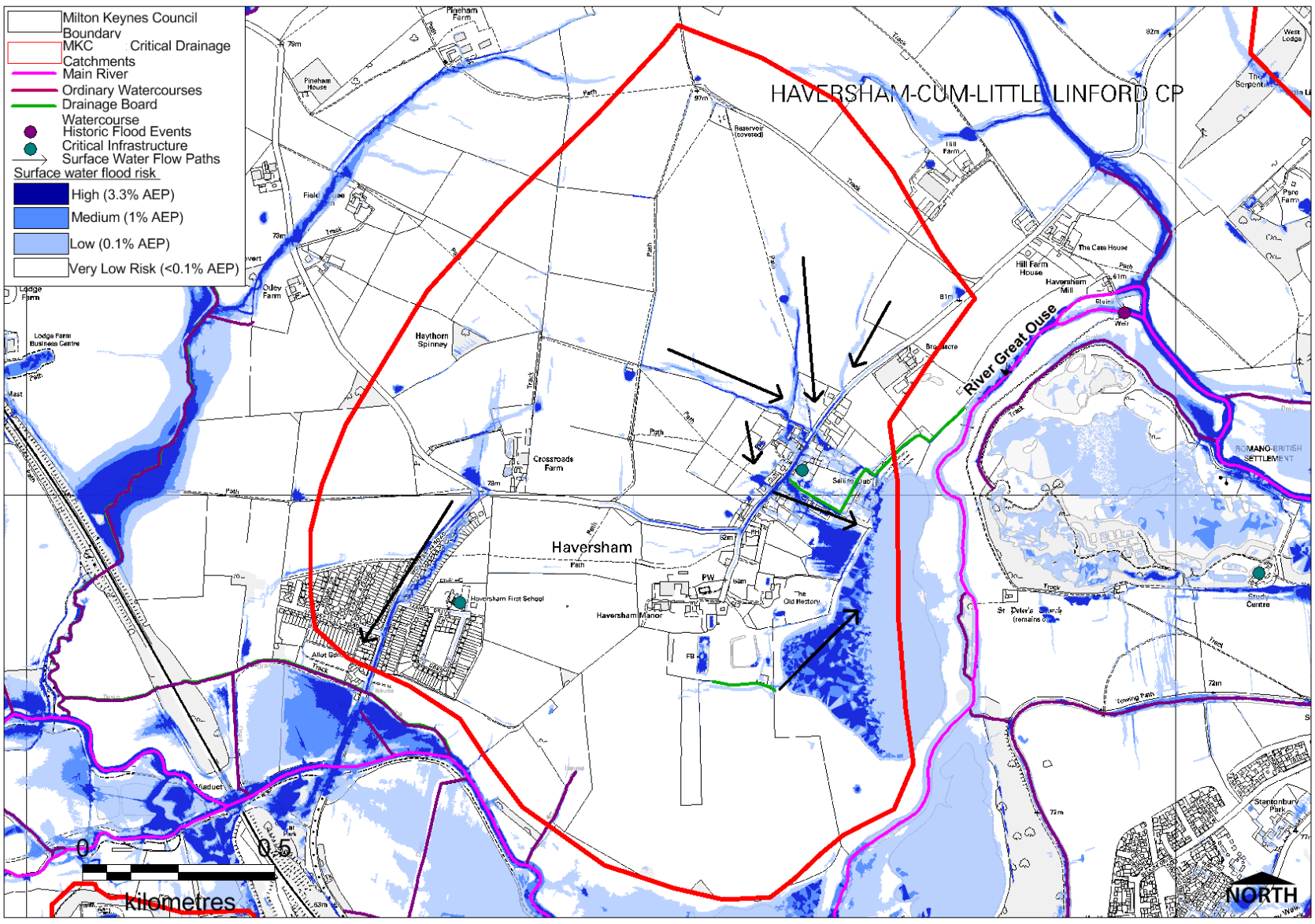

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Figure 4-25 HavershamSurface Water Flood Risk

5 Summary of Risk

5.1 Overview of Flood Risk within Milton Keynes

The results of the Phase 2 risk assessment combined with a site visit and a detailed review of existing data and historical flood records indicates that there is a significant risk of surface water flooding within Milton Keynes Borough. Although flood risks are widely dispersed across the borough (as demonstrated by the number and distribution of the identified CDCs), surface water flood risk is greatest to the south of the borough. This is due in part to the urbanised nature of the area where infiltration of surface water into the ground due is reduced due to impermeable surfaces. There are also more localised issues such as those relating to drainage and the containment of waters behind railway embankments and within subways.

One of the major flood risks in Milton Keynes is the potential for cumulative flooding as a result of fluvial and pluvial sources. Whilst fluvial flooding is largely related to main rivers such as the Ouse, smaller ordinary watercourses within the borough which perform an important local drainage function can also contribute to flooding. Other sources of flooding identified within the borough include groundwater and sewers.

5.2 Risk to Existing Properties and Infrastructure

The surface water flood depth and flood hazard maps for Milton Keynes Borough for the 3.3% AEP, 1% AEP and 0.1% AEP events (based on the uFMfSW dataset) are presented in Appendix A.9a-f.

Table 5-15-2 summarises the number of properties across Milton Keynes Borough at low, medium and high risk of surface water flooding by vulnerability classification and property type.

Table 5-15-2 Properties and infrastructure at risk from surface water flooding by NPPF vulnerability classification

NPPF Vulnerability Classification	Property Type	Risk		
		High (3.3% AEP)	Medium (1% AEP)	Low (0.1% AEP)
Essential Infrastructure	Sewage Treatment	2	4	5
	Electricity Infrastructure	3	8	25
	Subtotal	*5*	*12*	*30*
Highly Vulnerable	Fire / Ambulance	4	5	9
	Subtotal	*4*	*5*	*9*
More Vulnerable (excluding residential)	Residential	1753	4692	15161
	School / University / College	29	53	90
	Hospital	1	1	1
	Residential Home	1	2	3
	All Others	7	11	22
	Subtotal	*1791*	*4759*	*15286*
Less Vulnerable	Shops, restaurants, cafes, offices, general industry, storage and distribution, assembly, leisure, financial, professional and other services	173	384	969
	Subtotal	*173*	*384*	*969*
Water Compatible	Amenity/recreational open space	Not Assessed		
	Docks, marinas and wharves	Not Assessed		
	Subtotal	*0*	*0*	*0*
Unknown[22]		**635**	**1314**	**3445**
Total Non-residential		**855**	**1782**	**4578**
Total Residential		**1753**	**4692**	**15161**
Total		**2608**	**6474**	**19739**

In total, up to 2,608 residential and non-residential properties across Milton Keynes Borough could be at high risk of surface water flooding, i.e. at risk of flooding for a rainfall event with a 1 in 30 (3.3% AEP) probability of occurrence in any given year. Up to a further 3,866 residential and non-residential properties, totalling 6,474 properties, could be at medium risk of surface water flooding, i.e. at risk of flooding for a rainfall event with a 1 in 100 (1% AEP) probability of occurrence in any given year.

The Phase 2 Risk Assessment has shown that West Bletchley, Newport Pagnell and Bradwell contain the highest numbers of properties at high and medium risk of surface water flooding. This can be attributed to the urbanised nature of the areas, where impermeable surfaces generate increased surface water runoff. Throughout all three CDCs there are steep topographical gradients which result in surface water ponding in topographical low points. Additionally, the areas of West Bletchley and Medbourne/Crownhill encompass a number of ordinary watercourses which can exacerbate flooding.

5.3 Risk to Future Development

Milton Keynes' Level 1 SFRA provided an overview of flood risk issues across Milton Keynes (including surface water flooding) in order to inform the preparation of the Local Plan for Milton Keynes Borough (Plan:MK). Whilst a Level 2 SFRA would be required to consider the detailed nature of the flood zone characteristics of Milton Keynes (Appendix A.7), the Level 1 SFRA suggested that there are a number of areas across the borough where the risk of surface water flooding may place constraints upon development. These areas included:

– Natural topographic low points within **fluvial floodplains** of the River Great Ouse and the River Ouzel where surface water is shown to pond;

[22] Properties whose exact MCM category are not known or have not been verified, and have therefore been assigned the MCM code '999'.

- Within **Central Milton Keynes** where surface water flood risk is concentrated along the course of existing drains and small watercourses.
- In **Newport Pagnell** where a larger area of residential land to the west of the Bury Ground adjacent to Lakes Lane is shown to be at low to medium risk of surface water flooding.
- **Behind railway embankments** where surface water is shown to pond**,** e.g. in the north western part of the borough where tributaries of the River Tove flow across the route of the railway line, and in the south of the borough where tributaries of the Caldecotte Brook flow northwards. These are chiefly rural areas.

Consequently, it is likely that new developments (Appendix A.8) will need to address surface water management, ensuring that, at the very least runoff from new development is not increased and, if possible, is reduced. This will be achieved through careful design of the site layout and drainage system, giving due consideration to the implementation of strategic, integrated and maintainable SuDS solutions where appropriate. Drainage and flood risk guidance for developers is provided in the MKC Drainage Strategy Supplementary Planning Guidance (SPG)[23].

Phase 3 of this report assesses the potential mitigation options for surface water management across Milton Keynes Borough, in line with the options and recommendations outlined in the existing MKC flood risk and water management evidence base, including the Level 1 SFRA and LFRMS.

5.4 Impacts of Climate Change

Climate change is considered to be one of the most significant future pressures in terms of flood risk. Current predictions of future rainfall indicate that increasing numbers of severe and extreme weather events will be experienced in the future. Intense storms are the main cause of surface water flooding, which would also increase in frequency. Consequently, the number of properties, business and critical infrastructure at risk will also increase.

Climate change can affect local flood risk in several ways. Impacts will depend on local conditions and vulnerability. Winters with increasing rainfall along with increasing rainfall falling over generally wetter spells may increase river flooding in both rural and heavily urbanised catchments. In Milton Keynes Borough, more intense rainfall is likely to result in an increase in localised surface water flooding. In turn, this may increase pressure on drains, sewers and water quality. Storm intensity in summer could increase even in drier summers. Rising river levels may increase local flood risk inland or away from major rivers because of interactions with drains, sewers and smaller watercourses. Where appropriate, local assessments are needed to understand climate impacts in detail, including effects from other factors like land use.

Past emissions means some climate change is inevitable and it is essential that MKC responds by planning ahead. MKC can prepare by understanding the current and future vulnerability to flooding, developing plans for increased resilience and building the capacity to adapt. Regular review and adherence to these plans is essential in achieving long-term, sustainable benefits.

MKC considers climate change adaptation and mitigation to be essential to sustainability and sets high standards for new developments accordingly, such as the requirement for new developments to include renewable energy and sustainable design. The MKC's Corporate Plan (2012-2016)[24] aims to establish exemplar projects which will further distinguish Milton Keynes as a leading Smart City with a low carbon economy.

Although the broad climate change picture is clear, MKC has to make local decisions against deeper uncertainty. The Council will therefore consider a range of measures and retain flexibility to adapt. This approach, embodied within flood risk appraisal guidance, will help to ensure that the vulnerability of communities and businesses to flooding does not increase.

Sustainable development and drainage, including the use of Sustainable Drainage Systems (SuDS), will help to adapt to climate change and manage the risk of damaging floods in future.

The Environment Agency has produced guidance on Climate Change Allowances for Planners[25] to support the NPPF to outline requirements for preparing FRAs for Local Plans and planning applications.

[23] Milton Keynes Council (2004) Milton Keynes Drainage Strategy – Development and Flood Risk Supplementary Panning Guidance http://www.milton-keynes.gov.uk/planning-and-building/planning-policy/milton-keynes-drainage-strategy
[24] Milton Keynes Council's Corporate Plan (2012-2016) http://www.milton-keynes.gov.uk/your-council-and-elections/council-information-and-accounts/strategies-plans-and-policies/corporate-plan-2012-16
[25] Environment Agency (September 2013) Climate Change Allowances for Planners – Guidance to Support the National Planning Policy Framework. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/296964/LIT_8496_5306da.pdf

6 Prioritisation of Critical Drainage Catchments

The Phase 2 assessment of the risks posed by surface water flooding to Milton Keynes Borough identified 24 CDCs. In order to devise a programme for further works and owing to resource constraints, a basic method of prioritisation was adopted. Through the prioritisation of CDCs, the areas at greatest risk were identified along with the areas which would benefit the most from flood risk management measures. In order to prioritise the CDCs a number of considerations were made which included:

- CDC characteristics such as area and location;
- The number of buildings flooded within the CDC during a 3.3%, 1% and 0.1% AEP event, based on the uFMfSW dataset;
- Critical infrastructure within the CDC;
- Instances of historical flooding (from all sources bar Main Rivers yet including DG5 incident records and groundwater flooding);
- Whether there is significant proposed development in the CDC (housing and/or employment).

Prioritisation was initially based upon the number of buildings flooded within each CDC during a 1% AEP event. Subsequently, CDCs with historical flooding were ranked higher than other CDCs which did not have records of historical flooding. Where a CDC comprised significant proposed developments, these CDCs were also ranked higher.

For a number of CDCs (Tathall End (CDC22), Stoke Goldington (CDC8) and Lavendon (CDC2)), Flood Investigation Reports (FIR) have already been produced. FIRs typically include a number of proposed flood risk mitigation measures, and in some cases these measures have been implemented. Therefore these CDCs were scoped out of further assessment.

Other CDCs which were scoped out of further assessment included those which are subject to fluvial flooding associated with Main Rivers, those which have very limited surface water flooding or those where surface water flooding does not have the potential to significantly affect homes and businesses within Milton Keynes Borough.

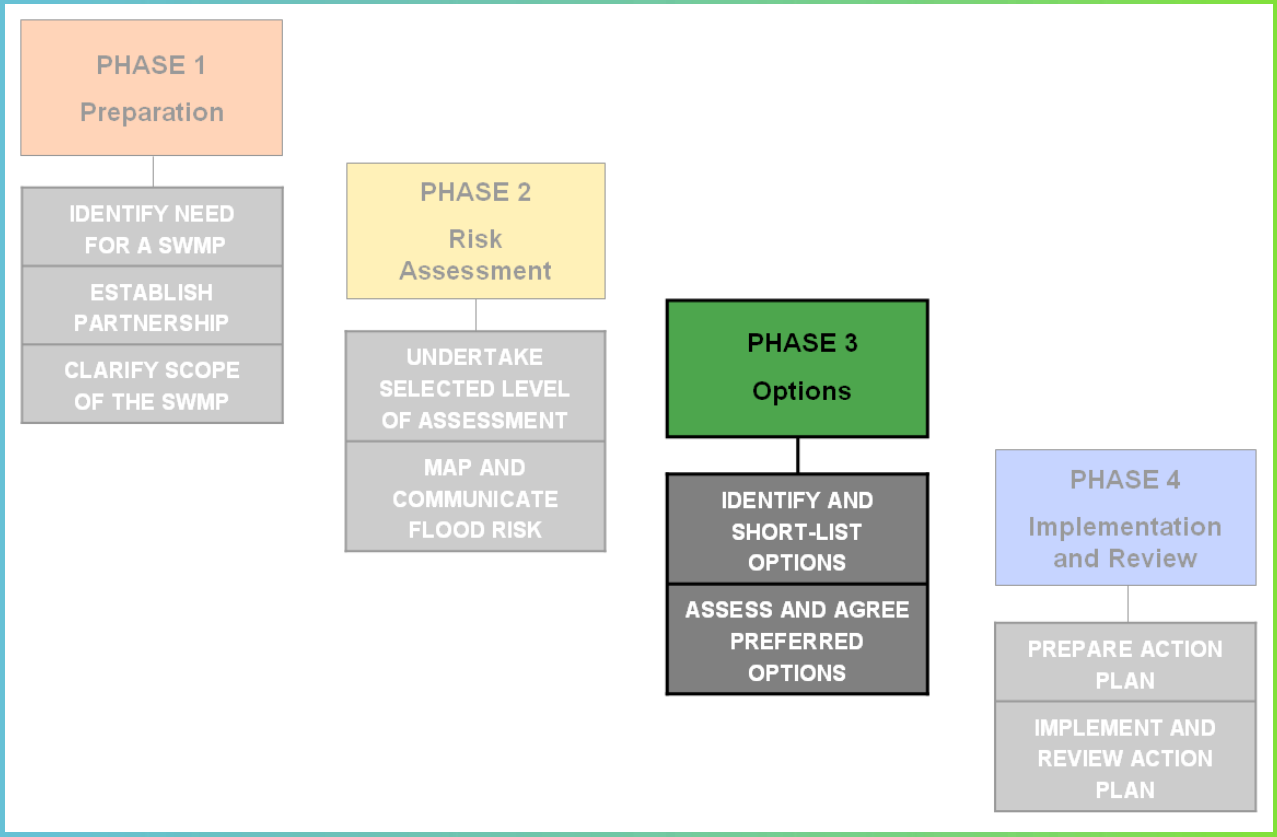
Table 6-1 provides a detailed overview of the CDC prioritisation. CDCs which are shown to be ‘greyed-out’ have been scoped out of further assessment within this SWMP.

