Leckhampstead Section 19 Flood Investigation

Technical Report

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Buckinghamshire Council

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Revision History

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Contract

This report describes work commissioned by Andrew Waugh, on behalf of Buckinghamshire Council, by an email dated 15 March 2021. Buckinghamshire Council's representative for the contract was Andrew Waugh. Thomasin Shorrock, Heather Forbes and Lisa Chatterjee of JBA Consulting carried out this work.

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Purpose

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JBA Consulting has no liability regarding the use of this report except to Buckinghamshire Council.

Acknowledgements

We would like to thank Buckinghamshire Council, Leckhampstead Parish Council and residents of Leckhampstead for their input and support.

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Executive summary

Background

Following a flood event in Leckhampstead on 23 December 2020, Buckinghamshire Council (BC) as the Lead Local Flood Authority (LLFA) is undertaking a formal flood investigation under Section 19 of the Flood and Water Management Act 2010[1]. It is a statutory requirement for LLFAs to investigate flooding to the extent that it considers it necessary or appropriate.

Leckhampstead is a village in the north of Buckinghamshire on the River Leck, and has been subject to flooding several times previously. In December 2020, flooding caused the village to be cut off for several hours and at least seven properties to be flooded internally.

Stakeholder Engagement

As part of the Section 19 investigation, we engaged with local stakeholders in Leckhampstead, including residents, community representatives and other Council departments.

The objectives of engagement are to:

- Gather facts, opinions and data to aid the understanding of the investigation,
- Enable the involvement and buy-in of the community in the investigation,
- Provide more technical debrief with Risk Management Authorities (RMAs) and operational partners, and
- Disseminate the findings of the investigation to the community.

Catchment characteristics and long-term flood risk

National Risk of Flooding from Rivers and the Sea mapping shows flood risk from the River Leck through the village for both 1% and 0.1% annual chance scenarios. Smaller watercourses are not shown on this mapping but can be picked up through the surface water mapping. Groundwater flood risk in the village is low. Risk of Flooding from Surface Water (RoFSW) mapping also suggests that the village is at high risk of flooding from heavy rainfall events.

Existing flood risk management

There are several existing flood risk management schemes and activities in the village, including the following:

- NFM scheme completed in 2019 to 2021, comprising 24 leaky dams and a small flood storage area installed in the upper catchment,
- Residents have installed PFR including flood barriers, and
- Community resilience measures comprising a river level gauge and local alert system, installed in 2019.

1 Flood and Water Management Act 2010 Section 19 (accessed 17 May 2021): https://www.legislation.gov.uk/ukpga/2010/29/section/19

Hydrological analysis of 23 December 2020 flood event

The rainfall during the 23 December storm event had a return period of 13 years (a 7% chance of occurring in any one year). This is not especially extreme but given that the soils were already completely saturated from the notably high rainfall over preceding months, the catchment was very sensitive to rainfall.

Hydraulic modelling showed that the peak flow of the observed December 2020 flood event was similar to the simulated peak flow for the return period of 100 years (1% chance of occurring in any one year).

For more information on the hydrological analysis see Section 6.

Incident Response

Several authorities including Thames Valley Police, Buckinghamshire Council and the Environment Agency responded to flooding in Leckhampstead, though the response was mostly sending out generic alerts about flooding in the wider area. Buckinghamshire Fire and Rescue service physically attended the village but could not access it due to flood water at the bridge.

The Parish Council's flood gauge was activated, alerting residents of the rising flood waters, and residents took practical steps such as moving furniture upstairs and deploying PFR measures.

Source-pathway-receptor analysis

The sources, pathways and receptors of flooding were as follows:

- Sources – extreme rainfall causing overland flow from saturated fields, and high river levels in the River Leck.
- Pathways – out of bank flows from the River Leck along Church End Road and overtopping to the rear of Church End properties, and overland flow paths and seasonal watercourse from the fields to the north.
- Receptors – confirmed internal flooding of 7 residential properties causing resident displacement and loss of possessions, negative mental and physical health impacts. Flooded infrastructure including the main road bridge access into the village.

Discussion, appraisal and recommendations

We undertook a high-level option appraisal focussing on benefit, practical and viability considerations. We carried out a multi-criteria analysis to compare each option which included consideration of a range of different factors, for example the potential contribution towards reducing flood risk to property, people and communities.

Doing nothing was the least beneficial option, followed by continuing with a 'business as usual' approach to managing flood risk in Leckhampstead. The options which scored the highest were those that could ultimately result in a more resilient community.

For more information on options, recommendations and conclusions see Section 11.

Recommended actions	Risk Management Authority/Stakeholder
Expansion of NFM scheme in the upper catchment of the River Leck	Buckinghamshire Council

Property Flood Resilience	Community / Buckinghamshire Council
Community flood resilience e.g. formation of a formal Flood Action Group	Community / Leckhampstead Parish Council / Buckinghamshire Council
Review alert and warning levels of the River Leck gauge	Community / Leckhampstead Parish Council

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Abbreviations

AEP	Annual Exceedance Probability
AOD	Above Ordnance Datum
BGS	British Geological Society
BC	Buckinghamshire Council
CCTV	Closed Circuit Television
DTM	Digital Terrain Model
EA	Environment Agency
FEH	Flood Estimation Handbook
GIS	Geographic Information Systems
JBA	Jeremy Benn Associates
LiDAR	Light Detection and Ranging
LLFA	Lead Local Flood Authority
PFR	Property Flood Resilience
RMA	Risk Management Authority
RoFSW	Risk of Flooding from Surface Water (Environment Agency mapping)
TfB	Transport for Buckinghamshire

Definitions

Culvert	Where a watercourse flows through a pipe, often underground.
Foul sewer	Sewer which carries wastewater (e.g., from toilets, sinks, showers and kitchen appliances) to a sewage works for treatment.
Gully	Drainage pit covered by an open metal grated, located at the edge of a road. Drains rainwater from the road into the sewerage system.
Lead Local Flood Authority	County councils and unitary authorities which lead in managing local sources of flood risk (i.e. flooding from surface water, groundwater and ordinary watercourses)
Main river	A large river or stream designated on the Main River Map. The Environment Agency has permissive powers to maintain and carry out improvements on main rivers, to manage flood risk.
Non-return valve	Hinged valve placed on a pipe outlet into a river. Stays open during normal flow but closes when it is submerged, to prevent flow from backing up the pipe.
Ordinary Watercourse	All rivers which are not designated as 'Main rivers'. Lead local flood authorities and internal drainage boards can carry out flood risk management work on ordinary watercourses.
Public sewer	Sewers owned and maintained by a Sewerage Company (e.g. Thames Anglian Water). Are usually located in roads or public open spaces by may run through private gardens.
Riparian owner	The owner of land that is next to a watercourse or has a watercourse running through or beneath it.
Soil moisture deficit	The difference between the amount of water actually present in the soil and the amount of water which the soil can hold.
Surface water sewer	Sewer which carries rainwater directly to a watercourse.