Table 6-1 Prioritised List of CDCs

CDC Number	CDC Name	CDC Area (km^2)	Flooded buildings 1 in 30 AEP event	Flooded buildings 1 in 100 AEP event	Flooded buildings 1 in 1000 AEP event	Critical Infrastructure	Historical Flooding (All Sources)	DG5 Incident	Groundwater Flooding	Significant Development Proposed
CDC15	Stony Stratford	1.21	34	119	408	10	10	Yes	Yes	Yes (Housing)
CDC8	Newport Pagnell	4.68	52	217	1070	8	13	No	No	Yes (Housing)
CDC10	Olney	1.76	71	199	586	14	5	No	Yes	Yes (Housing)
CDC20	West Bletchley	13.72	299	717	2377	46	0	Yes	No	Yes (Employment & Housing)
CDC4	Woburn Sands	5.28	52	194	769	17	1	Yes	No	Yes (Housing)
CDC1	Ravenstone	3.47	8	12	27	0	1	No	Yes	No
CDC14	Bradwell Abbey	1.74	85	170	438	4	1	No	No	No
CDC13	Wymbush/ Two Mile	1.15	52	80	191	4	1	No	No	No
CDC12	Medbourne/Crownhill	8.47	118	193	604	13	0	No	No	Yes (Employment & Housing)
CDC11	Brinklow	1.91	6	68	342	4	0	Yes	No	Yes (Housing)
CDC17	Oldbrook	1.46	149	339	714	7	0	No	No	Yes (Housing)
CDC19	Bradwell	3.59	115	292	828	9	0	No	No	Yes (Housing)
CDC6	Downs Barn and Conniburrow	6.43	88	260	677	7	0	No	No	Yes (Housing)
CDC7	Stoke Goldington **(FIR)**	4.45	30	42	74	1	15	No	No	No
CDC2	Lavendon **(FIR)**	4.68	38	55	111	5	1	No	No	Yes (Housing)
CDC9	Bletchley and Fenny Stratford	3.84	20	64	341	29	0	No	No	Yes (Housing)
CDC18	Bradwell (west of Conniburrow)	1.85	44	105	310	7	0	No	No	Yes (Housing)
CDC16	Wolverton	2.91	21	86	389	17	0	No	No	Yes (Housing)

CDC Number	CDC Name	CDC Area (km^2)	Flooded buildings 1 in 30 AEP event	Flooded buildings 1 in 100 AEP event	Flooded buildings 1 in 1000 AEP event	Critical Infrastructure	Historical Flooding (All Sources)	DG5 Incident	Groundwater Flooding	Significant Development Proposed
CDC22	Calverton	8.92	11	11	15	1	0	No	No	Yes (Housing)
CDC5	Eaglestone	0.96	25	46	148	6	0	No	No	No
CDC3	Sherrington	1.41	10	25	71	4	0	No	No	No
CDC24	Haversham	2.58	14	26	45	0	0	No	No	No
CDC21	Tathall End **(FIR)**	4.97	6	8	20	1	0	No	No	No
CDC23	Bow Brickhill	3.26	0	1	7	3	0	No	No	No

Phase 3: Options



7 Options – Identification and Assessment

7.1 Objectives

The purpose of Phase 3 is to identify and assess a range of structural and non-structural measures for alleviating surface water flood risk across Milton Keynes Borough. The assessment will eliminate those that are not technically, environmentally, economic and socially viable and/or those which do not meet the wider objectives of the SWMP and associated plans and programmes such as the Milton Keynes LFRMS. The remaining options are then developed and tested against their relative effectiveness, with associated costs being outlined.

The option identification has been undertaken for each of the 13 CDCs prioritised through the CDC prioritisation process (Section 6). Alongside this assessment, borough-wide measures (i.e. flood alleviation measures which could be implemented across the entirety of Milton Keynes Borough) have also been identified.

As part of the options assessment, a cost-benefit analysis can be conducted which ultimately generates a public funding score. However, due to a large number of CDCs and the high-level nature of the assessment, which has not included modelling, it was agreed with MKC that a cost-benefit analysis should be undertaken at a later date when further assessments have been undertaken. It is anticipated that this approach will provide a more representative cost-benefit analysis and prevent an overestimation of public funding scores.

Whilst flood mitigation costs have been determined using engineering judgement, they have not undergone detailed analysis. As such, the costs provided as part of this study have been assigned to cost bands to reflect that the costs presented are estimates and not based upon detailed analysis. The options assessment follows that described in the Defra SWMP Technical Guidance 2010, but is focussed on highlighting areas for further detailed analysis and immediate 'quick win' actions.

Milton Keynes recently produced local guidance for planning applications in regards to SuDS and surface water drainage[26] in order to assist developers and applicants in designing a suitable SuDS scheme for their site and in providing the relevant information required so as the LPA and LLFA can assess the surface water elements of the application. This guidance note supports MKC's aim of ensuring that development does not have a negative impact on flood risk and lowers the risk where possible. In support of this aim, SuDS have been identified as potential flood alleviation measures where practicable.

7.2 Linkages to Local Investment Plans

It is important to consider local investment plans and initiatives and committed future investment when identifying measures that could be implemented within Milton Keynes Borough. For instance, the continued and enhanced resource allocation for the maintenance of drainage systems is seen to be of utmost importance to sustainable flood and water management.

Linking development with the following schemes could provide linked funding solutions to flood alleviation work, which would provide a cost effective and holistic approach to surface water flood risk management:

- Environment Agency Partnership Funding;
- Local Development Plan Core Strategy, Area Action Plans and Infrastructure Delivery Plans;
- Local Green Infrastructure Plans;
- Major commercial and housing development;
- Local Transport Plans;
- Bedford Group of Drainage Boards Wildlife Conservation and Environmental Strategy;
- Bedford Group of Drainage Boards Buckingham and River Ouzel Biodiversity Action Plan;

26 Milton Keynes Flood and Water Management/Drainage. https://www.milton-keynes.gov.uk/planning-and-building/building-control/flood-and-water-management-drainage?chapter=2

– Bedford Group of Drainage Boards Buckingham and River Ouzel Works Programme; and,
– AWS Business Plans (for AMP6 and AMP7).

7.3 Options Identification and Assessment Approach

Phase 3 has been undertaken in four stages as summarised below. Each stage is discussed in more detail in the proceeding sections.

– Stage 1 – Identify Potential Measures: (structural and non-structural) based on the standard measures identified for all shortlisted CDCs irrespective of the costs or benefits associated with these.
– Stage 2 – Identify Potential Options: based on those measures identified in Stage 1 - an option may be a single measure or a combination of measures. This stage may also identify whether further investigations or confirmation of existing drainage infrastructure is required prior to taking forward options.
– Stage 3 – Short-list Potential Options: based on a range of social, environmental, technical and economic criteria to determine the preferred schemes for consideration in Stage 4.
– Stage 4 – Determine High-level Costs: identify the preferred option and determine the approximate cost(s).

7.3.1 Stage 1 – Identify Potential Measures

This stage aims to identify a number of measures that have the potential to alleviate surface water flooding in Milton Keynes Borough. This assessment has been informed by the knowledge gained as part of the Phase 1 and Phase 2 assessment. At this stage, the measure identification pays no attention to constraints such as funding or delivery mechanisms. This approach enables a robust assessment and ensures that no measures are overlooked. It simply identifies if there are opportunities for the measure to be implemented, and whether the measure could play a role in alleviating surface water flood risk.

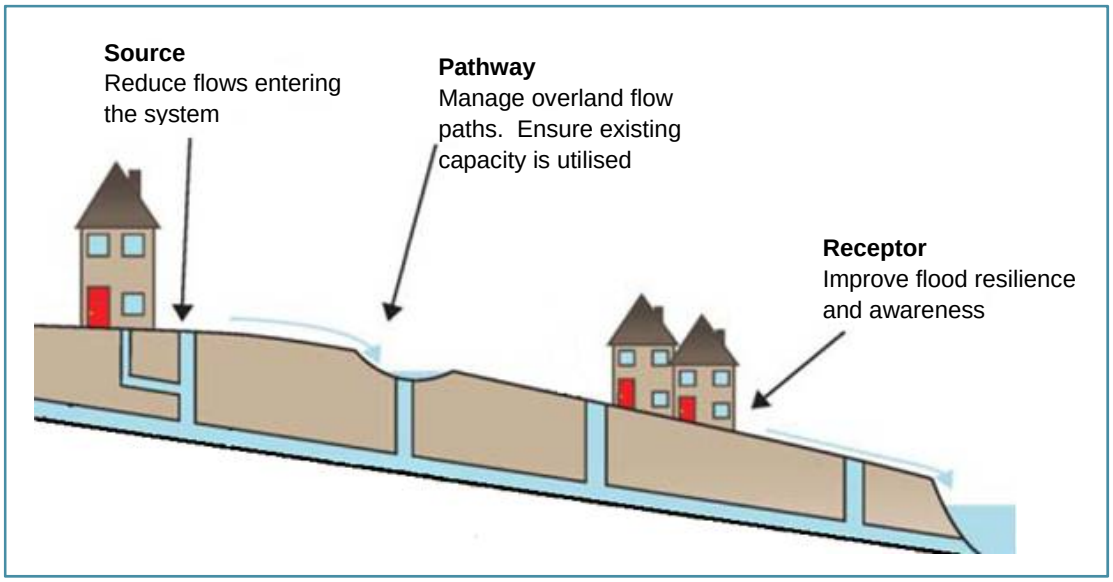
A standard set of structural[27] and non-structural[28] measures have been considered for each of the shortlisted CDCs (Table 7-1) following the source-pathway-receptor model (Figure 7-1).

Table 7-1 Structural and Non-Structural Measures for Consideration

Source	Pathway	Receptor
Green roofs Soakaways Swales Permeable Paving Rainwater Harvesting Detention Basins	Increasing capacity in drainage systems Separation of foul and surface water sewers Improved maintenance regimes Managing overland flows Land management practices	Improved weather warning Planning policies to influence development Temporary or demountable flood defences Social change, education and awareness Improved resilience and resistance measures

27 Structural measures are considered to be those which require fixed or permanent assets to mitigate flood risks.
28 Non-structural measures are those which are responses to urban flood risk that may not involve fixed or permanent facilities, and whose positive contribution to the reduction of flood risk is most likely through a process of influencing behaviour.

Figure 7-1 Source-Pathway-Receptor Model (adapted from SWMP Technical Guidance, 2010)



7.3.2 Stage 2 – Identify Potential Options

An options assessment was undertaken for each of the shortlisted CDCs to evaluate where there were opportunities for the implementation of structural and non-structural measures.

Each of the options has been assessed for initial feasibility within each of the CDCs, in terms of:

- Whether there are opportunities for the option to be implemented; and,
- Whether the option is likely to reduce or alleviate flood risk in the CDC.

All potential options have been considered including[29]:

- Options that change the source of risk;
- Options that modify the pathway or change the probability of flooding;
- Options that manage or modify receptors to reduce the consequences;
- Temporary as well as permanent options;
- Options that work with the natural processes wherever possible;
- Options that are adaptable to future changes in flood risk;
- Options that require actions to be taken to deliver the predicted benefits (for example, closing a barrier, erecting a temporary defence or moving contents on receiving a flood warning);
- Innovative options tailored to the specific needs of the project; and,
- Options that can deliver opportunities and wider benefits, through partnership working where possible.

Where possible options have been identified that have multiple benefits, for example to alleviate flooding from other sources, or provide environmental benefits such as water quality, biodiversity and amenity benefits. Table 7-2 outlines the potential options which have been considered for each CDC including a description of each option and the standard measures which comprise that option.

29 Environment Agency (March 2010) 'Flood and Coastal Flood Risk Management Appraisal Guidance', Environment Agency: Bristol.

Table 7-2 Potential Options

Description		Standard Measures Considered
Do Nothing	Make no intervention / undertake no maintenance	None
Do Minimum	Continue existing maintenance regime	None
Improved Maintenance	Improve existing maintenance regimes e.g. target improved maintenance to critical points in the system and ensure appropriate funding is available for effective and sustainable drainage network maintenance.	- Improved Maintenance Regimes - Other 'Pathway' Measures
Planning Policy	Use forthcoming development control policies to direct development away from areas of surface water flood risk or implement flood risk reduction measures.	- Planning Policies to Influence Development
Source Control, Attenuation and SuDS	Source control methods aimed to reduce the rate and volume of surface water runoff through infiltration or storage, and therefore reduce the impact on receiving drainage systems.	- Green Roof - Soakaways - Swales - Permeable paving - Rainwater harvesting - Detention Basins - Ponds and Wetlands - Land Management Practices - Other 'Source' Measures
Flood Storage / Permeability	Large-scale SuDS that have the potential to control the volume of surface water runoff entering the urban area, typically making use of large areas of green space. Upstream flood storage areas can reduce flows along major overland flow paths by attenuating excess water upstream.	- Detention Basins - Ponds and Wetlands - Managing Overland Flows (Online Storage) - Land Management Practices - Other 'Source' Measures - Other 'Pathway' Measures
Separate Surface Water and Foul Water Sewer Systems[30]	Where the CDC is served by a combined drainage network separation of the surface water from the combined system should be considered. In growth areas separation of existing systems creates capacity for new connections.	- Separation of Foul and Surface Water Sewers
De-culvert / Increase Conveyance	De-culverting of watercourses and improving in-stream conveyance of water.	- De-culverting Watercourse(s) - Other 'Pathway' measures
Preferential / Designated Overland Flow Routes	Managing overland flow routes through the urban environment to improve conveyance and routing water to watercourses or storage locations.	- Managing Overland Flows (Creating preferential flowpaths) - Temporary or Demountable Flood Defences - Other 'Pathway' measures
Community Resilience	Improve community resilience and resistance of existing and new buildings to reduce damages from flooding, through (predominantly) non-structural measures. This option is particularly useful where opportunities for structural measures to alleviate surface water flooding are limited.	- Improved Weather Warning - Temporary or Demountable Flood Defences - Social Change, Education and Awareness - Improved Resilience and Resistance Measures - Other 'Receptor' Measures
Infrastructure Resilience	Improve resilience of critical infrastructure in the CDC that is likely to be impacted by surface water flooding e.g. electricity substations, pump houses.	- Improved Resilience and Resistance Measures - Other 'Receptor' Measures

30 For all CDAs considered in the South Essex SWMP, separation of combined sewers is not a potential option as all of the CDAs have largely separate foul and surface water drainage systems.

Description		Standard Measures Considered
Other - Improvement to Drainage Infrastructure	Add storage to, or increase the capacity of, underground sewers and drains and improving the efficiency or number of road gullies.	- Increasing Capacity in Drainage Systems - Other 'Pathway' measures
Other or Combination of Above	Any alternative options that do not fit into above categories and any combination of the above options where it is considered that multiple options would be required to address the surface water flooding issues.	

After the initial assessment, a more detailed assessment of potential options for each CDC has been undertaken. Option assessment tables for each of the CDCs are included in Appendix C. A summary of the options assessment is provided in Table 7-3.

Following the high level options assessment for each of the CDCs, a range of preferred options for the delivery of local flood risk management were defined. Preferred options for each CDC are outlined in Section 8.

Table 7-3 Measures Opportunity Assessment

CDC ID	CDC Name	General		Source				Pathway							Receptor		
		Do Nothing	Do Minimum	Green Roofs	Rain Gardens	Infiltration SuDS	Attenuation SuDS	Increased capacity/conveyance of drainage systems	Sewer Separation	Enhanced Maintenance Regimes	Managing Overland Flows	Land Management Practices	Deculverting Watercourses	Other Pathway Measures	Planning Policies to Influence Development	Improved Resilience and Resistance Measures	Social Change, education and awareness
CDC1	Ravenstone	×	×	×	?	✓	✓	✓	×	✓	×	✓	×	N/A	✓	✓	✓
CDC4	Woburn Sands	×	×	×	?	×	✓	✓	×	✓	×	✓	×	N/A	✓	✓	✓
CDC6	Downs Barn and Conniburrow	×	×	?	?	×	✓	✓	×	✓	×	×	×	N/A	✓	✓	✓
CDC8	Newport Pagnell	×	×	×	?	×	✓	✓	×	✓	✓	×	×	✓	✓	✓	✓
CDC10	Olney	×	×	✓	?	✓	✓	✓	×	✓	✓	×	×	N/A	✓	✓	✓
CDC11	Brinklow	×	×	✓	?	×	✓	×	✓	×	?	×	×	N/A	✓	✓	✓
CDC12	Medbourne/Crownhill	×	×	×	?	×	✓	✓	×	✓	✓	×	×	N/A	✓	✓	✓
CDC13	Wymbush/ Two Mile	×	×	✓	?	×	✓	✓	×	✓	×	×	×	N/A	✓	✓	✓
CDC14	Bradwell Abbey	×	×	✓	?	×	✓	✓	×	✓	✓	×	×	N/A	✓	✓	✓
CDC15	Stony Stratford	×	×	✓	?	×	✓	✓	×	✓	×	×	×	N/A	✓	✓	✓
CDC17	Oldbrook	×	×	✓	?	×	✓	✓	×	✓	?	×	×	N/A	✓	✓	✓
CDC19	Bradwell	×	×	✓	?	×	✓	✓	×	✓	×	×	×	N/A	✓	✓	✓
CDC20	West Bletchley	×	×	✓	?	×	✓	✓	×	✓	×	×	×	N/A	✓	✓	✓

Measures Opportunity Assessment Criteria	
✓	There are opportunities for implementation of this mitigation measure within the CDC. Measure should be considered in the Options Assessment.
?	There may be some, but limited opportunities for implementation of this mitigation measure within the CDC. Measures should be considered in the Options Assessment but would likely be limited in effectiveness or be subject to site-specific investigations prior to consideration.
×	There are no opportunities for implementation of measure within CDC. The measure is either not suitable, or it is not required to address the surface water flood risk within the CDC.
N/A	Not applicable - to be used where no other measures are identified.

7.3.2.1 Quick Wins

In addition to the identification of measures, the first stage of the options assessment also identified potential 'quick wins' across each of the CDCs and across the borough as a whole. Quick wins are identified as actions that can be undertaken in the short-term and with low capital cost to immediately reduce the risk of surface water flooding in any given area. Quick win examples which have been identified within Milton Keynes Borough include:

- Improved maintenance regimes of drainage systems to allow for enhanced conveyance of waters;
- Clearance of the drainage network including ditch clearance to allow for enhanced conveyance of waters; and,
- Property level protection to enhance the resilience and resistance of properties to surface water flooding.