1 Introduction

1.1 Background to investigation

Following flooding in Leckhampstead on 23 December 2020, Buckinghamshire Council (BC) as the Lead Local Flood Authority (LLFA) is undertaking a formal flood investigation under Section 19 of the Flood and Water Management Act 2010[2].

It is a statutory requirement for LLFAs to investigate flooding to the extent that it considers it necessary or appropriate. Buckinghamshire Council has outlined its criteria for undertaking a Section 19 investigation in its Local Flood Risk Management Strategy[3].

- Internal flooding (including to basements) to five or more residential properties within an area of 1km^2;
- Internal flooding of two or more business premises within an area of 1km^2;
- Internal flooding (including to basements) of at least one property for one week or longer;
- Flooding of one or more critical infrastructure assets, which could include hospitals, health centres, clinics, surgeries, colleges, schools, day nurseries, nursing homes, emergency services (police, fire, ambulance) stations, utilities and substations; and
- Any flooding event that a risk management authority deems significant but does not meet the agreed thresholds should be assessed at the next strategic flood management group for consideration.

The flooding that occurred in Leckhampstead caused internal flooding to seven properties in the Church End area of the village, meeting the above criteria for a report under Section 19. Buckinghamshire Council has appointed JBA Consulting to undertake this investigation on its behalf.

1.2 Aims of the investigation

Section 19 of the Flood and Water Management Act 2010 sets out that a Lead Local Flood Authority (LLFA) must, to the extent that it considers it necessary or appropriate, investigate which risk management authorities have relevant flood risk management functions, and whether each of those authorities has exercised, or is proposing to exercise, those functions in response to the flood.

Within Buckinghamshire, the aims of such an investigation are extended to providing an overview of the flooding incident and its impact, any history of flooding, a rainfall analysis, and determining the main factors and mechanisms involved in the flooding. This investigation also seeks to outline the actions of the relevant authorities, with some discussion of what went well and where improvements could be made in future. However, it is not within the remit of a Section 19 Flood Investigation to apportion blame to any organisation nor hold any risk management authority to account for their response to the floods.

We have also proposed a list of recommendations to help the various stakeholders learn from the event and improve the management of flood risk locally. We have undertaken a high-level appraisal of these recommendations, focussing on benefit, practical and viability considerations. However, it is not within the remit of a Section 19 Flood Investigation to provide designed solutions. The investigation process does not provide Buckinghamshire

2 Flood and Water Management Act 2010 Section 19 (accessed 17 May 2021): https://www.legislation.gov.uk/ukpga/2010/29/section/19

3 Buckinghamshire Local Flood Risk Management Strategy (2017): https://www.buckscc.gov.uk/media/4511603/bcc-lfrms-final-version-may-2017.pdf

Council, nor any other authority, with the funding or mandate to undertake flood management works on the ground.

The intention is instead to provide a clear understanding of the issues, since this is the first step towards being able to help address a flooding problem.

Given that the scope of the investigations is limited to developing a preliminary high-level screening of options, the reports should not be viewed as an action plan nor strategy that will set out definitive flood management actions that will be taken. However, it does make several recommendations that may be actioned in the short to medium term.

It will be for the relevant responsible party to assess these recommendations in terms of their legal obligation, resource implications, priority and the costs and benefits of undertaking such options. It is therefore important for stakeholders to view the Section 19 Flood Investigation report as a first step in a process, rather than a final solution.

1.3 Site location

Leckhampstead is situated in north Buckinghamshire in the valley of the River Leck, which is a small tributary of the Great Ouse. Church End is the name given to the road within the village which runs past St Mary's Parish Church, upstream of the River Leck road crossing. The area is rural and lies approximately 5km northeast of the county town of Buckingham. A location map is shown in Figure 1-1 below.

To simplify the discussion in this report, the properties on the south side of Church End road will be referred to as Church End south, whilst the properties to the north side will be referred to as Church End north.