Potential quick wins have been identified through a combination of:

- Site visits undertaken at each CDC as part of Phase 2 of the SWMP;
- Discussions with drainage engineers at each of the partner authorities; and
- The parallel development of the Milton Keynes LFRMS.

In general, the quick wins identified are recommended for the Borough as a whole. Where a quick win is considered to be of particular importance to an individual CDC, it is identified within Section 8.

7.3.3 Stage 3 – Short-list Options

This stage takes the options identified through Stage 2 and short-lists them based on the following criteria, to which a high-level scoring system for each option has been developed:

- Technical feasibility;
- Economic viability;
- Environmental responsibility;
- Social acceptance; and,
- Whether the measure will help to achieve the objectives of the SWMP i.e. to reduce surface water flood risks.

The above criteria are assessed through the following high-level scoring system:

Table 7-3 Options Assessment Short-listing Criteria

Criteria	Description	Score
Technical	- Is it technically possible and buildable? - Will it be robust and reliable? - Would it require the development of a new technique for its implementation?	N/A: Measure is not feasible within this CDC and has therefore been eliminated from further assessment -2: Severe negative outcome -1: Moderate negative outcome 0: Neutral +1: Moderate positive outcome +2: High positive outcome
Economic	- Will benefits exceed costs? - Is the measure likely to be within the available budget? - Estimate the whole life costs of the option including asset replacement, operation and maintenance. The scoring of this measure will depend on the budget available from the local authority although it should be remembered that alternative routes of funding could be available.	
Social	- Will the community benefit or suffer from implementation of the measure? - Does the option promote social cohesion or provide an improved access to recreation/open space? - Does the option result in opposition from local communities for example if an option involves the displacement of houses?	
Environmental	- Will the environment benefit or suffer from implementation of the measure? - Would the option have a positive or negative effect on the environment for example, water quality and biodiversity?	
Objectives	- Will it help to achieve the objectives of the SWMP partnership? - Does the option meet the overall objective of alleviating flood risk?	

This approach to short-listing the measures is based on the guidance in Flood and Coastal Erosion Risk Management (FCERM) appraisal guidance and Defra's SWMP Technical Guidance 2010.

An Options Workshop was held with the Milton Keynes SWMP Working Group on 18th June 2015 which comprised representatives from MKC, AWS, the Environment Agency and the Bedford Group of Drainage Boards. The purpose of the workshop was to discuss and agree the short-listed options identified for each CDC through the options assessment. The process ensured that inappropriate measures were eliminated early in the optioneering process to avoid investigation of options that would not be acceptable to stakeholders. This approach promotes collaborative working and stakeholder partnerships whilst ensuring resources are optimised.

The agreed short-listed options have been progressed to the preferred options stage where they have been developed further and costed.

7.3.4 Stage 4 – Determine High-Level Costs and Benefits

Following the Options Workshop and consultation with relevant stakeholders, the preferred options have been identified for each of the shortlisted CDCs and further assessed to:

- Estimate high-level benefits; and,
- Estimate the approximate high- level implementation costs.

7.3.4.1 Benefits

In addition the qualitative assessment of benefits undertaken in Stage 3 (based on social, environmental, economic and technical considerations), a further assessment of benefits derived for the implementation of specific measures on a CDC by CDC basis has been undertaken as part of Stage 4. This exercise has been achieved through engineering judgement to identify the number of properties which may benefit from reduced flood risk during a 1 in 30 year AEP event (inclusive of a 0.15m threshold). These approximate benefits are estimates only and are subject to further assessment through modelling and feasibility studies etc.

7.3.4.2 Costs

An estimated cost for the preferred flood mitigation option for each shortlisted CDC has been calculated based on standard unit costs. No monetised damages have been calculated, and flood mitigation costs have been determined using engineering judgement, but have not undergone detailed analysis. The following standard assumptions have been applied:

- The costs are the capital costs for implementation of the scheme only;
- Costs do not include provisions for consultancy, design, supervision, planning process, permits, environmental assessment or optimum bias;
- No provision is made for weather (e.g. winter working);
- No provision is made for access constraints;
- No provision is made for costs associated with land acquisition components;
- No operational or maintenance costs are included; and,
- No provision is made for disposal of materials (e.g. for flood storage or soakaway clearance).

As a result, costs have been provided as cost bands[31], reflecting the strategic nature of the SWMP and options identification. The focus is on providing an indicative cost per option to assist in decision making regarding further investigation into option identification. An estimated cost for the preferred flood mitigation option for each identified CDC has been calculated using standard unit costs based on best available industry standards and guidance. No

7.4 Borough-wide Options

As part of Phase 3, Policy Areas have been defined across the Study Area within which appropriate planning, maintenance and management and community policies should be applied to manage and mitigate flood risk. These Policy Areas cover each of the Councils administrative areas, and are not limited to CDC extents. The reason for the inclusion of these areas is to highlight the fact that even if an area does not fall within a CDC, it does not mean that surface water

31 The cost bands to be used are: <£25k, £26k - £50k, £51k - £100k, £101k - £250k, £251k - £500k, £501k - £1m and >£1m.

discharge from these areas is not a concern and does not need to be managed or mitigated; merely that the need for considering direct options for the area are not as critical.

The borough-wide options identified within the SWMP will complement the LFRMS and help to deliver the LFRMS objectives. Where relevant, options which align with the LFRMS have been highlighted for each CDC below.

The preferred Borough-wide options include:

- Sustainable land management;
- Surface Water Management Network Maintenance Plan;
- Ongoing Improvements to Maintenance of the Drainage Network;
- Social change, education and awareness;
- Planning and development control policies; and,
- Improving Resilience to Flooding.

Borough-wide Options: Sustainable Land Management

The management of open land can play a positive role in reducing the generation of surface water runoff. Whilst this measure has been recommended specifically for certain CDCs on the rural-urban fringe, this option should be considered at a wider scale, across Milton Keynes Borough. Sustainable land management can include areas such as school playing fields, recreational grounds and farmland. Where these fall within a CDC, additional maintenance measures could be taken to ensure the infiltration potential of the land is maximised, and the surface water runoff is reduced.

School grounds and recreational areas: The intensity of an extreme rainfall event is likely to exceed the infiltration rate of the soil, especially one which is heavily compacted. The aeration (or spiking) of sports fields and recreation grounds will help to ensure the top soils retain a higher infiltration potential and create a greater surface roughness. Such an action could reduce the volumes and velocity of surface water runoff generated from this land use. This practice could be incorporated into the site maintenance schedule of the school or recreational ground and could be undertaken as part of the maintenance work.

Farmland: There is a large area of agricultural land within Milton Keynes. Practices such as ensuring the direction the land is ploughed follows contours, or the duration that land is left bare could be considered. The direction the land is ploughed could influence the channelling of surface water runoff generated from the land. By ploughing perpendicularly to the slope of the land, the rivets created act to obstruct the flow of surface water, so reducing the velocity of the surface water runoff. By minimising the duration that the land is bare of vegetation may increase the surface roughness for a greater duration. Leaving plants in the soil throughout the winter may provide a greater surface roughness than leaving the land bare. In addition, this may help in ensuring the stability of the soil and therefore preventing the leaching of nutrients during the non-growing season.

Urban centres: Where there is a high level of urban development, the planting of trees and shrubs could be encouraged, to intercept rainfall and reduce the velocity of surface water runoff. Alternatively the use of bio-retention systems could be utilised to assist in the removal of pollutants carried from impermeable surfaces.

Land management options could provide multiple benefits in addition to flood risk management interests. Natural England and Defra operate grant assistance for some schemes under the Catchment Sensitive Farming initiative (http://www.naturalengland.org.uk/ourwork/farming/csf/default.aspx).

This Borough-wide option aligns with the following actions as derived through the Milton Keynes LFRMS:

- Target landowner engagement to specific areas at risk of flooding;
- Meet with landowner representatives to understand their priorities and communicate those of MKC;
- Link up with existing catchment based approach through the Environment Agency to work on initiatives to reduce flood risk (e.g. Catchment Sensitive Farming, Water Framework Directive schemes);
- Public information signs for linear parks and balancing ponds to explain their role in flood management, alongside water safety signs;
- Identity riparian owners within Milton Keynes;
- Contact riparian owners to inform them of their rights and responsibilities;
- Update MKC website to include information on riparian owners' rights and responsibilities; and,
- Engage with riparian owners of higher risk watercourses to agree maintenance activities and frequency and highlight the benefits.

Option A	Introducing operational maintenance regimes for aeration of sports grounds, school playing fields and football pitches to improve infiltration potential.
Option B	Encourage the uptake of beneficial farming practices that will assist in the infiltration of surface water and prevent the generation of overland flow. Engage with farmers who have land within the CDCs to determine feasible options and encourage the implementation of these practices.
Option C	Increase vegetation coverage within urban areas, such as trees along roadside and walkways. This may additionally improve the ecological and amenity value of the urban spaces.

Borough-wide Options: Surface Water Management Network Maintenance Plan

The ongoing management and maintenance of the surface water management network inclusive of Furzton, Willen, Caldecotte Lakes (as provided by The Parks Trust) is crucial in reducing the risk of surface water flooding across the borough.

The water balancing network operates in such a way that attenuated flows pass from one storage area to the next, via engineered channels and is regulated by structures at the outfalls of major storage areas. The network performs a vital role in storing surface water flows and preventing flooding further downstream in urban areas; however, it is essential that these systems continue to function to their optimum and their operational performance is not limited by poor understanding of how each system works and what maintenance is required to maintain storage levels and outfalls.

Areas identified as already having an important flood storage function, or with the potential to be used as flood storage areas, in relation to future flood management options, should be protected from being allocated for development by the Local Planning Authority, particularly in CDCs where attenuation SuDS are identified as providing the greatest benefits (Section 8).

It is recommended that the following is undertaken on all existing and new flood storage areas:

- Formalise the owner and operator of each flood storage area (designate it as FRM Infrastructure);
- Establish what maintenance is currently undertaken, and by whom;
- Create a Flood Storage Area Management Plan, the purpose of which must be primarily concerned with the integrity of the flood storage area as a drainage and flood management asset, rather than any residual uses such as how its open space role; and,
- Engage local residents in the multi-functional use of the space.

Figure 7-2 Furzton Lake (The Parks Trust 2015)

This Borough-wide option aligns with the following actions as derived through the Milton Keynes LFRMS:

- Identify implications of reduced maintenance;
- Ensure that planning policy addresses Sustainable Drainage requirements in Milton Keynes borough;
- Establish a virtual maintenance working group; and,
- Maintain MoU between Bedford Group of Drainage Boards and Parks Trust for asset maintenance.

Option A	Formalise flood storage areas as Flood Zone 3b to ensure their existing function is not compromised by the planning and development process. Formalise an owner and operator of each storage area to ensure effective maintenance.
Option B	Create a Flood Storage Area Management Plan
Option B	Undertake a comprehensive survey of connecting channels to ensure that they are free of blockages.

Borough-wide Options: Ongoing Improvements to Maintenance of the Drainage Network

The management and maintenance of the drainage network in Milton Keynes Borough is the responsibility of a number of organisations:

- MKC – responsible for highway drainage including gully pots,
- AWS – responsible for main sewers and lateral sewers;
- Environment Agency – responsible for flood risk management of assets on main rivers including culverts, raised defences, trash screens, and main river channel;
- Highways England - responsible for managing highway drainage from the motorways and major trunk road network, including the slip roads to and from trunk roads;
- Parks Trust - manages some balancing lakes within the linear parks and has the rights and responsibilities of riparian owners
- Bedford Group of Drainage Boards – responsible for all matters relating to the drainage of land within their district in order to facilitate improved maintenance of the drainage system and to regulate activities in and alongside the drainage system other than waterbodies designated as main rivers[32]; and,
- Network Rail – responsible for railway drainage (pertinent to Milton Keynes as a borough when considering the tendency for surface waters to pond behind railway embankments).

Figure 7-3 Examples of Milton Keynes Watercourses Requiring Enhanced Maintenance.

Effective cleansing of gully pots and other associated highway drainage features is fundamental to the effective operation of drainage infrastructure across Milton Keynes and the Council operates a regular maintenance regime for the clearing of the drainage network. Gully pots are fundamental to integrated urban drainage in that during intense precipitation events, surface water runoff is routed off roadways and other hard-standing and into gully pots and then into the public sewer system or watercourse. In essence, highway drainage features are a critical link in the performance of the overall drainage network.

However, in recent years and as a result of limited resources, a number of maintenance regimes have been curtailed. Consequently, it is seen to be essential that resources for effective drainage maintenance are secured.

The proposed borough-wide option of facilitating ongoing improvements to the maintenance of drainage systems supports Objective One of the Milton Keynes LFRMS: *'Ensure that drainage management is tailored to Milton Keynes unique drainage systems'* which aims to enhance understanding of the Milton Keynes drainage network, facilitate effective maintenance and ensure it is resilient to future flood risks.

Option A	Focus attention on the maintenance of gully pots in the identified CDCs which are considered to be high risk and on those areas identified as being at risk from blocked gullies
Option B	Develop a GIS database of all Council-owned flood / drainage assets.
Option C	Record and investigate incidents of flooding. It is recommended that the source of flooding be recorded.
Option D	Agree with the Environment Agency an ongoing protocol for sharing resources of operational teams for routine clearance works on ordinary watercourses, drainage ditches and sections of main river.
Option E	Undertake drainage capacity assessment of the existing system through modelling of different size events to improve understanding of resilience thresholds. Use the modelling outcomes to update the Milton Keynes Drainage Study.
Option F	Produce an overview of all RMA's maintenance programmes.
Option G	Identify implications of reduced maintenance.

[32] Bedford Group of Internal Drainage Boards (2015). Powers and Duties. Available online: http://www.idbs.org.uk/legal-financial/powers-duties/

Borough-wide Options: Social Change, Education and Awareness

A 'quick win' action that should be implemented in the short-term is to increase the awareness of flooding within communities at risk, and across the borough as a whole. The aim behind this measure is to improve community resilience through enhanced preparedness as a function of increasing both awareness and education regarding flood risk.

Social change, education and awareness could be achieved through a number of measures including:

- Newsletters (see example in Figure 7-4));
- Drop-in surgeries in CDCs;
- Promotion of MKC's Flooding website (Figure 7-5); and,
- Preparation of a Community Flood Plan.

There are also a number of actions outlined within the LFRMS which would help in delivering the aim of social change, enhanced education and awareness which include:

- Working with Parish Councils to disseminate flood awareness information, including an individual's actions impacts flood risk, e.g. fly tipping blocking a drain;
- Advertise the AWS Keep It Clear campaign;
- Contact riparian owners to inform them of their rights and responsibilities (information could be disseminated through the Council website); and,
- Incorporate drainage issues and information into the Highways Roadshow.

The aim of this borough-wide option is to highlight the risks and consequences of surface water flooding amongst local communities and, through this, encourage residents to take up measures to combat flooding, such as installation of water butts to capture roof runoff, and consideration to the extent of (and materials used) when replacing permeable areas with hard standing areas within their property e.g. through the installation of driveways and patios. Similarly enhanced awareness is also likely to enhance preparedness and therefore increase the resilience of communities to surface water flood risks.

Figure 7-4 Example Newsletter (URS Scott Wilson, 2011)

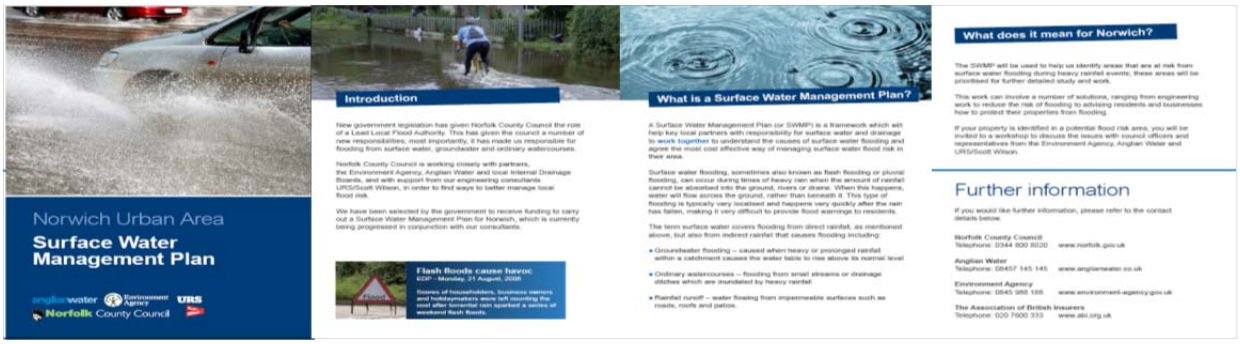
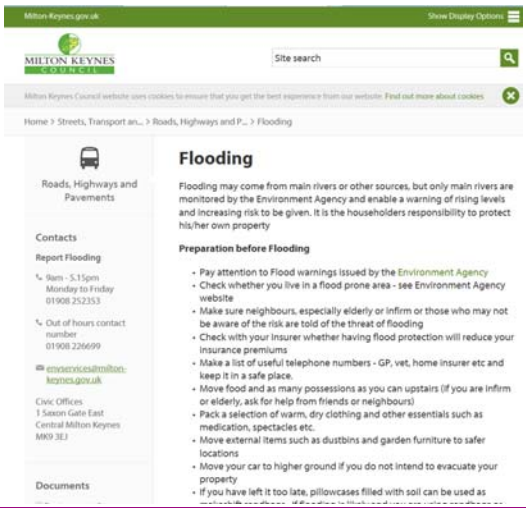


Figure 7-5: Example Website (Milton Keynes Council 2016)



Borough-wide Options: Social Change, Education and Awareness	
Option A	Undertake a letter drop to highlight the improvement works that have been implemented (i.e., through quick wins and the requirements of the FWMA) as well as works that are planned for the future. Use parish newsletters and local newspapers/magazines to disseminate information on the latest Milton Keynes flood management activities
Option B	Hold a public meeting following the letter drop where residents can highlight any local issues and flooding/drainage concerns. This could include a talk from the key partner organisations, including the Environment Agency, AWS, Bedford Group of Drainage Boards and MKC – on the work that is being undertaken and who is responsible. Such a meeting could also outline how residents can help themselves and highlight their responsibility for maintaining private drainage, soakaways, driveway drainage etc.
Option C	Develop an information and discussion portal. This could provide up to date information about ongoing work, contact details of council members and references to supporting documents as well as an opportunity for members of the public to record incidences or evidence of localised surface water flooding. A discussion forum could be set up to allow residents to comment on actions and raise any concerns they may have. The portal could provide: – A list of appropriate property-level flood risk resilience measures that could be installed; – A list of 'approved' suppliers for providing local services, such as repaving of driveways; – A link to websites / information sources providing further information (such as emergency procedures); – An update on work being undertaken in the borough by the Council and/or other stakeholders to address surface water flood risk; and, – A calendar showing when gullies are to be cleaned in given areas, to encourage residents to ensure that cars are not parked over gullies / access is not blocked during these times.
Option D	Formalise Parish council's role in community awareness of recording flood events

Borough-wide Options: Planning and Development Policies

Extensive development of both residential and employment land is proposed within Milton Keynes Borough.

Plan:MK states that *"In planning the New Town of Milton Keynes, it was recognised that its development could create an additional flood risk. A primary objective in the original design of the town was therefore that its development should not increase flooding more than that which would have been experienced has development not taken place. To achieve this, the early masterplan developed an innovative approach based on a strategic water management system and planned open space provision".* In support of this aim, SuDS have been identified as potential flood alleviation measures where practicable within the SWMP.

In December 2014, the Government issued a written statement outlining the strengthening of existing planning policy in relation to SuDS with the clear stipulation that the Government expects SuDS to be provided in new developments. In addition, where planning applications constitute major development, the LPA must ensure SuDS are included within development plans unless it can be demonstrated that they would be inappropriate.

Consequently the LPA will have to determine whether all major planning applications are in accordance with national standards i.e. Defra's Non-Statutory technical standards for SuDS and local policy. Milton Keynes recently produced local guidance for planning applications in regards to SuDS and surface water drainage[33] in order to assist developers and applicants in designing a suitable SuDS scheme for their site and in providing the relevant information required so as the LPA and LLFA can assess the surface water elements of the application. This guidance note supports MKC's aim of ensuring that development does not have a negative impact on flood risk and lowers the risk where possible.

From 6 April 2015, the LPA (upon assessing applications) must be sure that:

- Any proposal meets national and local policies'
- The proposed minimum standards of operation are appropriate;
- The minimum standard is set out to which the sustainable drainage systems must be maintained;
- Through the use of planning conditions or planning obligations there are clear arrangements in place for ongoing maintenance over the lifetime of the development, including clearly identifying who will be responsible for maintaining SuDS and that funding for maintenance is fair for householders and premises occupiers.

MKC should consult the CIRIA SuDS manual throughout this process for best practice guidance.

In order for surface water flood risk and runoff rates to remain at that of a greenfield runoff rate, measures including SuDS (such as permeable garden paving) will have to be put in place for new or redevelopments and opportunities should be sought to retrofit SuDS into existing urban areas.

33 Milton Keynes Flood and Water Management/Drainage. https://www.milton-keynes.gov.uk/planning-and-building/building-control/flood-and-water-management-drainage?chapter=2

Borough-wide Options: Planning and Development Policies

Paved Gardens

Impermeable paving in gardens can significantly increase surface water runoff entering the local drainage network. Since 1st October 2008, permitted development rights that previously allowed householders to pave their front gardens with hard standing without planning permission was removed. Residents could be encouraged to design their gardens in a way that optimises drainage and reduces runoff. The Council could publicise this issue and refer to standard guidance on the surfacing of front gardens provided by the CLG and the Environment Agency.

Figure 7-6: Examples of Permeable Front Gardens Allowing for Parking

(Source: CLG/EA Guidance on the permeable surfacing of front gardens 2008; Richmond Scrutiny Report 2008)

SuDS

There are a number of SuDS measures which have been considered across the borough including the following:

- Green Roofs: Installing layers of planting onto buildings (green roofs) or reprofiling gardens (rain gardens). It also helps to slow runoff from the building in lower return period rainfall events. Rain gardens should be designed to overflow into areas in which it is safe to do so, such as existing surface water sewers.
- Infiltration SuDS: E.g. permeable paving, soakaways, filter strips that provide a pathway for rainwater to infiltrate into the ground at a restricted rate. Infiltration SuDS are easier and more economical to install on new developments but can be retrofitted. All methods of infiltration can silt up over time, which will lead to the volume of storage for surface water runoff decreasing.
- Attenuation SuDS - e.g. storage basins, tanked permeable paving, rainwater harvesting and swales. All methods store surface water before discharging at a restricted flow rate. All methods of attenuation can silt up over time, which will lead to the volume of storage for surface water runoff decreasing.

Option A	MKC could encourage residents to ensure that paved areas in front gardens drain onto flower beds rather than running onto the highway, and that where possible, impermeable areas are minimised.
Option B	MKC could aim to raise awareness of the options for installation and maintenance of permeable surfaces within property grounds.
Option C	MKC could aim to provide an information portal that residents can consult for further information on permeable paving and other SuDS measures, including links to other organisations (e.g. Environment Agency, Defra, SuSDrains and CIRIA) who can provide 'best practice' guidance and examples.
Option D	MKC could aim to educate/train their staff to ensure that planning officers: – Are aware of the existing planning policies, guidance and best practice; – Are in a position to educate the public if enquiries are made regarding planning permission to change the surfaces of their drive/garden; and, – Can identify/enforce for non-compliance or non-permitted conversion (in particular in CDCs where it exacerbates the problem).
Option E	Ensure future development does not have a negative impact on flood risk and lowers the risk where possible (in line with Objective Three of the Milton Keynes LFRMS). – Ensure planning policies include designation powers, consenting powers and byelaws; – Ensure that planning policy addresses Sustainable Drainage requirements in Milton Keynes borough;

Borough-wide Options: Planning and Development Policies	
	– Investigate development of a MoU with neighbouring LPAs so that MKC will be consulted on any development close to the border that may impact on the drainage of Milton Keynes Borough; – Ensure resources are available to enforce the SuDS policy; – Create SuDS Standing Advice where relevant; – Run training for Planning officers on SuDS requirements and benefits; – Consider including caveats within planning policy about paving driveways; – Develop site-specific case studies to model influence of SuDS in flood prone areas in MK and improve understanding of maintenance; and, – Use regional partnerships to share new findings and best practice
Option F	Review existing and emerging policy with regards to drainage infrastructure for new developments.

Borough-wide Options: Improving Resilience to Flooding

Property Level Protection

Property level protection can help to reduce the risk of surface water flooding to a property through various mechanisms, one of which is through raising property thresholds. Raising the threshold of entrances to property land may offer flood resilience benefits, especially where the property contains a basement or where roads are predicted to flood and the properties are at road level (Figure 7-7).

Thresholds, as shown in Figure 7-7 are a useful and accepted method of defending property against flooding, although this can conflict with possible accessibility issues within Part M, Section 6 of the Building Regulations 2004 and the requirements of the Disability Discrimination Act 1996. Until such time as national guidance or best practice is available MKC should, when required, work with residents to realise suitable, sensible and cost effective solutions which allow access and deliver mitigation against possible flooding.

Other property-level protection measures which could be implemented across the borough to alleviate surface water flooding include:

- Anti-flood airbricks and airbrick covers;
- Non-return valves;
- Sewage defence systems i.e. toilet bungs;
- Flood doors; and,
- Flood barriers.

Further information relating to property-level-protection can be found on the National Flood Forum: http://www.nationalfloodforum.org.uk/property-level-protection-community-tool/

In December 2014, Defra released a report on the effectiveness of varying property level protection techniques which can be found here: http://evidence.environment-agency.gov.uk/FCERM/Libraries/FCERM_Project_Documents/fd2668_final_report.sflb.ashx

Objective Five of the Milton Keynes LFRMS is to *'Help communities to become more resilient to flooding".* In order to facilitate enhanced resilience to flooding amongst local communities, the Council aims to disseminate information relating to property level protection across their website and through local newspapers.

Figure 7-7 Examples of Raised Property Thresholds

Areas where property level protection is considered to be of particular value includes:

- Woburn Sands;
- Downs Barn and Conniburrow;
- Newport Pagnell;
- Olney;
- Brinklow;
- Medbourne/Crownhill;
- Wymbush/ Two Mile Ash;
- Bradwell Abbey;
- Stony Stratford;
- Oldbrook;
- Bradwell;
- Tathall End;
- Lavendon; and,
- West Bletchley.

Borough-wide Options: Improving Resilience to Flooding

Community Flood Plans

Completing a Community Flood Plan will help communities decide what practical actions to take before and during a flood, which may help reduce the damage flooding could cause. The flood planning process makes use of local knowledge and experience to produce a plan that caters for (a) preparing for a flood, (b) during a flood, and (c) after a flood, and should aim to complement the authorities' emergency plans and to provide essential information to help manage a flood event.

Working together as a community or group has multiple benefits, including:

- Sharing information on what to expect and what to do before, during and after a flood incident;
- Identify and clarify the responsibilities of all those involved (this avoids duplication, saving time and money);
- Clarifying the responsibilities of all those involved;
- Improving communication throughout the community and with the organisations involved before, during and after a flood;
- Helping to share local knowledge and that of people who have been flooded with professional organisations and ensure people's concerns are heard;
- Increasing preparedness to reduce the damage and distress of a flood;
- Being involved in flood planning will enable a community or group to take control and help during a flood, when other organisations could be overstretched or unable to reach them; and,
- Increasing community resilience.

Further information regarding Community Flood Plans (including a Community Flood Plan Pack) is available on the Environment Agency's website:
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/292939/LIT_5286_b9ff43.pdf

Improved Weather Warning

The Flood Forecasting Centre produce Flood Guidance Statements which provide flood forecast information for five days and highlights the risks of all types of flooding. The Flood Guidance Statement provides information for Category 1 and 2 responders to help them with emergency planning and resourcing decisions. Information relating to Flood Guidance Statements can be found here: http://www.ffc-environment-agency.metoffice.gov.uk/services/guidance.html

Providing a warning to key Council operational departments and emergency services will enable the preparation and implementation of the Flood Incident Management Strategy. Relaying this information to households and businesses before a large rainfall event could be achieved through text messages or phone calls warning of potential flooding, as the Environment Agency currently do with their fluvial flood alert system. This, with prior education and the development of Community Flood Plans, will allow individuals to respond with appropriate actions and measures.

Option A	It is recommended that MKC consider raising the awareness of the options for increasing property thresholds through the Council's website, and/or local newspapers.
Option B	It is recommended that MKC work with residents to realise suitable, sensible and cost effective property level resilience to potential flooding (through, for example raising property thresholds to 100mm), particularly in areas where roads / properties are known / identified to be susceptible to surface water flooding.
Option C	Investigating the potential for funding opportunities for areas at greatest risk.

8 Preferred Options

8.1 Milton Keynes Overview of Options

Following the options assessment process (presented in Appendix B), a series of preferred options have been shortlisted for each prioritised CDC. Due to the strategic nature of this SWMP, many of the options (such as the implementation of SuDS) require further investigation and feasibility studies to be undertaken. Where it is considered that further investigation and/or collaboration with third parties such as AWS, Environment Agency and Bedford Group of Drainage Boards is required before determining the preferred capital option for a CDC, this has been highlighted.

For each CDC, a range of preferred specific options have been identified for consideration that could help to alleviate flooding. These 'packages' of measures could be implemented in their entirety or independently.

It is expected that the preferred options presented within this section will be developed and/or altered as further information, potentially through on-site investigation and/or third party collaborations, becomes available.

Generally, the preferred options for each CDC are similar in nature. For instance, the majority of options refer to the implementation of attenuation SuDS, retrofitting of green roofs and increasing the capacity and conveyance of drainage networks. This is due to the characteristics of the area and general constraints which are presented across the borough such as the impermeable urban nature of Central Milton Keynes and how this affects infiltration and surface runoff.

In addition to the preferred options, a range of other potential options have been presented for each CDC. Other potential options are those which are considered to have technical, environmental, social, or economic limitations and therefore received a lower 'score' during the options assessment but may contribute to reducing flood risk in the CDC. The links below can be used to go directly to specific CDC preferred options;

CDC ID	CDC Name
CDC1	Ravenstone
CDC4	Woburn Sands
CDC6	Downs Barn and Conniburrow
CDC8	Newport Pagnell
CDC10	Olney
CDC11	Brinklow
CDC12	Medbourne/Crownhill
CDC13	Wymbush/ Two Mile
CDC14	Bradwell Abbey
CDC15	Stony Stratford
CDC17	Oldbrook
CDC19	Bradwell
CDC20	West Bletchley

8.2 Wider Environmental Benefits

During consultation upon the preferred options with various stakeholders, a number of linkages were identified between the preferred options of the SWMP and wider environmental objectives, such as those associated with the Water

Framework Directive (WFD) and associated River Basin Management Plans. The Environment Agency consider that the following measures could help achieve WFD objectives in the watercourses that lie within the CDCs.

- Infiltration SuDS (both retrofitted and new measures);
- Attenuation SuDS (both retrofitted and new measures);
- Land management practices – sustainable agriculture and rural practices;
- Green roofs (both retrofitted and new measures);
- Planning policies to influence development if they include sustainable drainage, guidance to avoid diffuse and point source pollution and water saving messages;
- Social change, education and awareness again if they include sustainable drainage, guidance to avoid diffuse and point source pollution and water saving messages;
- Retrofitting rain gardens;
- Improved maintenance regimes of drainage systems if this included increased gully pot maintenance to remove silt and associated accumulated pollutants; and,
- Managing overland flows if it prevented displacement and mobilisation of soil, silt and other pollutants.

8.3 Ravenstone Preferred Options

CDC1: Ravenstone

Preferred Option - Combined Measures:

- Infiltration SuDS to the north of Northend Farm and the northwest of Abbey Farm; **or,**
- Attenuation SuDS to the north of Northend Farm and the northwest of Abbey Farm (basins or bunded areas); and,
- Land management practices – sustainable agricultural and rural practices.

Infiltration SuDS: The majority of the geological strata underlying Ravenstone is classified as the Blisworth Limestone Formation which has a high permeability, allowing for effective infiltration. Consequently, infiltration SuDS could be utilised north of Northend Farm and north-west of Abbey Farm. The installation of these measures in this area has the potential to attenuate surface water close to the source, thus reducing surface water flood risk along the main roads along adjacent residential areas in Ravenstone such as Common Street and Northend (Figure 8-1).

If infiltration SuDS are not deemed to be technically feasible following site investigations and detailed modelling, attenuation SuDS could be utilised. Basins or bunded areas could be located north of Northend Farm and north-west of Abbey Farm.

As a result of these measures, attenuated stormwater would discharge to the existing public surface water sewers over specified overland routes at a restricted rate.

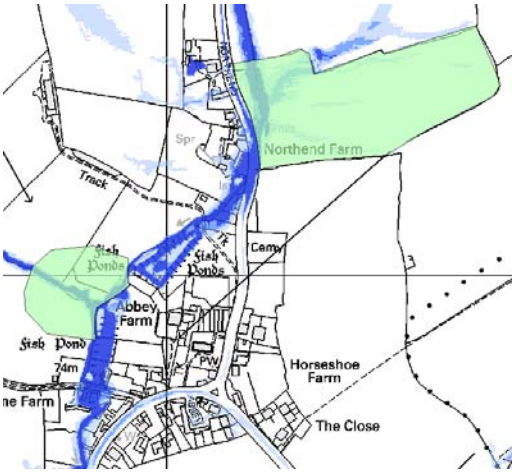


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Figure 8-1: Recommended SuDS for Ravenstone

Sustainable Land Management Practices: Ravenstone is predominantly a vegetated, rural area with agricultural land uses. Where not already implemented, perpendicular ploughing could be applied across agricultural land to the north, east and west of Ravenstone. Other potential measures include the increased coverage of vegetation and hedge rows. This could reduce the velocity of surface water runoff and could assist in removing diffuse pollutants from runoff arising from agricultural practices.

Approximate Cost	Infiltration SuDS (based upon a 800m length of swale): £26k - £50k Attenuation SuDS: >£1m* *It should be noted that the cost of >£1m comprises two attenuation SuDS schemes which cover an area of 69,000m^3. These costs have been derived based on industry standard costs. It is likely that following further assessment the overall size of the schemes may be reduced and subsequently costs for construction of these may decrease.
Potential Benefits	The installation of SuDS at both Northend and Abbey Farm could protect up to **21 buildings**.
Quick Wins	The following measures (**some of which are Borough-wide options**) could be implemented alongside the preferred options as 'quick wins'. – Ditch clearance alongside Common Street to enhance the conveyance of surface waters and to increase the capacity of the waterbody to alleviate flooding; and, – Improved maintenance regimes of drainage systems across Ravenstone and ensuring resources are available to deliver this measure.
Relevant Borough-wide Options	The following Borough-wide measures, as outlined in Section 7.4 are relevant to Ravenstone: – Planning and development control measures; – Ongoing improvements to maintenance of the drainage network; and, – Social change, education and awareness.
Other Potential Options for Consideration	
Option A	Further works could include the interception (through further attenuation SuDS) of a surface water flow path located in the south of the CDC, which flows east-to-west between Weston Road and Common Street. This proposed measure has not been included within the preferred option and should be modelled as part of further works.