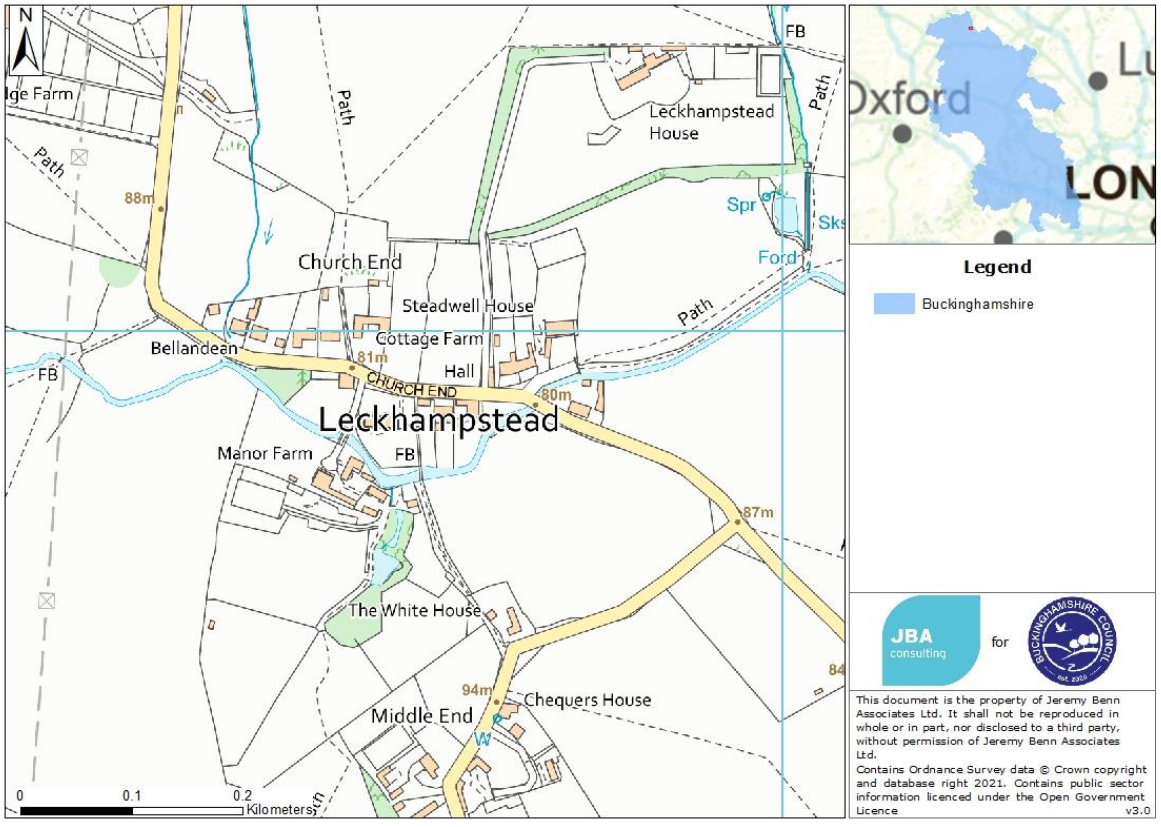

Figure 1-1: Location of Leckhampstead

1.4 Data collection

A wide range of data has been collected and assessed to inform the Section 19 investigation. This has been used to understand the causes and impacts of flooding in Leckhampstead and to establish the context of the area. This includes the following:

- Open source data from GOV.UK – for example the Risk of Flooding from Surface Water mapping (RoFSW), the Flood Map for Planning, LiDAR etc;
- Historic flooding datasets;
- Rainfall data;
- Asset datasets from Buckinghamshire Council including the highway drainage system;
- Level gauge data from the River Leck;
- JBA's Groundwater map
- Residents' questionnaires; and
- Other data such as photos, newspaper articles and notes from the event.

2 Stakeholder engagement

We engaged with multiple local stakeholders in each location including residents, community representatives, other Council departments, Council Members and RMA partners.

The objectives of engagement are to:

- Gather facts, opinions and data to aid the understanding of the investigation
- Enable the involvement and buy-in of the community in the investigation
- Disseminate the findings of the investigation to the community

A list of key stakeholders and how we engaged with them is given in Table 2-1. The engagement terminology is taken from Environment Agency's 'Working with Others' (2013) methodology:

- Inform - provide information
- Consult - receive, listen, understand and feedback
- Involve - decide together
- Collaborate - act together
- Empower - support independent action

Five responses to the online questionnaire were received from affected residents.

Table 2-1: Key stakeholders

Role	Organisation	How to engage	Type of engagement
Parish Council	Leckhampstead Parish Council	Consult	Invitation to contribute, site visit, online survey distribution, correspondence
Council Members	Buckinghamshire Council	Consult	Invitation to contribute
Residents	N/A	Involve	Site visit, online questionnaire, correspondence

3 Catchment characteristics

3.1 Drainage system and river network

3.1.1 Watercourses

The River Leck is an ordinary watercourse which flows in a south-easterly direction through Leckhampstead. The river enters Leckhampstead village from the west then flows past St Mary's Parish Church to the rear of the properties in Church End south, before it crosses under Leckhampstead's main access bridge from the A422 to the east.

The River Leck is joined by several tributaries both upstream and downstream of Leckhampstead village. The most notable are three smaller channels joining the River Leck from the fields to the north of Leckhampstead, one joining the River Leck upstream of the village, one joining upstream of Church End via a culvert under the road, and the other joining downstream of the River Leck Bridge to the east of the village. These channels do not always have a base flow, but are key flow routes in heavy rainfall. Figure 3-1 shows the watercourses in and around the Church End.

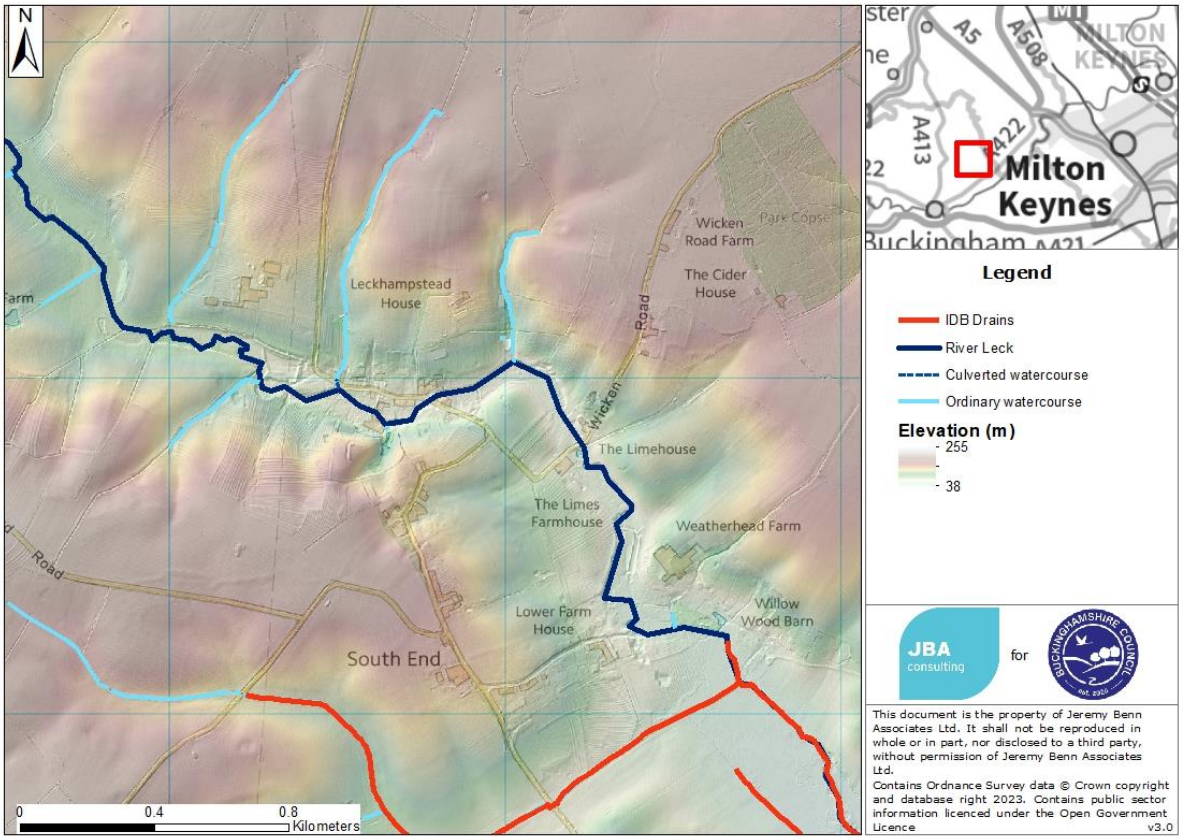

Figure 3-1: Watercourses in the Leckhampstead area

3.1.2 Highway drainage

Buckinghamshire Highways, who are responsible for highways and highway drainage across Buckinghamshire, have very few assets in the area of Leckhampstead. There are two gullies situated to the east of Church End, south of where the River Leck crosses underneath the road and slightly elevated from the bridge. Due to their location we

assume that they discharge into the river. Figure 3-2 shows the highways assets in the area of Church End[4].

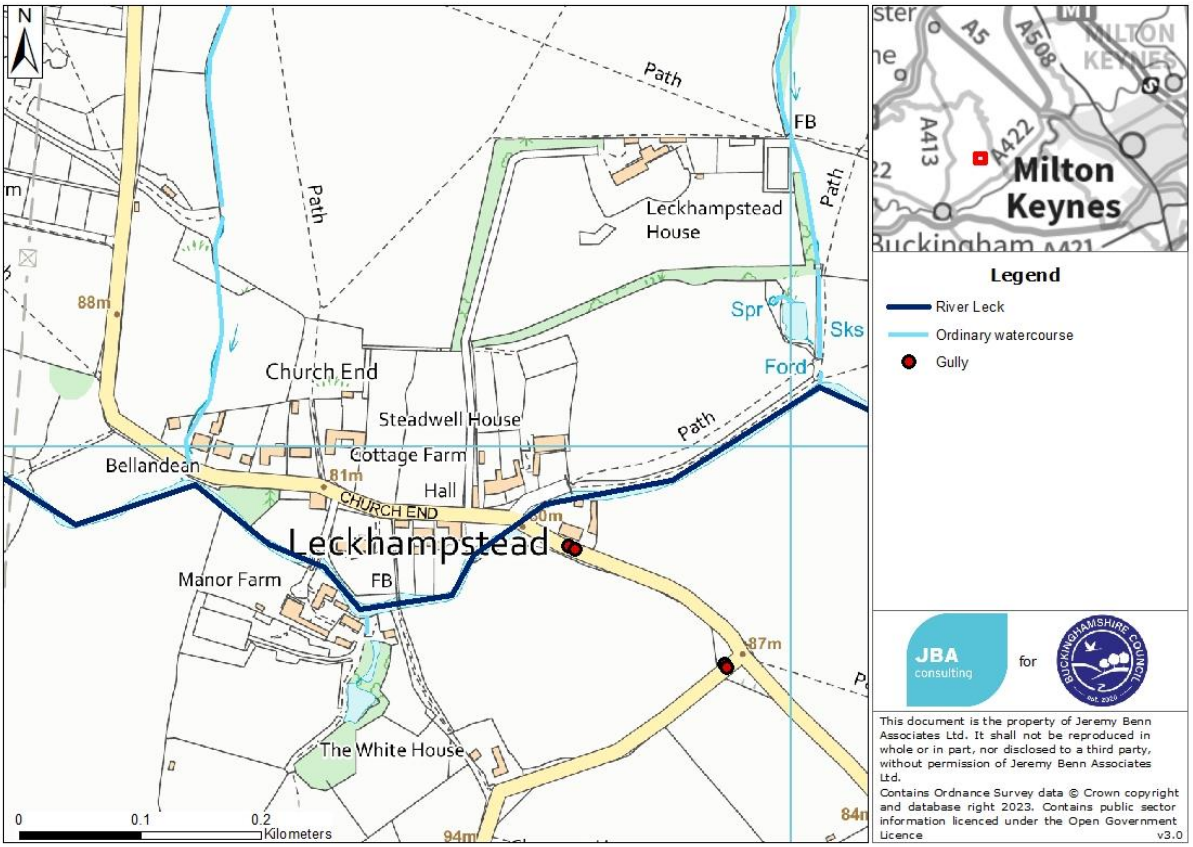

Figure 3-2: Buckinghamshire Highways assets in Leckhampstead Church End

3.2 Catchment characteristics

3.2.1 Topography

Leckhampstead is situated in the River Leck valley at around 80mAOD elevation, as shown in Figure 3-3. Around Church End the valley sides rise to just over 100mAOD immediately to the north and south, and the river valley falls gently to the south-east. The top of the catchment rises to approximately 150m at Silverstone 7km to the north-west. The nature of the topography channels the River Leck and runoff from the valley sides through the village of Leckhampstead.

4 TFB drainage assets for the Buckinghamshire Public Flood Asset Register. Supplied to TFB by KaarbonTech. Updated July 2021.