8.4 Woburn Sands Preferred Options

CDC4: Woburn Sands

Preferred Option - Combined Measures:

- Attenuation SuDS at Old Park Farm and southeast of Walton High School playing field;
- Watercourse clearance and increasing capacity at Cranfield Road through use of an oversized pipe; and,
- Land management practices – sustainable agricultural and rural practices.

It should be noted that the Bedford Group of Drainage Boards has a scheme on the Environment Agency's medium term plan called the 'Caldecotte Flood Risk Management Scheme', which has indicative funding from 2015/16. This scheme focuses on the Caldecotte Brook and the area to the south of the attenuation SuDS mentioned below. The detail of the Bedford Group of Drainage Boards scheme should be considered alongside the options mentioned below.

Attenuation SuDS:
There are two potential areas for attenuation SuDS within Woburn Sands. The first area is at Old Park Farm. The installation of a bund or basin in this area could intercept the surface water flow path which follows the ordinary watercourse within this CDC which extends from the west of the catchment down to Browns Woods. Consequently, this measure may reduce surface water flood risk to the large residential area in the centre of the Woburn Sands CDC which comprises Quilter Meadow and Britten Grove (Figure 8-2).

The second area which may be appropriate for the installation of Attenuation SuDS is the south-eastern extent of Walton High School's playing field. Surface waters are shown to flow in a south-westerly direction and therefore the installation of a basin or bund in this area is may reduce surface water flood risk to the residential area to the south and east of Walnut Tree inclusive of Hockcliffe Brae (Figure 8-2).

As a result of these measures, attenuated stormwater would discharge to the existing public surface water sewers over specified overland routes at a restricted rate.

Increasing Capacity and Conveyance of the drainage network:
There are a number of ordinary watercourses and Bedford Group of Drainage Boards watercourses which could be suitable for clearance works within Woburn Sands. MKC's highways department proposed an over-sized pipe along Cranfield Road to help alleviate surface water ponding around Turnpike Court prior to the development of the SWMP.

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Figure 8-2: Recommended SuDS for Woburn Sands

Sustainable Land Management Practices: Woburn Sands is bordered by agricultural land to the east. Where not already implemented, perpendicular ploughing could be applied across this agricultural land. Other potential measures include the increased coverage of vegetation and hedge rows. This would slow down flow rates of surface water runoff and could assist in removing diffuse pollutants from runoff arising from agricultural practices

Approximate Cost	Attenuation SuDS: £1m - £10m Increasing Capacity and Conveyance of the drainage network:£101k- £250k* *It should be noted that estimated costs for increasing culvert capacity are based upon a cross-sectional area of 1m^2 and 50m in length (to give an average cost per m length of culvert of £3,700). A length of 30m has subsequently been assumed.
Potential Benefits	The installation of SuDS at both Old Park Farm and the south-eastern extent of the Walton High School's playing field could protect up to **10 buildings**.
Quick Wins	The following measures (**some of which are considered to be Borough-wide options**) could be implemented alongside the preferred options as 'quick wins'. – Improved maintenance regimes of drainage systems and ensuring resources are available to deliver this measure; and, – Property level protection (dependent upon number of properties, proposed measures and associated costs). Property level protection has been recommended for this CDC as it is not deemed possible to alleviate surface water flooding extensively through source control measures.

CDC4: Woburn Sands	
Relevant Borough-wide Options	The following Borough-wide measures, as outlined in Section 7.4 are relevant to Woburn Sands: – Planning and development control measures; and, – Social change, education and awareness.
Other Potential Options for Consideration	
Option A	– Retrofitting of rain gardens (if environmental and economic barriers can be overcome), see Appendix C.

8.5 Downs Barn and Conniburrow Preferred Options

CDC6: Downs Barn and Conniburrow

Preferred Option:

– Attenuation SuDS at land south of Dansteed Way including land west of Capel Drive, land west of Overstreet and land west of the Grand Union Canal.

Attenuation SuDS: There are a number of opportunities for attenuation SuDS in the Downs Barn and Conniburrow CDC. These opportunities include three separate areas across the land south of Dansteed Way including:

– Land to the west of Capel Drive;

– Land west of Overstreet; and,

– Land to the west of the Grand Union Canal.

The three areas could be used as basins which would act as flood storage basins in the event of heavy rainfall. Subsequently, attenuated stormwater could discharge to the existing public surface water sewers over specified overland routes at a restricted rate. The areas which may benefit from the implementation of these measures include a number of residential properties south of Dansteed Way including those adjacent to Downs Barn Boulevard and Colesbourne Drive (Figure 8-3).

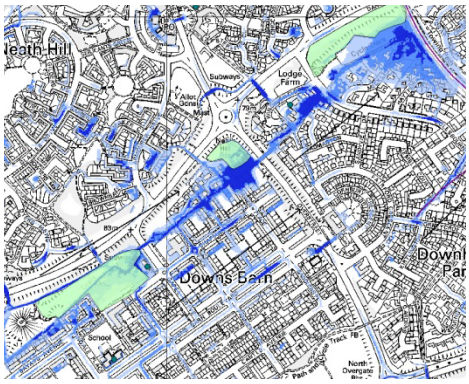

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Figure 8-3: Recommended SuDS for Downs Barn and Conniburrow.

Due to the urban nature of Downs Barn and Conniburrow, there is a very limited number of areas where surface water flood management measures could be implemented. Consquently, property level protection measures may be of greater value within this area than in other CDCs across Milton Keynes.

An area for further assessment is Linfood Wood where SuDS could be implemented to attenuate surface waters which ultimately pose a flood risk to the residential areas of Woodruff and Bramble Avenue. However, this area is densely vegetated and the potential benefits of this scheme would have to be assessed in further detail prior to reccomendation to ensure the benefits outweighed the costs, which are largely related to environmental degradation.

Approximate Cost	The approximate cost for implementing the attenuation SuDS described above was estimated to be £501k - £1M based upon best industry guidelines. However, the technical nature of the scheme (i.e. the requirement to begin a new river outfall and work back) may mean a cost of £1m-£10m is more realistic.
Potential Benefits	The installation of SuDS at the three locations south of Dansteed Way could protect up to 36 **buildings**.
Quick Wins	The following measures (**some of which are borough-wide options**) could be implemented alongside the preferred options as 'quick wins'. – Enhanced ditch maintenance and initial clearing (land south of Dansteed Way); – Improved maintenance regimes of drainage systems and ensuring resources are available to deliver this measure; and, – Property level protection (dependent upon number of properties, proposed measures and associated costs). Property level protection has been recommended for this CDC as it is not deemed possible to alleviate surface water flooding extensively through source control measures.
Relevant Borough-wide Options	The following Borough-wide measures, as outlined in Section 7.4 are relevant to Downs Barn and Conniburrow: – Planning and development control measures; and, – Social change, education and awareness.
Other Potential Options for Consideration	
Option A	– Retrofitting of rain gardens (if environmental and economic barriers can be overcome), see Appendix C.

8.6 Newport Pagnell Preferred Options

CDC8: Newport Pagnell

Preferred Option - Combined Measures:

- Attenuation SuDS at the playing field of Portfield Combined Schools, Newport Pagnell Youth Club Playing Field, Green Park School Playing Field and Kingfisher Park and permeable paving in their car parks and Industrial estate;
- Increased capacity of drainage systems in key locations such as the High Street;
- Managing overland flows through kerb raising; and,
- Implementation of flood gates at Little Linford Lane.

The opportunity for the installation of surface water management measures is limited within Newport Pagnell due to the lack open space and urban nature of the CDC. Four small areas which may be suitable for the implementation of **Attenuation SuDS** in the forms of basins for flood storage include:

- The playing field of Portfield Combined Schools;
- Newport Pagnell Youth Club Playing Field;
- Green Park School Playing Field; and,
- Kingfisher Park

Attenuated stormwater would discharge to the existing public surface water sewers over specified overland routes at a restricted rate. These measures could reduce surface water flood risk in the following residential areas:

- Properties to the north-east of the Portfield School extending up to Lakes Lane Farm;
- Properties to the north-east of Westbury Lane extending up to Bury Field; and,
- Properties to the east of Ousedale School.

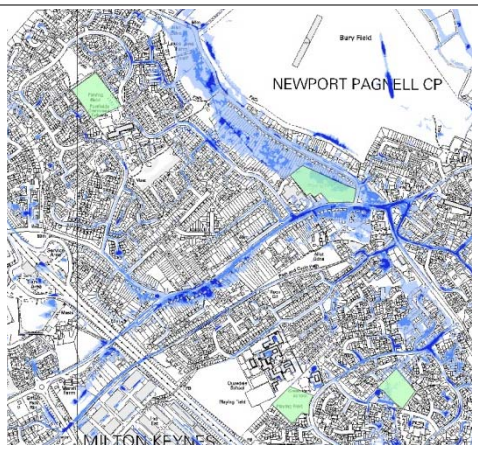

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Figure 8-4: Attenuation SuDS Recommended at Newport Pagnell.

Increasing Capacity and Conveyance of Drainage Systems: The surface water sewers and highway drains in the worst affected areas of Newport Pagnell (such as on the High Street) could be increased in size to aid in the conveyance of waters. This could be coupled with increasing the maintenance of the existing gullies and installation of new gullies or channel drains to increase conveyance further. There are also numerous watercourses across this CDC which could benefit from vegetation maintenance to improve conveyance.

Managing Overland Flows: In the most at-risk residential areas of Newport Pagnell, surface water flood flow routes tend to follow highways. However, in some residential areas, kerbs heights are generally low and would subsequently benefit in being raised to channel water away from at risk properties.

Installation of Flood Gates: The MKC Drainage Team is considering implementing flood gates along Little Linford Lane to prevent residents accessing an area of high flood risk.

Approximate Cost	Attenuation SuDS (tanked permeable paving or tanked geocellular storage) retrofitted across school parking areas and the industrial estate to the east of the CDC: £251-£500k Flood storage areas or basins implemented in fields at Portfield Combined Schools, Newport Pagnell Youth Club, Green Park School and Kingfisher Park: £1m - £10m Increasing Capacity and Conveyance of Drainage Systems: £101k-£250k* Installation of Flood Gates:£3-5k *It should be noted that estimated costs for increasing culvert capacity are based upon a cross-sectional area of 1m^2 and 50m in length (to give an average cost per m length of culvert of £3,700). A length of 30m has subsequently been assumed.
Potential Benefits	The installation of attenuation SuDS as proposed in Newport Pagnell could protect up to **12 buildings**.
Quick Wins	The following measures (**some of which are Borough-wide options**) could be implemented alongside the preferred options as 'quick wins'. – Improved maintenance regimes of drainage systems and ensuring resources are available to deliver this measure; and, – Property level protection (dependent upon number of properties, proposed measures

CDC8: Newport Pagnell	
	and associated costs). Property level protection (a receptor measure) has been recommended for this CDC as it is not deemed possible to alleviate surface water flooding extensively through source control measures.
Relevant Borough-wide Options	The following Borough-wide measures, as outlined in Section 7.4 are relevant to Newport Pagnell: – Planning and development control measures; and, – Social change, education and awareness.
Other Potential Options for Consideration	
Option A	– Retrofitting of rain gardens (if environmental and economic barriers can be overcome) , see Appendix C.

8.7 Olney Preferred Options

CDC10: Olney

Preferred Option - Combined Measures:

- Attenuation SuDS – Retrofitting of tanked permeable paving or tanked geocellular storage across the vehicle parking areas/play areas at Olney Junior and Middle School; and,
- Increased capacity of drainage systems.

Attenuation SuDS: Attenuation SuDS in the form of tanked permeable paving or tanked geocellular storage or bunds/basins dependent upon the land use cover (i.e. hardstanding or green space) could be installed across Olney Junior and Middle School (Figure 8-5). Generally, surface waters flow in an easterly direction across Olney, with the flow paths surrounding the two schools flowing in a south-westerly direction. Therefore the installation of attenuation SuDS in these two areas could reduce surface water flood risk in the residential area of Spring Lane (and surrounding cul-de-sacs) and Dinglederry leading to Newton Street.
If onsite investigations show that attenuation SuDS are not feasible, Infiltration SuDS may be utilised, though the exact location of the potential area for infiltration SuDS (i.e. Olney Middle and Junior School) would need to be determined.

Increasing Capacity of Drainage Systems: The surface water sewers and highway drains in the worst affected areas could be increased in size, most significantly in the High Street. This could be coupled with increasing the maintenance of the existing gullies and installation of new gullies or channel drains to increase conveyance further.

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Figure 8-5: Recommended Attenuation SuDS in Olney

Approximate Cost	Attenuation SuDS – Tanked permeable paving or tanked geocellular storage could be retrofitted across the vehicle parking areas at the schools across Olney: £1m-£10m Attenuation SuDS - bunds or basins could be installed within the school green space: £1m-£10m Infiltration SuDS: <£25k Increasing Capacity of Drainage Systems: £101k - £250k* *It should be noted that estimated costs for increasing culvert capacity are based upon a cross-sectional area of 1m^2 and 50m in length (to give an average cost per m length of culvert of £3,700). A length of 30m has subsequently been assumed.
Potential Benefits	The installation of attenuation SuDS as proposed in Olney could protect up to **23 buildings**.
Quick Wins	The following measures (**some of which are Borough-wide options**) could be implemented alongside the preferred options as 'quick wins'. – Improved maintenance regimes of drainage systems and ensuring resources are available to deliver this measure; and, – **Property level protection (**dependent upon number of properties, proposed measures and associated costs). Property level protection (a receptor measure) has been recommended for this CDC as it is not deemed possible to alleviate surface water flooding extensively through source control measures.
Relevant Borough-wide Options	The following Borough-wide measures, as outlined in Section 7.4 are relevant to Olney: – Planning and development control measures; and, – Social change, education and awareness.
Other Potential Options for Consideration	
Option A	– Retrofitting of rain gardens (if environmental and economic barriers can be overcome) , see Appendix C.
Option B	– Managing overland flows (High Street and Spring Lane) if economic challenges can be overcome, see Appendix C.

8.8 Brinklow Preferred Options

CDC11: Brinklow

Preferred Option - Combined Measures:

- Attenuation SuDS (tanked permeable paving or tanked granular storage) retrofitted across vehicle parking areas of Brinklow industrial estate and at the Kingston Centre;
- Attenuation SuDS at Monkston Primary School's playing field; and,
- Increasing capacity of drainage systems such as those along Chippenham Drive.

Attenuation SuDS: Whilst permeable paving would not be suitable due to heavy goods vehicles on site, tanked permeable paving or tanked geocellular storage could be retrofitted across the vehicle parking areas in Brinklow industrial estate and the Kingston Centre. This measure could reduce surface water flood risk to the industrial estate and may also provide benefits to the wider area including the residential areas leading off Tongwell Street such as Chetwode Avenue, Lanercost Crescent and Lindisfarne Drive. Flood alleviation is likely to be enhanced further by attenuation SuDS at Monkston Drive Primary School's playing field which could take the form of a basin or bund. Attenuated stormwater could discharge to the existing public surface water sewers over specified overland routes at a restricted rate. Where surface water would be discharged to the Broughton Brook through the AWS sewer system, consent would be required from the Bedford Group of Drainage Boards.

Increasing Capacity of Drainage Systems: Extra gullies in the road around the roundabout north of the Kingston Centre in Chippenham Drive could assist with conveying surface water flood flows away from the roundabout and into the surface water sewer, subject to AWS agreement/approval. This could therefore reduce surface water flood risk to the wider environment, providing the capacity of the sewer network is adequate.

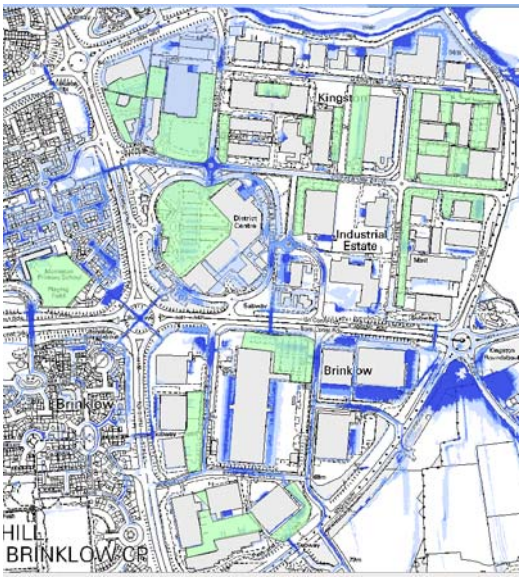

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Figure 8-6: Recommended Attenuation SuDS in Brinklow

Approximate Cost	Attenuation SuDS at the Brinklow Industrial Estate and Kingston Centre: £1m-£10m Attenuation SuDS at Monkston Primary School : £251k-£500k Initial estimates for increasing the capacity of drainage systems was estimated to be approximately £101k - £250k*, however due to the technical requirements of the scheme (i.e. the requirement to start a new outfall into the river and work back possibly using micro tunnelling under buildings on the east side of the High Street) means realistically this option may be more realistically costed at £1m-£10m. *It should be noted that estimated costs for increasing culvert capacity are based upon a cross-sectional area of 1m^2 and 50m in length (to give an average cost per m length of culvert of £3,700). A length of 30m has subsequently been assumed.
Potential Benefits	The installation of attenuation SuDS at Monkston Primary School and Brinklow Industrial Estate/Kingston Centre could protect up to **36 buildings** respectively.
Quick Wins	The following measures **(some of which are Borough-wide options)** could be implemented alongside the preferred options as 'quick wins'. – Improved maintenance regimes of drainage systems and ensuring resources are available to deliver this measure; and, – Property level protection (dependent upon number of properties, proposed measures and associated costs). Property level protection (a receptor measure) has been recommended for this CDC as it is not deemed possible to alleviate surface water flooding extensively through source control measures.
Relevant Borough-wide Options	The following Borough-wide measures, as outlined in Section 7.4 are relevant to Brinklow: – Planning and development control measures; and,

CDC11: Brinklow	
	– Social change, education and awareness.
Other Potential Options for Consideration	
Option A	– Retrofitting of rain gardens (if environmental and economic barriers can be overcome), see Appendix C.
Option B	– Managing overland flows – Reprofiling of the commercial area of Brinklow and Kingston to redirect flows.

8.9 Medbourne/Crownhill Preferred Options

CDC12: Medbourne/Crownhill Preferred Options

Preferred Option - Combined Measures:

- Attenuation SuDS located at the recreation ground at Grange Farm, green space forming the Medbourne Community Sports Pavilion, Loughton Manor First School and the Green Space in between Shenley Wood and Chalkdell Drive. Tanked permeable paving or tanked geocellular storage could also be retrofitted across the vehicle parking areas of Chalkdell Drive; and,
- Increasing capacity of drainage systems.

Attenuation SuDS: Within Medbourne and Crownhill there are a number of potential areas for the implementation of attenuation SuDS. Generally, surface waters flow from the south-west to the north-east within this CDC. Therefore, in order to attenuate surface waters at the catchment source, flood alleviation measures should be implemented within the Medbourne/Shenley Wood area.

The following areas have been suggested as suitable for SuDS measures:

- Recreation ground at Grange Farm;
- Green space forming the Medbourne Community Sports Pavilion;
- Loughton Manor First School playing field (provides surface water attenuation further down in the catchment to alleviate surface water flooding to the residential areas located off Olde Bell Lane); and,
- Green Space in between Shenley Wood and Chalkdell Drive.

The rationale behind the implementation of the above measures is to reduce the flood risk posed by the well-defined surface water flow paths which span the CDC, ultimately affecting the residential areas of Medbourne/Crownhill including: Monro Avenue, Pascal Drive, Duncan Grove, Shepperds Green, Edmund Court, Haddon, Holyrood, and Highgrove Hill. Stormwater attenuated from these measures could discharge to the existing surface waters sewers at a restricted rate.

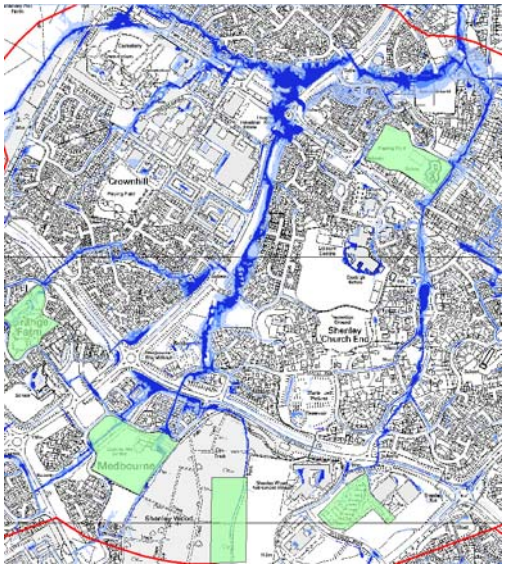

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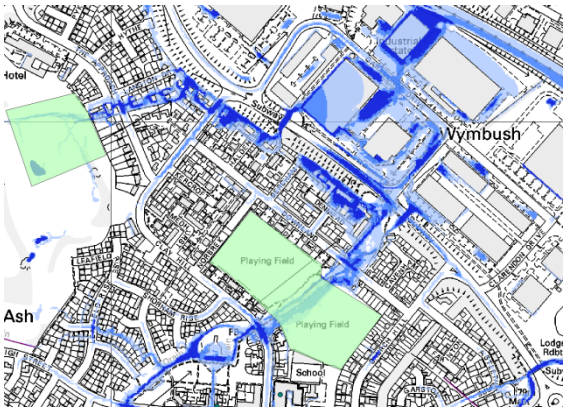
Figure 8-7: Recommended SuDS at Medbourne/Crownhill.

Increasing Capacity of Drainage Systems: Upsizing the existing surface water sewer network in flood hotspots, possibly compiled with increasing the number of gullies or installing channel drains which outfall into upsized sewers, could assist in alleviating the surface water flood risk across this CDC. Potential areas where increasing the capacity of drainage systems may alleviate surface water flooding includes Loughton Roundabout.

Approximate Cost	Attenuation SuDS: £1m - £10m Tanked permeable paving around Chalkwell Drive, community centre and schools: £1m - £10m Increasing Capacity of Drainage Systems: £101k - £250k* *It should be noted that estimated costs for increasing culvert capacity are based upon a cross-sectional area of 1m^2 and 50m in length (to give an average cost per m length of culvert of £3,700). A length of 30m has subsequently been assumed.
Potential Benefits	The installation of attenuation SuDS as proposed in Medbourne/Crownhill could protect up to **114 buildings**.
Quick Wins	The following measures **(some of which are Borough-wide options)** could be implemented alongside the preferred options as 'quick wins'. – Improved maintenance regimes of drainage systems and ensuring resources are available to deliver this measure such at Shenley Church End; and, – Property level protection (dependent upon number of properties, proposed measures and associated costs). Property level protection (a receptor measure) has been recommended for this CDC as it is not deemed possible to alleviate surface water flooding extensively through source control measures.

Relevant Borough-wide Options	The following Borough-wide measures, as outlined in Section 7.4 are relevant to Medbourne/Crownhill: – Planning and development control measures; and, – Social change, education and awareness.
Other Potential Options for Consideration	
Option A	– Retrofitting of rain gardens (if environmental and economic barriers can be overcome), see Appendix C.
Option B	– Managing overland flows across the residential areas to the north of Medbourne Community Sports Pavilion, southeast of Shenley Church End Recreation Ground and east of Crownhill.

8.10 Wymbush/ Two Mile Ash Preferred Options

CDC13: Wymbush/Two Mile Ash	
Preferred Option: – Attenuation SuDS at the Golf Course to the west of the CDC and the school playing fields adjacent to Downland.	
Attenuation SuDS: There are two potential areas within Wymbush and Two Mile Ash where attenuation SuDS could be utilised to alleviate surface water flooding. These areas include the Golf Course to the west of the CDC and the school playing fields adjacent to Downland. In both of these areas there is the potential to implement a flood storage basin, with the option of a bund on the two school playing fields. The implementation of these measures could benefit the north-eastern extent of the CDC, including the Wymbush Industrial estate and the residential areas south of Great Monks Street such as Denmead and Langton Drive. Storm waters attenuated from these measures could discharge to the existing surface waters sewers at a restricted rate.	 *Contains Ordnance Survey data © Crown copyright and database right 2016* **Figure 8-8: Recommended SuDS for Wymbush/Two Mile Ash**
Approximate Cost	Attenuation SuDS: £1m - £10m
Potential Benefits	The installation of attenuation SuDS as proposed in Wymbush/Two Mile Ash could protect up to **64 buildings**.
Quick Wins	The following measures **(some of which are Borough-wide options)** could be implemented alongside the preferred options as 'quick wins'. – Clearance of the ditch which separates the two school playing fields adjacent to Downland; – Improved maintenance regimes of drainage systems and ensuring resources are available to deliver this measure; and, – Property level protection (dependent upon number of properties, proposed measures and associated costs). Property level protection (a receptor measure) has been recommended for this CDC as it is not deemed possible to alleviate surface water flooding extensively through source control measures.
Relevant Borough-wide Options	The following Borough-wide measures, as outlined in Section 7.4 are relevant to Wymbush/Two Mile Ash: – Planning and development control measures; and, – Social change, education and awareness.
Other Potential Options for Consideration	
Option A	– Retrofitting of rain gardens (if environmental and economic barriers can be overcome), see Appendix C.

8.11 Bradwell Abbey Preferred Options

CDC14: Bradwell Abbey

Preferred Option - Combined Measures:

- Attenuation SuDS at Bradwell Abbey Golf Course opposite Dalvina and Kildonan Place. Attenuation SuDS could also be implemented at the northern extent of Bradwell Abbey cricket field (next to Calvie Croft) and at the vegetated area to the south of Millers Way just north of Myrtle Bank;
- Increased capacity and conveyance of drainage systems i.e. upsizing of existing surface water sewer network at White Alder; and,
- Managing overland flows through kerb raising at White Alder.

Attenuation SuDS: There are a number of potential areas for attenuation SuDS within Bradwell Abbey including:

- Bradwell Abbey Golf Course opposite Dalvina and Kildonan Place;
- The northern extent of Bradwell Abbey cricket field (next to Calvie Croft); and,
- The vegetated area to the south of Millers Way just north of Myrtle Bank.

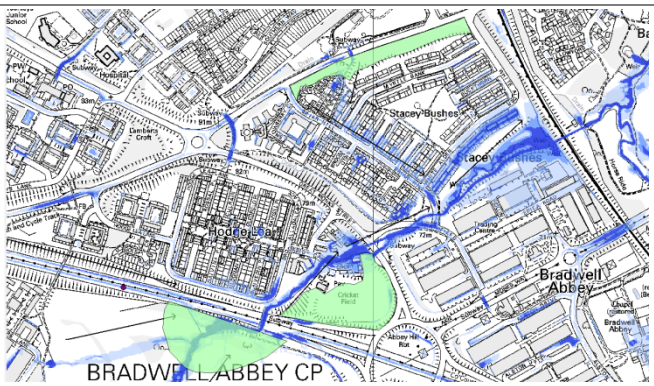


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Figure 8-9: Recommended SuDS at Bradwell Abbey

The installation of the of an attenuation bund at the Bradwell Abbey Golf Course opposite Dalvina and Kildonan Place has the potential to reduce surface water flood risk across the CDC by intercepting and attenuating the well-defined surface water flow path which flows in a north-easterly direction originating from Upper Weald. This measure in conjunction with an attenuation basin at the Bradwell Abbey Cricket Field and the lakes in the western expansion area could reduce surface water flood risks in the residential areas of Hodge Lea and to a certain extent, Stacey Bushes. Stacey Bushes could be offered further flood alleviation by the installation of an attenuation basin to the north of Myrtle Bank. Storm waters attenuated from these measures could discharge to the existing surface waters sewers at a restricted rate.

Increasing Capacity and Conveyance of Drainage Systems: Upsizing the existing surface water sewer network in flood hotspots, such as White Alder, possibly in conjunction with increasing the number of gullies or installing channel drains which outfall into upsized sewers, could assist in alleviating the surface water flood risk across this CDC. There is also an ordinary watercourse which cuts across this CDC which could benefit from vegetation clearance and maintenance.

Managing Overland Flows: There is the potential for raising the kerb heights of highway networks which are shown to at a high risk of surface water flooding, particularly in residential areas such as White Alder which has lower kerbs.

Approximate Cost	Attenuation SuDS at Bradwell Abbey Golf Course opposite Dalvina and Kildonan Place with approximately 140m^3 of embankment: <£25k Attenuation SuDS could also be implemented at the northern extent of Bradwell Abbey Cricket Field with approximately 150m^3 of embankment: <£25k. Increasing Capacity and Conveyance of Drainage Systems: £101k - £250k* *It should be noted that estimated costs for increasing culvert capacity are based upon a cross-sectional area of 1m^2 and 50m in length (to give an average cost per m length of culvert of £3,700). A length of 30m has subsequently been assumed.
Potential Benefits	The installation of attenuation SuDS as proposed in Bradwell Abbey could protect up to **83 buildings**.
Quick Wins	The following measures **(some of which are Borough-wide options)** could be implemented alongside the preferred options as 'quick wins'. – Improved maintenance regimes of drainage systems and ensuring resources are available to deliver this measure; and, – Property level protection (dependent upon number of properties, proposed measures and associated costs). Property level protection (a receptor measure) has been recommended for this CDC as it is

CDC14: Bradwell Abbey	
	not deemed possible to alleviate surface water flooding extensively through source control measures.
Relevant Borough-wide Options	The following Borough-wide measures, as outlined in Section 7.4 are relevant to Bradwell Abbey: – Planning and development control measures; and, – Social change, education and awareness.
Other Potential Options for Consideration	
Option A	– Retrofitting of rain gardens (if environmental and economic barriers can be overcome) , see Appendix C.

8.12 Stony Stratford Preferred Options

CDC15: Stony Stratford

Preferred Option - Combined Measures:

- Attenuation SuDS (tanked permeable paving or tanked geocellular storage) could be retrofitted across the vehicle parking areas for the school in Stony Stratford. Attenuation basins could also be installed at the green space between the residential areas of Latimer and Millford Avenue. Permeable paving could also be implemented at the vehicle parking area at Vicarage Road; and,
- Increased conveyance and capacity of drainage systems along the High Street and Clarence Road.

Attenuation SuDS: Tanked permeable paving or tanked geocellular storage could be retrofitted across the vehicle parking area of the school in Stony Stratford. AWS have looked into the potential of implementing an upsized sewer at the school yet due have not yet done so due to the potential for future development at the site.

Further attenuation SuDS in the form of permeable paving could be implemented at the vehicle parking area of Vicarage Road. This measure, along with the proposed measures at St. Mary and St. Giles Church of England Junior School have the potential to alleviate flooding in the wider residential and commercial area including properties on the High Street.

Similarly, the proposed flood storage basin across the green space between the residential areas of Latimer and Millford Avenue has the potential to provide flood alleviation across a wide residential area including Goran Avenue and The Limes. These measures may act to attenuate storm water and could subsequently discharge it to the existing public surface water sewers at a restricted rate.

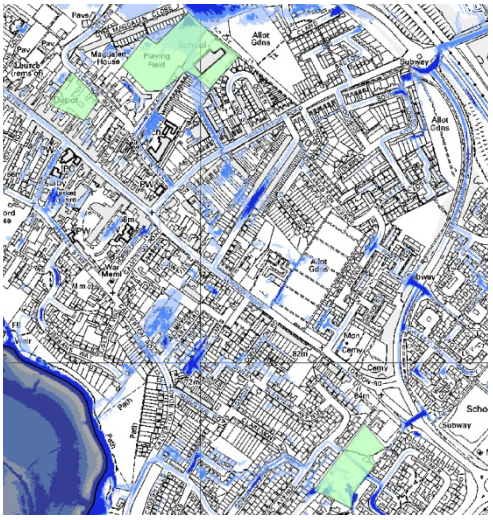

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Figure 8-10: Recommended SuDS for Stony Stratford.

Increasing Capacity and Conveyance of Drainage Systems: Whilst there are a number of gullies in the areas of defined surface water flow paths, this infrastructure may not have the capacity required to convey surface waters effectively and may subsequently result in surface water flooding. Upsizing the existing surface water sewer network in flood hotspots, possibly in conjunction with increasing the number of gullies or installing channel drains which outfall into upsized sewers, could assist in alleviating the surface water flood risk across this CDC. The High Street and Clarence Road are areas which may benefit from this measure.

Approximate Cost	Tanked permeable paving or tanked geocellular storage could also be retrofitted across the vehicle parking areas of the school:£51k-£100k Attenuation basin in the green space between Latimer and Milford Avenue: £251k-£500k Permeable paving at vehicle parking area of Vicarage Road: £1m-£10m* Increasing Capacity and Conveyance of Drainage Systems: £101k - £250k** *It should be noted that the permeable paving proposed across the parking area of Vicarage Road covers a large area. Should it be possible to reduce the area of coverage, costs could be limited to £500k-£1m. **It should be noted that estimated costs for increasing culvert capacity are based upon a cross-sectional area of 1m^2 and 50m in length (to give an average cost per m length of culvert of £3,700). A length of 30m has subsequently been assumed.
Potential Benefits	The installation of attenuation SuDS as proposed in Stony Stratford is likely to protect **11 buildings.**
Quick Wins	The following measures **(some of which are Borough-wide options)** could be implemented alongside the preferred options as 'quick wins'. – Improved maintenance regimes of drainage systems and ensuring resources are available to deliver this measure; and, – Property level protection (dependent upon number of properties, proposed measures and associated costs). Property level protection (a receptor measure) has been recommended for this CDC as it is not deemed possible to alleviate surface water flooding extensively through source control measures.

CDC15: Stony Stratford	
Relevant Borough-wide Options	The following Borough-wide measures, as outlined in Section 7.4 are relevant to Stony Stratford: – Planning and development control measures; and, – Social change, education and awareness.
Other Potential Options for Consideration	
Option A	– Retrofitting of rain gardens (if environmental and economic barriers can be overcome), see Appendix C.

8.13 Oldbrook Options

CDC17: Oldbrook

Preferred Option - Combined Measures:

- Attenuation SuDS (tanked permeable paving or tanked geocellular storage) could be retrofitted across the vehicle parking areas in Winterhill Retail Park;
- Attenuation SuDS could also be implemented at the playing field of the Jubilee Wood Primary School; and
- Increasing capacity and conveyance of drainage systems throughout the residential areas surrounding Oldbrook Cricket Ground.