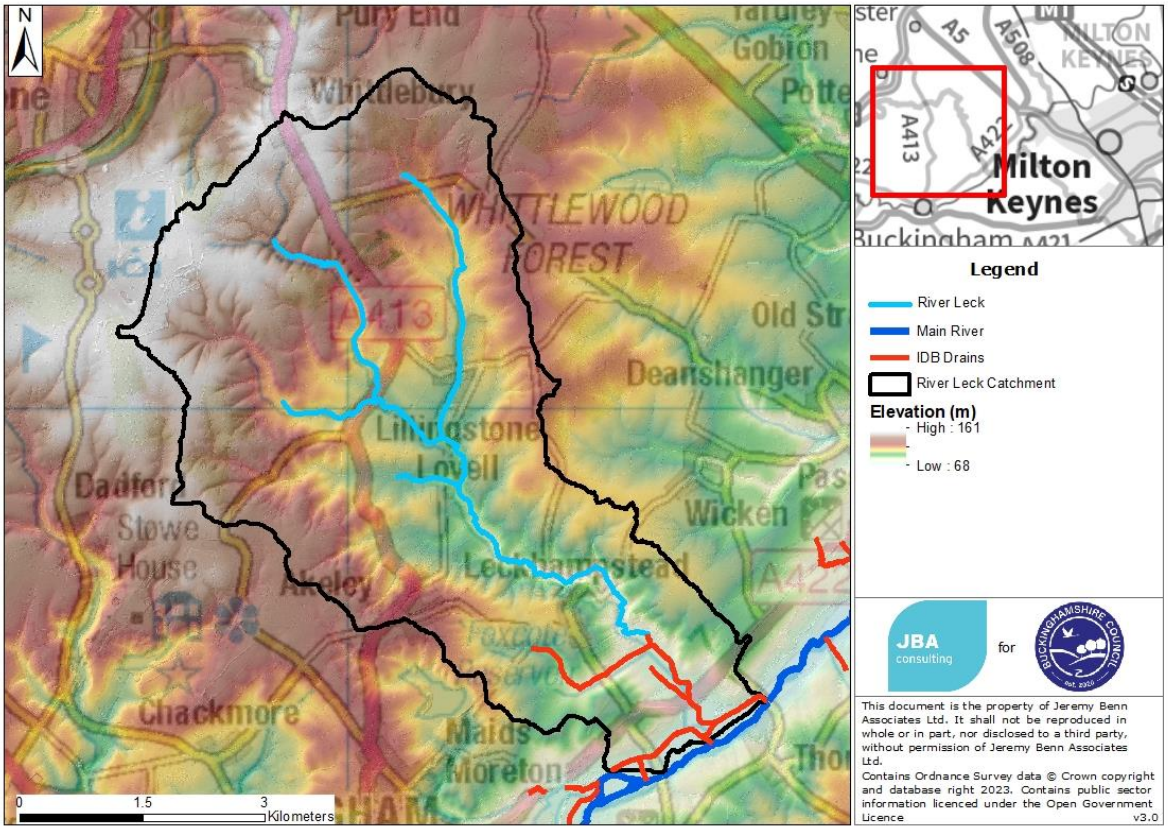

Figure 3-3: Leckhampstead topography, from the Environment Agency's 1m resolution LiDAR DTM

3.2.2 Catchment geology

BGS data indicates that the catchment sits primarily on the Great Oolite group formation, which comprises sandstone, limestone and argillaceous rocks[5]. The entire area is underlain by superficial deposits of Till which may have variable permeability. Soilscapes mapping[6] characterises the soil type in Leckhampstead as 'lime-rich loamy and clayey soils with impeded drainage', and some soils in the upper catchment as 'slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils'.

The geology of the catchment suggests that drainage is slightly impeded, therefore under wet, wintry conditions the soil can be waterlogged.

5 BGS Geology of Britain viewer: https://mapapps.bgs.ac.uk/geologyofbritain/home.html

6 Cranfield University soilscapes mapping: http://www.landis.org.uk/soilscapes/

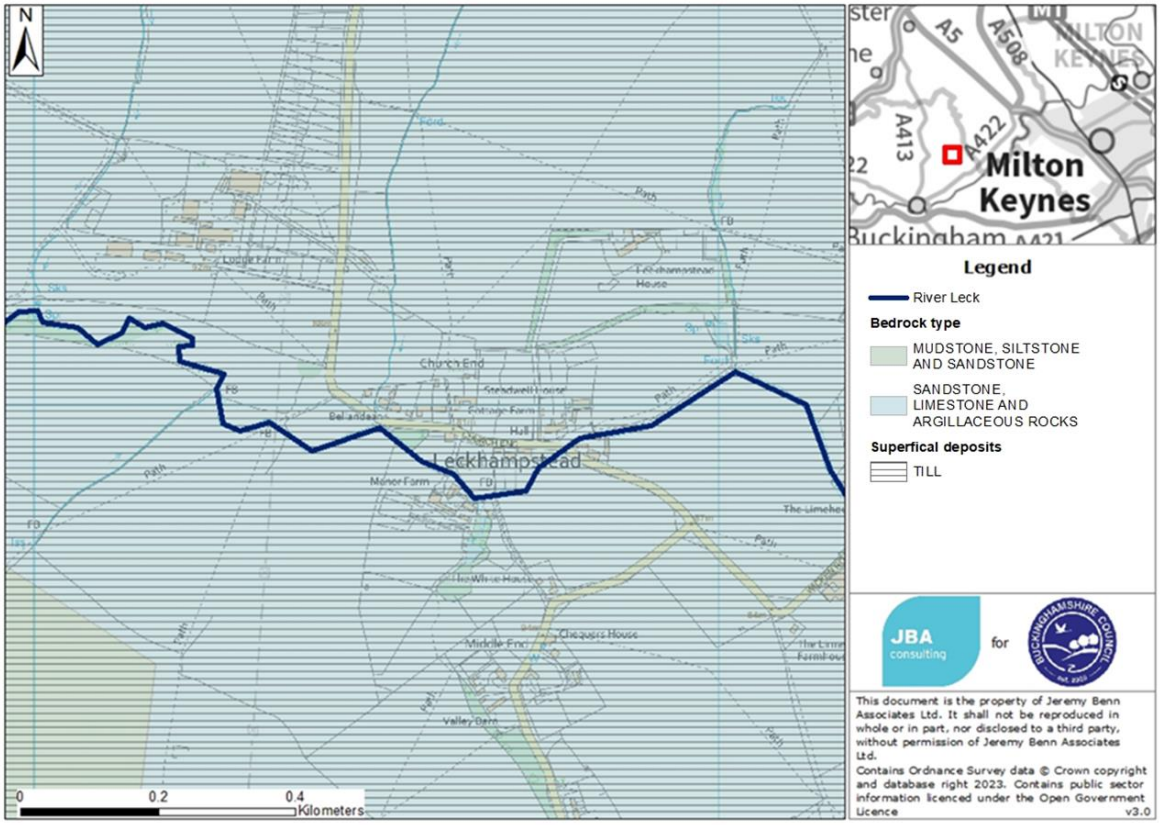

Figure 3-4: Geology in Leckhampstead, from the BGS database.

4 Long-term flood risk information

4.1 Risk of flooding from rivers and sea

The Environment Agency's Risk of Flooding from Rivers and Sea (RoFRS) mapping is shown in Figure 4-1. This is a national assessment of flood risk for England, showing the chance of flooding from rivers and/or the sea. The River Leck poses fluvial flood risk to several properties on Church End which fall within Flood Zones 2 (0.1% annual chance) and 3 (1% annual chance).

The smaller watercourses around the village are not represented. This is because their catchment areas are less than 3km², meaning they were too small to be modelled in the Environment Agency's national Flood Zone mapping. For these smaller watercourses the more detailed Risk of Flooding from Surface Water (RoFSW) mapping can also be used as an indication of the flood risk. This has been assessed in section 4.2 below.

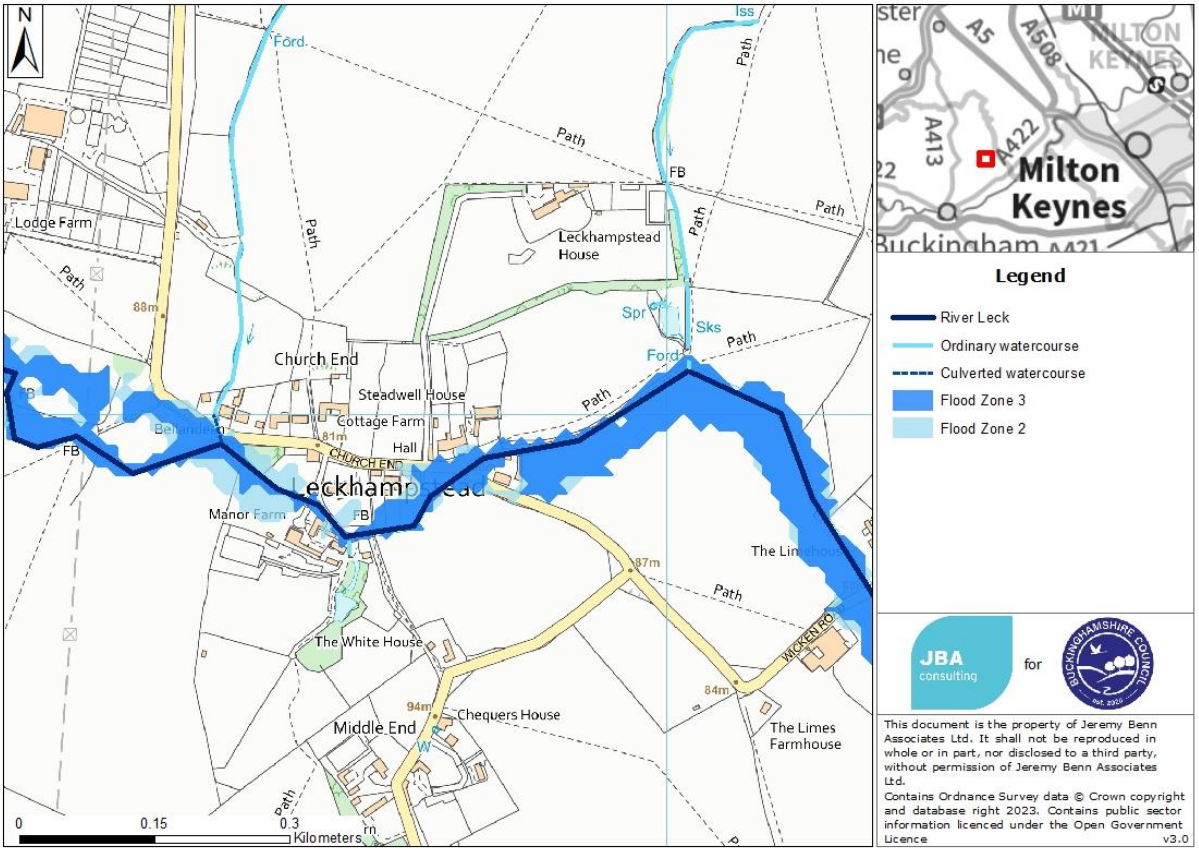

Figure 4-1: Risk of flooding from rivers and the sea

4.2 Risk of flooding from surface water

The Environment Agency's Risk of Flooding from Surface Water (RoFSW) mapping is provided in Figure 4-2. This information is not suitable for identifying whether an individual property will flood, though it does give an indication of the broad areas likely to be affected at 3.3% 1% and 0.1% annual chance scenarios.

The mapping shows out of bank flows from the River Leck channelled along Church End road for the range of scenarios. Water is shown encroaching onto properties along both the River Leck and the smaller watercourses to the north, and pooling at the downstream end of Church End near the road bridge. In the 0.1% annual chance event, a new overland flow route develops from the fields to the north of the centre of the village. This flow path

was witnessed by residents during the December event, who noted that it was the first time they observed significant overland runoff from the fields on to Church End road.