Attenuation SuDS: Two areas within the Oldbrook CDC were highlighted as being potential areas for the implementation of attenuation SuDS; the Winterhill Retail Park and the playing field of the Jubilee Wood Primary School. At the Winterhill Retail Park, the installation of attenuation SuDS across vehicle parking areas has the potential to alleviate surface water flood risk at both the retail park and the wider environment, in particularly the residential area to the east of the industrial estate including Grace Avenue and Douglas Place which are shown to be at a high risk of surface water flooding. Flood alleviation within this area is also offered by the proposed flood attenuation basin at the Oldbrook Cricket Ground. This measure also has the potential to reduce surface water flood risk to the residential areas of Boycott Avenue, Shackleton Place and Hutton Avenue. Attenuated stormwater could discharge to existing public surface water sewers at a restricted rate.

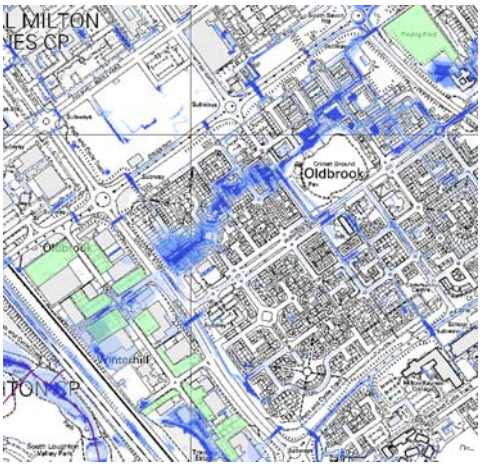

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Figure 8-11: Recommended SuDS in Oldbrook.

Increasing Capacity and Conveyance of Drainage Systems: Whilst there are a number of gullies in the areas of defined surface water flow paths, this infrastructure may not have the capacity required to convey surface waters effectively and may subsequently result in surface water flooding once the capacity is exceeded. Upsizing the existing surface water sewer network in flood hotspots, possibly in conjunction with increasing the number of gullies or installing channel drains which outfall into upsized sewers, could assist in alleviating the surface water flood risk across this CDC. The residential areas surrounding the Oldbrook Cricket Ground could to benefit from this measure.

Approximate Cost	Tanked permeable paving or tanked geocellular storage could be retrofitted across the vehicle parking areas of Winterhill Retail Park:£1m-£10m* Attenuation SuDS at the playing field of Jubilee Primary School: £251k-£500k Increasing Capacity and Conveyance of Drainage Systems: £101k - £250k* *It should be noted that the permeable paving proposed across the parking area of the Winterhill Retail Park covers a large area. Should it be possible to reduce the area of coverage, costs could be limited to £500k-£1m. Estimated costs for increasing culvert capacity are based upon a cross-sectional area of 1m^2 and 50m in length (to give an average cost per m length of culvert of £3,700). A length of 30m has subsequently been assumed.
Potential Benefits	The installation of attenuation SuDS as proposed in Oldbrook could protect up to **135 buildings**.
Quick Wins	The following measures **(some of which are Borough-wide options)** could be implemented alongside the preferred options as 'quick wins'. – Improved maintenance regimes of drainage systems and ensuring resources are available to deliver this measure; and, – Property level protection (dependent upon number of properties, proposed measures and associated costs). Property level protection (a receptor measure) has been recommended for this CDC as it is not deemed possible to alleviate surface water flooding extensively through source control measures.
Relevant Borough-wide Options	The following Borough-wide measures, as outlined in Section 7.4 are relevant to Oldbrook: – Planning and development control measures; and,

CDC17: Oldbrook	
	– Social change, education and awareness.
Other Potential Options for Consideration	
Option A	– Retrofitting of rain gardens (if environmental and economic barriers can be overcome).
Option B	– Managing overland flows – reprofiling of hardstanding areas of commercial buildings in Winterhill Retail Park (if found to be technically feasible), see Appendix C.

8.14 Bradwell Preferred Options

CDC19: Bradwell

Preferred Option - Combined Measures:

- Attenuation SuDS (tanked permeable paving or tanked geocellular storage) retrofitted across the vehicle parking areas of the Bradville Industrial Estate, Stantonbury School, Pepper Hill School and the industrial estate surrounding Fingle Drive. Where these areas also comprise green space i.e. Stanton School and Pepperhill School attenuation SuDS such as bunds etc. should be considered; and,
- Increased capacity conveyance of drainage systems at the junction between Monks Way and Grafton Street.

Attenuation SuDS: There are a number of areas across this CDC where attenuation SuDS could be installed. These include:

- The Bradville Industrial Estate;
- Stantonbury School;
- Pepper Hill School; and,
- The Industrial Estate surrounding Fingle Drive (permeable paving would not be suitable in areas used by heavy goods vehicles).

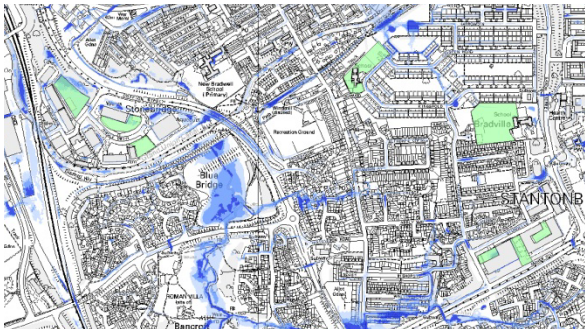

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Figure 8-12: Recommended SuDS for Bradwell

The installation of these measures has the potential to benefit a wide area in particularly New Bradwell, Bradville and Bradwell. The residential areas of Wallingford, Withington, Newport Road and St. Peters Way are anticipated to benefit the most from the installation of these measures. The development of the local centre may provide an opportunity for the installation of such measures. Attenuated stormwater could discharge to existing public surface water sewers at a restricted rate.

Increasing Capacity and Conveyance of Drainage Systems: Whilst there are a number of gullies in the areas of defined surface water flow paths, this infrastructure may not have the capacity required to convey surface waters effectively and may subsequently result in surface water flooding. Upsizing the existing surface water sewer network in flood hotspots, possibly in conjunction with increasing the number of gullies or installing channel drains which outfall into upsized sewers, could assist in alleviating the surface water flood risk across this CDC. The junction between Monks Way and Grafton Street could benefit from this measure.

Approximate Cost	Tanked permeable paving or tanked geocellular storage could also be retrofitted across the vehicle parking areas of Bradville Industrial Estate, Stanton School, Pepper hill School: £1m-10m Attenuation SuDS in green spaces at school: £251k-£500k Increasing Capacity and Conveyance of Drainage Systems: £101k – £250k* *It should be noted that estimated costs for increasing culvert capacity are based upon a cross-sectional area of 1m^2 and 50m in length (to give an average cost per m length of culvert of £3,700). A length of 30m has subsequently been assumed.
Potential Benefits	The installation of attenuation SuDS as proposed in Oldbrook could protect up to **102 buildings**.
Quick Wins	The following measures **(some of which are Borough-wide options)** could be implemented alongside the preferred options as 'quick wins'. – Improved maintenance regimes of drainage systems and ensuring resources are available to deliver this measure; and, – Property level protection (dependent upon number of properties, proposed measures and associated costs). Property level protection (a receptor measure) has been recommended for this CDC as it is not deemed possible to alleviate surface water flooding extensively through source control measures.
Relevant Borough-wide Options	The following Borough-wide measures, as outlined in Section 7.4 are relevant to Bradwell: – Planning and development control measures; and, – Social change, education and awareness.
Other Potential Options for Consideration	
Option A	– Retrofitting of rain gardens (if environmental and economic barriers can be overcome), see Appendix C.

8.15 West Bletchley Preferred Options

CDC20: West Bletchley

Preferred Option - Combined Measures:

- Attenuation Suds in Oxley Park Academy, Howe Park wood, Green space next to the N of Snelshall West Industrial Estate, Windmill Hill Golf course, Chestnuts School (Green Space), St. Thomas Aquinas Catholic Primary School and Barleyhurst park Primary School; and,
- Increased conveyance and capacity of drainage networks in residential areas across the CDC.

Attenuation SuDS: A number of areas across this CDC could be suitable for the implementation of attenuation SuDS. These areas include:

- Oxley Park Academy;
- Howe Park wood;
- Green space next to the N of Snelshall West Industrial Estate;
- Windmill Hill Golf course;
- Chesnuts School (Green Space);
- St. Thomas Aquinas Catholic Primary School; and,
- Barleyhurst park Primary School.

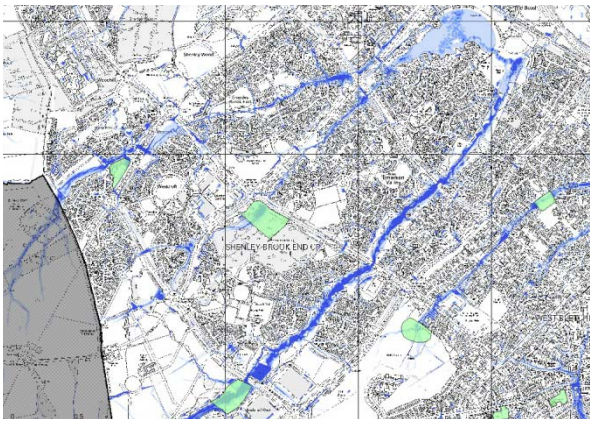

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Figure 8-13: Recommended SuDS for West Bletchley

The implementation of these measures has the potential to intercept the well-defined surface water flow paths across this CDC which flow in a north-easterly direction, some of which are constrained by the fluvial floodplains of the ordinary watercourses which are apparent within this CDC. Subsequently surface water flood risks could be reduced across the wider area including the residential areas of Westcroft, Emerson Valley and Selbourne Avenue. Attenuated stormwater could discharge to existing public surface water sewers or to local watercourses at a restricted rate.

Increasing Capacity and Conveyance of Drainage Systems: Whilst there are a number of gullies in the areas of defined surface water flow paths, this infrastructure may not have the capacity required to convey surface waters effectively and may subsequently result in surface water flooding. Upsizing the existing surface water sewer network in flood hotspots, possibly in conjunction with increasing the number of gullies or installing channel drains which outfall into upsized sewers, could assist in reducing the surface water flood risk across this CDC. Residential areas across this CDC could benefit from increasing the capacity and/or conveyance of highway drainage networks.

Approximate Cost	Attenuation SuDS at Oxley Park Academy, Howe Park wood, Green space next to the N of Snelshall West Industrial Estate, Windmill Hill Golf course, Chesnuts School (Green Space), St. Thomas Aquinas Catholic Primary School and Barleyhurst park Primary School: £1m-£10m Increasing Capacity and Conveyance of Drainage Systems: £101k – £250k* *It should be noted that estimated costs for increasing culvert capacity are based upon a cross-sectional area of 1m^2 and 50m in length (to give an average cost per m length of culvert of £3,700). A length of 30m has subsequently been assumed.
Potential Benefits	The installation of attenuation SuDS as proposed in West Bletchley could protect up to **175 buildings**.
Quick Wins	The following measures **(some of which are Borough-wide options)** could be implemented alongside the preferred options as 'quick wins'. – Improved maintenance regimes of drainage systems and ensuring resources are available to deliver this measure; and, – Property level protection (dependent upon number of properties, proposed measures and associated costs). Property level protection (a receptor measure) has been recommended for this CDC as it is not deemed possible to alleviate surface water flooding extensively through source control measures.
Relevant Borough-wide Options	The following Borough-wide measures, as outlined in Section 7.4 are relevant to West Bletchley:

CDC20: West Bletchley	
	– Planning and development control measures; and, – Social change, education and awareness.
Other Potential Options for Consideration	
Option A	– Retrofitting of rain gardens (if environmental and economic barriers can be overcome), see Appendix C.

8.16 Preferred Options Summary

Table 8-1 summarises the preferred options identified through the Phase 3 for addressing surface water flood risk in the prioritised CDCs.

Table 8-1: Preferred Options Summary

CDC_ID	CDC Name	Option Category	Option Description	Combination Scheme?	Costing & Storage Volumes									Benefits	
					Measures	Unit Cost (£)	Unit Description	Units	Length	Area	Depth	Volume	Cost Band (£000s)	Cost Band for Combination Scheme (£000s)	Number of buildings with reduced flood risk
CDC 1	Ravenstone	Source Control, Attenuation and SUDS	Infiltration SuDS to the north of Northend Farm and the northeast of Abbey Farm.	✓	Swales	28	m2 of swale area	m2	800	1600	0.2	-	£26k - £50k	**£26-50k OR £1m - £10m (Dependent upon choice of measure implemented)**	21
			OR Attenuation SuDS to the north of Northend Farm and the northeast of Abbey Farm (basins or bunded areas).		Bund / Flow Restriction	46	m3 of embankment	m3	-	69,000	1	69000	£1m - £10m		
CDC 4	Woburn Sands	Source Control, Attenuation and SUDS	Attenuation SuDS at Old Park Farm and southeast of Walton High School playing field.	✓	Detention Basin	22	m3 of detention volume	m3	-	55,000	1	55000	£1m - £10m	**£1m-£10m**	10
		De-culvert / Increase Conveyance	Watercourse clearance and increasing capacity at Cranfield Road through use of an oversized pipe.		Increasing Capacity in Drainage Systems	3,700	m of culvert	m	30	-	-	-	£101k - £250k		
CDC 6	Downs Barn and Conniburrow	Source Control, Attenuation and SUDS	Attenuation SuDS at land south of Dansteed Way including land west of Capel Drive, land west of Overstreet and land west of the Grand Union Canal	✓	Detention Basin	22	m3 of detention volume	m3	-	37,000	1	37000	£501k - £1m	**£501k - £1m**	36
CDC 8	Newport Pagnell	Source Control, Attenuation and SUDS	Attenuation SuDS (tanked permeable paving or tanked geocellular storage) retrofitted across school parking areas and the industrial estate to the east of the CDC.	✓	Permeable Paving using Grasscrete	65	m2 of surface	m2	-	2875	-	-	£501k-£1m	**£1m - £10m**	12
		Flood Storage / Permeability	Flood storage areas or basins implemented in fields at Portfield Combined Schools, Newport Pagnell Youth Club, Green Park School and Kingfisher Park		Detention Basin	22	m3 of detention volume	m3	-	62000	1	62000	£1m - £10m		
		Other - Improvement to Drainage Infrastructure	Increased capacity of drainage systems in key locations such as the High Street.		Increasing Capacity in Drainage Systems	3,700	m of culvert	m	30	-	-	-	£101k - £250k		
		Infrastructure Resilience	Implementation of flood gates at Little Linford Lane		Temporary or Demountable Flood Defences (Large Scale)	MKC have suggested this will cost £3-5k.									
CDC 10	Olney	Source Control, Attenuation and SUDS	Attenuation SuDS – Tanked permeable paving or tanked geocellular storage could be retrofitted across the vehicle parking areas of the schools across Olney and across the industrial estate to the north of the CDC.	✓	Permeable Paving using Grasscrete	65	m2 of surface	m2	-	5700	-	-	£501k-£1m	**£1m - £10m**	23
			Attenuation SuDS - bunds or basins could be installed within the schools green space.		Detention Basin	22	m3 of detention volume	m3	-	48000	1	48000	£1m - £10m		
			Infiltration SuDS- Schools green space		Soakaways (5 required)	551.8	per soakaway	-	-	-	-	-	<£25k		
		Other - Improvement to Drainage Infrastructure	Increased capacity of drainage systems		Increasing Capacity in Drainage Systems	3,700	m of culvert	m	30	-	-	-	£101k - £250k		
CDC 11	Brinklow	Source Control, Attenuation and SUDS	Attenuation SuDS (Tanked permeable paving or tanked granular storage) retrofitted across vehicle parking areas of Brinklow industrial estate and at the Kingston Centre.	✓	Permeable Paving using Grasscrete	65	m2 of surface	m2	-	71500	-	-	£1m - £10m	**£1m-£10m**	36
			Attenuation SuDS - bunds or basins could be installed within the Monkston primary school green space		Detention Basin	22	m3 of detention volume	m3	-	18000	1	-	£251k - £500k		
		Other - Improvement to Drainage Infrastructure	Increasing capacity of drainage systems such as those along Chippenham Drive		Increasing Capacity in Drainage Systems	3,700	m of culvert	m	30	-	-	-	£101k - £250k		
CDC 12	Medbourne / Crownhill	Source Control, Attenuation and SUDS	Attenuation SuDS located at the recreation ground at Grange Farm, green space	✓	Detention Basin	22	m3 of detention volume	m3	-	120,000	1	120000	£1m - £10m	**£1m - £10m**	114