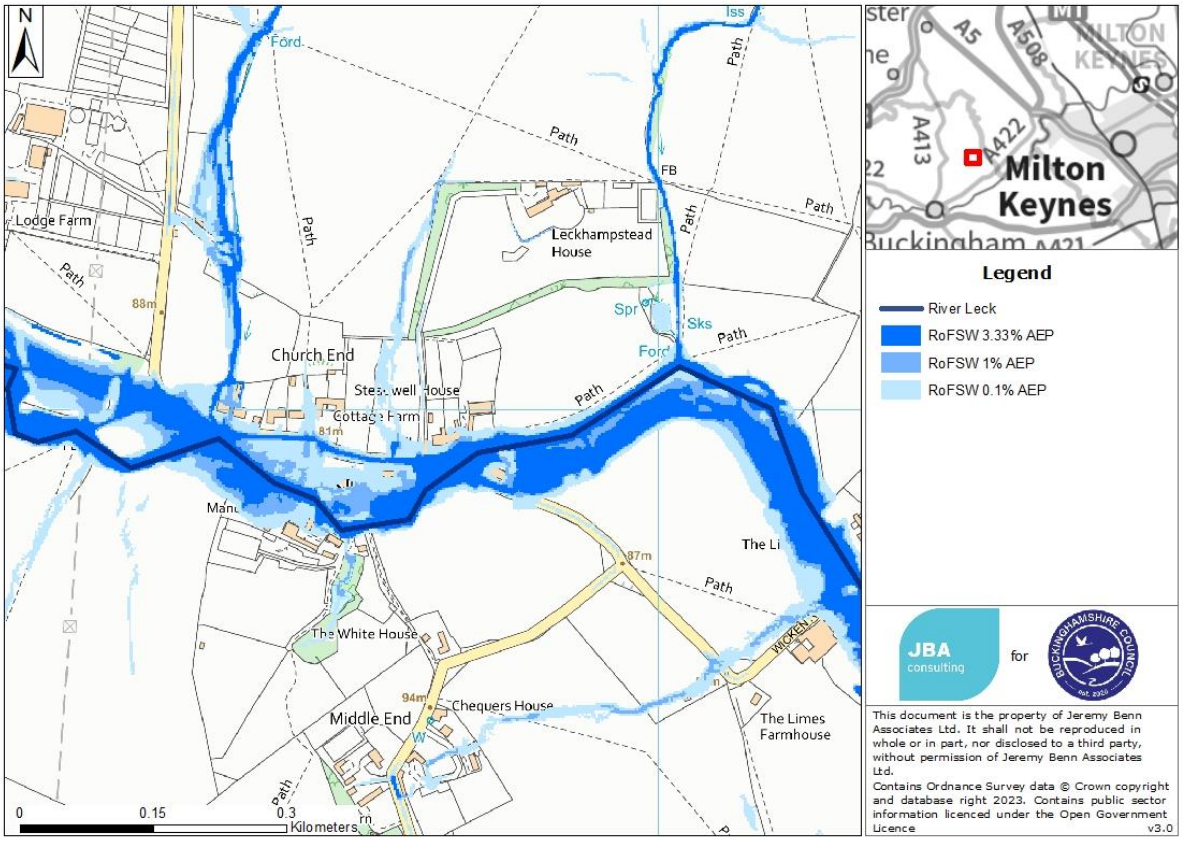

Figure 4-2: Risk of flooding from surface water

4.3 Risk of flooding from groundwater

The JBA Groundwater Flood Map for Leckhampstead is provided in Figure 4-3 below which indicates the risk of groundwater flooding during a 1% annual chance event.

The map shows the predicted depth of groundwater beneath the surface, with higher groundwater levels being associated with higher groundwater flood risk. According to the map there is no risk of groundwater flooding in most of Leckhampstead, meaning that the area is deemed as having a negligible risk from groundwater flooding due to the nature of the local geological deposits.

However, immediately to the north and south of the area there is a moderate risk, with groundwater levels rising to 0.5 -5m below the ground surface. Here there is a risk of groundwater emergence or flooding to subsurface assets, but the surface manifestation of groundwater is unlikely.

The map does also show an area upstream of Leckhampstead where groundwater levels are either at or very near the ground surface: the red area shown on Figure 4-3 below. These high groundwater levels upstream of Leckhampstead could limit storage and infiltration and any emergence could be carried down to the village and Church End.

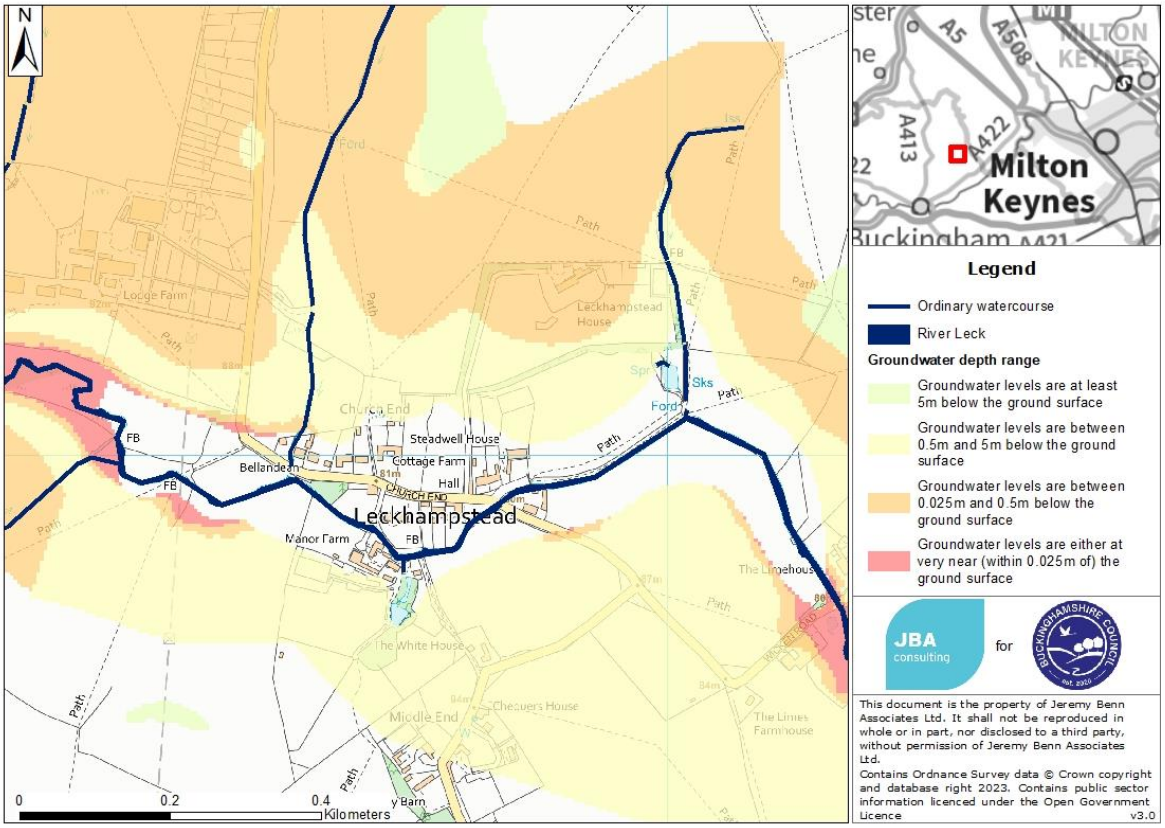

Figure 4-3: Risk of flooding from groundwater.