CDC_ID	CDC Name	Option Category	Option Description	Combination Scheme?	Costing & Storage Volumes									Cost Band for Combination Scheme (£000s)	Benefits
					Measures	Unit Cost (£)	Unit Description	Units	Length	Area	Depth	Volume	Cost Band (£000s)		Number of buildings with reduced flood risk
			forming the Medbourne Community Sports Pavilion and green space surrounding Chalkdell Drive												
			Tanked permeable paving or tanked geocellular storage could also be retrofitted across the vehicle parking areas of Chalkdell Drive, Medbourne Community Sports Pavilion and the schools across this CDC		Permeable Paving using Grasscrete	65	m2 of surface	m2	-	55250	-	-	£1m - £10m		
		Other - Improvement to Drainage Infrastructure	Increasing capacity of drainage systems.		Increasing Capacity in Drainage Systems	3,700	m of culvert	m	50	-	-	-	£101k - £250k		
CDC 13	Wymbush/Two Mile	Source Control, Attenuation and SUDS	Attenuation SuDS at the Golf Course to the west of the CDC and the school playing fields adjacent to Downland.	✓	Detention Basin	22	m3 of detention volume	m3		200000	1	200000	£1m - £10m	**£1m - £10m**	64
CDC 14	Bradwell Abbey	Source Control, Attenuation and SUDS	Attenuation SuDS at Bradwell Abbey Golf Course opposite Dalvina and Kildonan Place.	✓	Bund / Flow Restriction	46	m3 of embankment	m3	140	140	1	140	<£25k	**£101k - £250k**	83
			Attenuation SuDS could also be implemented at the northern extent of Bradwell Abbey Cricket Field		Bund / Flow Restriction	46	m3 of embankment	m3	150	150	1	150	<£25k		
		Other - Improvement to Drainage Infrastructure	Increasing capacity of drainage systems.		Increasing Capacity in Drainage Systems	3,700	m of culvert	m	50	-	-	-	£101k - £250k		
		Preferential / Designated Overland Flow Routes	Kerb heights could be raised on highway networks at high risk		Managing Overland Flows (Preferential Flowpaths)	Unknown									
CDC 15	Stony Stratford	Source Control, Attenuation and SUDS	Tanked permeable paving or tanked geocellular storage could also be retrofitted across the vehicle parking areas of the school	✓	Permeable Paving using Grasscrete	65	m2 of surface	m2	-	500	-	-	£51-£100k	**£1m - £10m**	11
			Attenuation basin in the green space between Latimer and Milford Avenue		Detention Basin	22	m3 of detention volume	m3	-	11500	1	11500	£251k - £500k		
			Permeable paving at vehicle parking area of Vicarage Road		Permeable Paving using Grasscrete	65	m2 of surface	m2	-	4000	-	-	£501k - £1m		
		Other - Improvement to Drainage Infrastructure	Increasing capacity of drainage systems.		Increasing Capacity in Drainage Systems	3,700	m of culvert	m	50		-	-	£101k - £250k		
CDC 17	Oldbrook	Source Control, Attenuation and SUDS	Tanked permeable paving or tanked geocellular storage could also be retrofitted across the vehicle parking areas of Winterhill Retail Park	✓	Permeable Paving using Grasscrete	65	m2 of surface	m2	-	44000	-	-	£1m - £10m	**£1m - £10m**	135
			Attenuation SuDS at the playing field of Jubilee Primary School		Detention Basin	22	m3 of detention volume	m3	-	15500	1	15500	£251k - £500k		
		Other - Improvement to Drainage Infrastructure	Increasing capacity of drainage systems.		Increasing Capacity in Drainage Systems	3,700	m of culvert	m	50	-	-	-	£101k - £250k		
CDC 19	Bradwell	Source Control, Attenuation and SUDS	Tanked permeable paving or tanked geocellular storage could also be retrofitted across the vehicle parking areas of Bradville Industrial Estate, Stanton School, Pepper hill School	✓	Permeable Paving using Grasscrete	65	m2 of surface	m2	-	16000	-	-	£1m - £10m	**£1m - £10m**	102
			Attenuation SuDS in green spaces at schools		Detention Basin	22	m3 of detention volume	m3	-	20000	1	20000	£251k - £500k		
		Other - Improvement to Drainage Infrastructure	Increasing capacity of drainage systems at junction between Monks Way and Grafton Street		Increasing Capacity in Drainage Systems	3,700	m of culvert	m	30	-	-	-	£101k - £250k		
CDC 20	West Bletchley	Source Control, Attenuation and SUDS	Attenuation SuDS at Oxley Park Academy, Howe Park wood, Green space next to the N of Snelshall West Industrial Estate, Windmill Hill Golf course, Chesnuts School	✓	Detention Basin	22	m3 of detention volume	m3	-	170000	1	170000	£1m - £10m	**£1m - £10m**	175

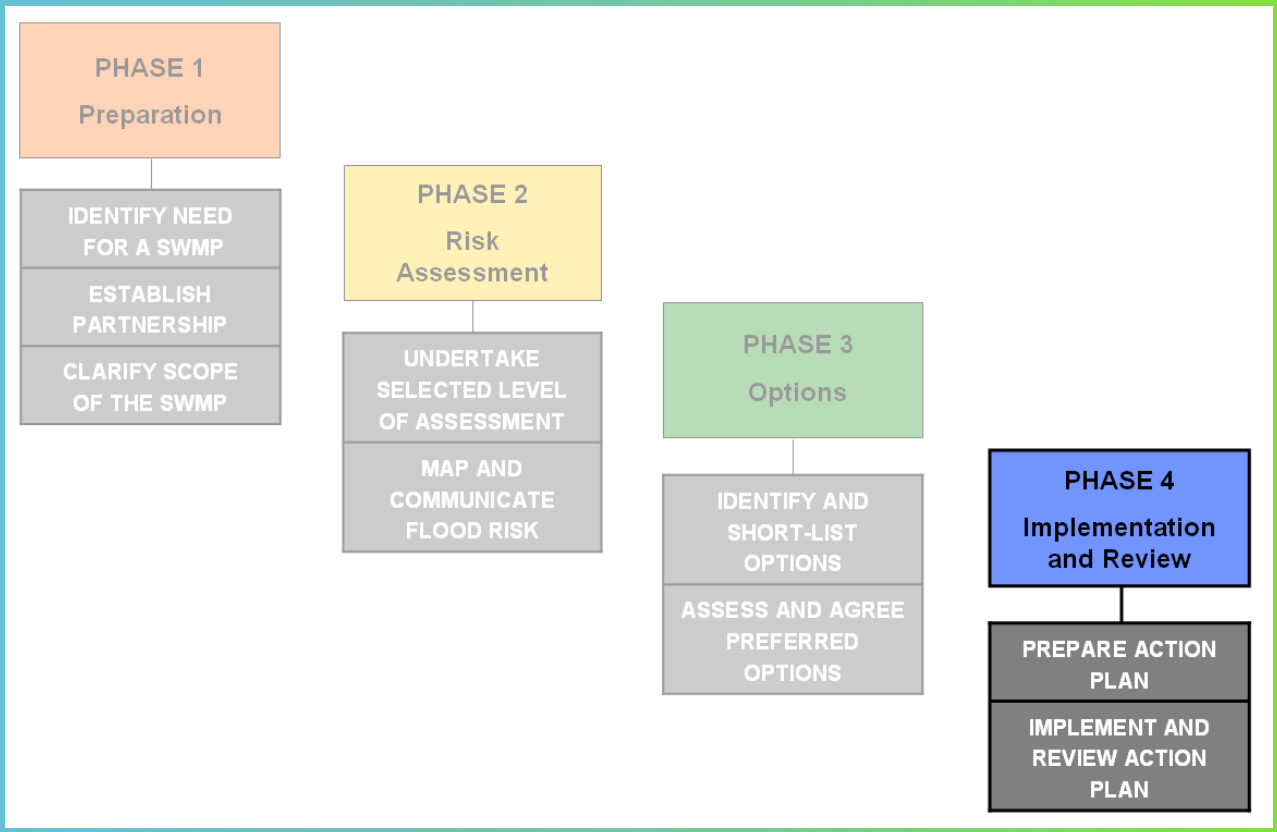
CDC_ID	CDC Name	Option Category	Option Description	Combination Scheme?	Costing & Storage Volumes									Cost Band for Combination Scheme (£000s)	Benefits
					Measures	Unit Cost (£)	Unit Description	Units	Length	Area	Depth	Volume	Cost Band (£000s)		Number of buildings with reduced flood risk
			(Green Space), St. Thomas Aquinas Catholic Primary School and Barleyhurst park Primary School												
		Other - Improvement to Drainage Infrastructure	Increasing capacity of drainage systems in residential areas across the CDC		Increasing Capacity in Drainage Systems	3,700	m of culvert	m	50				£101k - £250k		

Note: This table has been produced to assist with the preliminary cost estimates as part of the Milton Keynes SWMP. All dimensions and costs are indicative and should only be used for preliminary estimates due to the generalised nature of the information used to compile it. An estimated cost for the preferred flood mitigation option for each identified CDC has been calculated using standard unit costs based on best available industry standards and guidance. No monetised damages have been calculated, and flood mitigation costs have been determined using engineering judgement, but have not undergone detailed analysis. The following standard assumptions have been applied:

- The costs are the capital costs for implementation of the scheme only.
- Costs do not include provisions for consultancy, design, supervision, planning process, permits, environmental assessment or optimum bias.
- No provision is made for weather (e.g. winter working).
- No provision is made for access constraints.
- No provision is made for costs associated with land acquisition components.
- No operational or maintenance costs are included.
- No provision is made for disposal of materials (e.g. for flood storage or soakaway clearance).

As a result, costs have been provided as cost bands, reflecting the strategic nature of the SWMP study and options identification.

Phase 4: Implementation and Review



9 Implementation and Review Introduction

Phase 4 establishes a long-term Action Plan for Milton Keynes based on the findings of the previous stages of the SWMP. The purpose of the Action Plan is to:

- Outline the actions required to implement the preferred options identified in Phase 3;
- Identify the partners or stakeholders responsible for implementing the action;
- Provide an indication of the priority of the actions and a timescale for delivery; and,

Outline actions that can be undertaken across the borough by MKC

The Action Plan outlines a wide range of recommended measures that could be undertaken to more effectively manage surface water within Milton Keynes. The Action Plan has been developed to outline the responsibilities and implications of both structural and non-structural preferred options discussed in Phase 3 of the SWMP and details the methods, timescale and responsibility of each proposed action.

Within the Action Plan there are details of general measures that could be implemented across Milton Keynes Borough, as well as specific measures for each of the prioritised CDCs. These have been developed from the preferred options described in Section 8. The general actions are non-structural and encourage improved surface water management through planning policy and public education and awareness. The general actions also include the development of a flood response strategy and surface water flood warning system, which would be beneficial in ensuring successful response, with minimal harmful consequences, in the event of extreme surface water flooding.

It is the intention that the Action Plan is a live document, maintained and regularly updated by MKC, as actions are progressed and investigated. It should be understood that following further detailed investigation, the preferred option in each CDC may be discounted. Likewise new actions may be identified, or may be required by changes in legislation and guidance over time.

The Action Plan is aligned with the Milton Keynes LFRMS (consultation draft), and will be used to support and inform future flood risk management studies in the borough. The timeframe for each action is outlined as short, medium or long-term.

The Action Plan identifies:

- Actions to help manage flood risk and to meet the requirements under the FWMA and FRR;
- Future studies and consultations for investigation and confirming the level of flood risk;
- An estimation of costs for investigations and optioneering works – including possible sources of funding – for each of the shortlisted CDCs, as identified in Phase 3 of the SWMP;
- The partners or stakeholders responsible for implementing and supporting the actions;
- An indication of when the actions should be undertaken, reviewed and updated (these should be confirmed upon adoption of the Action Plan);
- An indication of the priority of the actions – high, medium or low to aid prioritisation of the actions; and,
- Linkage between actions.

Actions within the Action Plan have been categorised according to different actions types as summarised in Table 9-1.

Table 9-1 Structural and Non-Structural Measures for Consideration

Definition	Description
FWMA / FRR	Duties and actions required under the FRR and FWMA - Refer to the LGA 'Framework to assist the development of the Local Strategy for Flood Risk Management' 2nd Edition (November 2011)[34] for minimum requirements.
Policy Action	Spatial planning or development control actions.
Communication / Partnerships	Actions to communicate risk internally or externally to LLFA or create / improve flood risk related partnerships.
Financial / Resourcing	Actions to secure funding internally / externally to support works or additional resources to deliver actions.
Investigation / Feasibility / Design	Further investigation / feasibility study / Design of mitigation.
Flooding Mitigation Action	Maintenance or capital works undertaken to mitigate flood risk.

[34] LGA 'Framework to assist the development of the Local Strategy for Flood Risk Management' 2nd Edition (November 2011) for minimum requirements. http://www.local.gov.uk/c/document_library/get_file?uuid=ac7cd7c8-3388-4707-b4c2-10a7ab0f0940&groupId=10180

10 Milton Keynes Action Plan

10.1 Summary of Key Actions

10.1.1 Borough-wide Actions

The Action Plan outlines a number of generic actions that MKC, as LLFA, could undertake across the Borough (Appendix D). These actions are summarised in Table 10-1.

Table 10-1: Actions to be undertaken across Milton Keynes Borough

Recommendation	Action Type	Timeframe	Action Plan ID
Implement a standardised Flood Incident Log to record and investigate future flooding incidents across Milton Keynes Borough	Flood and Water Management Act / Flood Risk Regulations	Short	**Action 1**
Raise Community Awareness - Identify areas where Community Flood Plans may be effective and consider opportunities to develop these, in conjunction with the local community	Communication / Partnerships	Short	**Action 2**
Land management - Increase urban vegetation coverage	Flooding Mitigation Action	Medium	**Action 3**
Ongoing Improvements to the Maintenance of the Drainage Network - targeted maintenance of drainage network	Flooding Mitigation Action	Medium	**Action 4**
Planning Policy - Formalisation of flood storage areas in Flood Zone 3b.	Policy Action	Medium	**Action 5**
Planning Policy - Runoff Rates from New Development	Policy Action	Medium	**Action 6**
Planning Policy - Use of SUDS	Policy Action	Short	**Action 7**
Planning policy - Information on SUDS	Policy Action	Short	**Action 8**
Planning policy - Paved driveways	Communication / Partnerships	Medium	**Action 9**
Planning policy - Permeable surfaces	Policy Action	Medium	**Action 10**
FCRM GiA funding for priority schemes	Flooding Mitigation Action	Short	**Action 16**
Develop, update and maintain the Action Plan	Flood and Water Management Act / Flood Risk Regulations	Short	**Action 17**
Collaborative Working	Communication / Partnerships	Medium	**Action 18**
Review of SWMP Action Plan against the LFRMS Action Plan	N/A	Medium	**Action19**

10.1.2 CDC Specific Actions

The preferred options and ‘quick wins’ identified for each CDC have been included in the Action Plan (Appendix D). A number of ‘High Priority’ actions have been identified; these are actions that MKC should consider addressing as a priority and allocate resources to in the first instance.

Generally, high priority actions relate to undertaking further investigation of the preferred options, and alternative options across each CDC to determine the suitability, feasibility and benefit of each proposed measure. This should be undertaken, where required, with the riparian owners, MKC, the Environment Agency, AWS, the Parks Trust and Bedford Group of Drainage Boards. The outcome of this action will determine whether or not further actions are required. Other high priority actions include works currently being undertaken and/or priority works highlighted by key stakeholders (such the installation of flood gates at Little Linford Lane by the MKC highways team). These measures include the installation of flood gates at Little Linford Lane and increasing drainage network capacity at Cranfield Road through use of an oversized pipe.

It should be noted that MKC is identified as the 'lead organisation' for the majority of the actions identified within the Action Plan. It is envisaged that though many of the actions should be taken forward in collaboration with third-parties such as AWS or the Environment Agency, and could be partly or fully funded by these parties, the initial emphasis is likely to come from the Council as the LLFA.

The Action Plan identifies the relevant internal departments and external partnerships that should be consulted and asked to participate when addressing an action, though these should be checked and confirmed by MKC as the first stage in taking forward their Action Plan recommendations. After an action has been addressed, it is recommended that the responsible department (responsible for completing the action) inform and provide feedback to MKC who will subsequently be responsible for updating the Action Plan. It is recommended that the Action Plan is reviewed and updated on an annual basis to reflect any works undertaken by the Council and other stakeholders.

10.2 Ongoing Monitoring

Stakeholders who facilitated the development of the SFRA, LFRMS and SWMP (e.g. MKC, Environment Agency, Bedford Group of Drainage Boards and AWS) should continue beyond the completion of the SWMP in order to discuss the implementation of the proposed actions, review opportunities for operational efficiency and to review any legislative changes.

The Action Plan should be reviewed and updated annually as a minimum, but there may be circumstances which might trigger a review and/or an update of the Action Plan in the interim, for example:

- Occurrence of a surface water flood event;
- Additional data or modelling becoming available, which may alter the understanding of risk within the study area;
- If the outcome of an investment decision by partners is different to the preferred option, which may require a revision to the Action Plan, and;
- Additional (major) development or other changes in the catchment which may affect the surface water flood risk.

10.3 Updating the SWMP Reports and Figures

It is proposed that a full update of the SWMP should be scheduled for 2020, and thereafter every five years (as a minimum) to coincide with the LFRMS update.

In keeping with this principle, the following tasks should be undertaken when updating SWMP reports and figures:

- Undertake further analyses as required after SWMP review;
- Document all new technical analyses by rewriting and replacing relevant chapter(s) and appendices;
- Amend and replace relevant SWMP Maps; and,
- Reissue to departments within MKC and other stakeholders.

11 Appendices

Appendix A. Figures

Figure A.1a – Bedrock Geology

Figure A.1b – Superficial Geology

Figure A.2 – LiDAR

Figure A.3 – Historic Flood Incidents

Figure A.4a –Susceptibility to Groundwater Flooding (BGS)

Figure A.5 – Watercourses and Waterbodies

Figure A.6a – Updated Flood Map for Surface Water

Figure A.6b – Updated Flood Map for Surface Water and Critical Infrastructure

Figure A.7 – Risk of Fluvial Flooding

Figure A.8 – New Development Sites (Employment and Housing)

Figure A.9a – Milton Keynes 3.3% AEP Surface Water Flood Depth

Figure A.9b – Milton Keynes 3.3% AEP Surface Water Flood Hazard

Figure A.9c – Milton Keynes 1% AEP Surface Water Flood Depth

Figure A.9d – Milton Keynes 1% AEP Surface Water Flood Hazard

Figure A.9e – Milton Keynes 0.1% AEP Surface Water Flood Depth

Figure A.9f – Milton Keynes 0.1% AEP Surface Water Flood Hazard

Appendix B. Critical Drainage Catchment Maps

Appendix C. Options Assessment Tables

Appendix D. SWMP Action Plan

AECOM

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AECOM,
Scott House,
Alençon Link,
Basingstoke,
RG21 7PP.