4.4 Flood history

Available records of historic flooding in Leckhampstead have been examined, using information sources including the Buckinghamshire Preliminary Flood Risk Assessment (PFRA)[7], Aylesbury Vale Strategic Flood Risk assessment (SFRA)[8], residents' surveys, and the Section 19 report from previous flooding in 2016[9].

During the 2016 study a review of the flood history by Buckinghamshire Council using information provided by local residents. The conclusions are repeated here for completeness. The Chronology of British Hydrological Events[10] and JBA British Chronology

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7 https://old.buckscc.gov.uk/media/2275631/pfra_prelim_assessment_report_final.pdf

8 https://www.aylesburyvaledc.gov.uk/aylesbury-vale-strategic-flood-risk-assessment-2017

9 https://www.buckscc.gov.uk/media/4512634/s19-investigation-report-march-2016-leckhampstead_final.pdf

10 https://www.cbhe.hydrology.org.uk/

of flash floods[11] were also consulted, though no entries for flooding were found for Leckhampstead specifically.

Reports of previous flooding in Leckhampstead have noted the danger to people due to the depth and velocity of floodwater in the village, a typical rapid onset of flooding, and isolation of the village due to floodwater. Anecdotal information includes a report of a vehicle driver requiring rescuing from floodwater near South End bridge on Church End during a previous flood event.

A timeline showing all reported historic flood events is provided in Table 4-1. The timeline shows that there have been at least 11 recorded flood events in the village since 1932, however reports from residents note that the river can overtop into the road at least once a year. It is therefore likely that these dates refer to larger and more notable events, though much of the detail regarding impacts and sources is unavailable in the records.

Table 4-1: Flood history

Date	Source of flooding	Description of impacts
1932	No further information recorded.	No further information recorded.
1959	No further information recorded.	No further information recorded.
1983	No further information recorded.	No further information recorded.
1986	Fluvial and overland flow.	No further information recorded.
1988	No further information recorded.	No further information recorded.
1990	No further information recorded.	No further information recorded.
Easter 1998	Fluvial and overland flow.	No further information recorded.
Winter 2001	Ordinary Watercourse (from PRFA)[12].	No further information recorded.
July 2007	Fluvial and overland flow.	No further information recorded.
October 2007	No further information recorded.	No further information recorded.
March 2016	Fluvial and overland flow.	Out of bank flows from the River Leck along Church End Road, cutting off the village and resulting in two properties being flooded.

11 https://www.jbatrust.org/how-we-help/publications-resources/rivers-and-coasts/uk-chronology-of-flash-floods-1/

12 https://old.buckscc.gov.uk/media/2275631/pfra_prelim_assessment_report_final.pdf

5 Flood risk management

Responsibility for flood risk can be divided into "flood risk management" and "emergency response", separately defining roles related to the preventative management of flood risk, and the response following a flood event. The following section describes the roles of the various bodies involved in flood management, with roles and responsibilities for emergency response described in section 5.2.

5.1 Flood risk management roles and responsibilities

Flood risk in England is managed by a range of different Risk Management Authorities (RMAs)[13]. The Flood and Water Management Act places a duty on all flood risk management authorities to co-operate with each other. The act also provides Lead Local Flood Authorities and the Environment Agency with a power to request information required in connection with their flood risk management functions.

5.1.1 Lead Local Flood Authority (LLFA)

Lead Local Flood Authorities (LLFAs) are responsible for coordinating the mitigation of risk of flooding from surface water, groundwater (water which is below the water table under the ground) and ordinary watercourses (non-main rivers). The LLFA is also responsible for developing, maintaining and applying a strategy for local flood risk management in their area and for maintaining a register of flood risk assets. LLFAs also have a statutory duty to investigate significant flood events to the extent they consider necessary.

Buckinghamshire Council is the LLFA for the whole of Buckinghamshire, including this area.

5.1.2 Environment Agency

The Environment Agency is sponsored by the Government's Department for Environment, Food & Rural Affairs (Defra), and is tasked with the protection and conservation of the water environment in England, the natural beauty of rivers and wetlands and the wildlife that lives there.

The Environment Agency's responsibilities include: water quality and resources; fisheries; conservation and ecology; and operational responsibility for managing the risk of flooding from main rivers (usually large streams and rivers), reservoirs, estuaries and the sea.

Flood risk management work can include: constructing and maintaining 'assets' (such as flood banks or pumping stations) and works to main rivers to manage water levels and make sure flood water can flow freely; operating flood risk management assets during a flood; dredging the river; and issuing flood warnings.

The Environment Agency can also do work to prevent environmental damage to watercourses, or to restore conditions where damage has already been done.

The strategies for flood and coastal erosion risk management show how communities, the public sector and other organisations can work together to manage this risk.

The River Leck is an ordinary watercourse, and therefore does not fall under the jurisdiction of the Environment Agency.

5.1.3 Internal Drainage Board (IDB)

Internal drainage boards (IDB) are independent public bodies, established in areas of special drainage need known as drainage districts. The IDB is responsible for the supervision of land drainage, water level management and flood risk management works and regulation of ordinary watercourses. The IDB also plays an important role in the areas

13 https://www.gov.uk/guidance/flood-risk-management-information-for-flood-risk-management-authorities-asset-owners-and-local-authorities

they cover (approximately 10% of England at present) in working in partnership with other authorities to actively manage and reduce the risk of flooding.

The River Leck falls under the jurisdiction of the Buckingham and River Ouzel IDB, approximately 1.5 km downstream of Leckhampstead village.

5.1.4 Highway Authority

The Highway Authority for Leckhampstead is Buckinghamshire Council, and the Highways function is managed by Buckinghamshire Highways (previously Transport for Buckinghamshire). It is responsible for maintaining the highway drainage system to an acceptable standard and ensuring that road projects do not increase flood risk.

5.1.5 Riparian landowners

Riparian landowners who own land or property next to a river, stream or ditch, (including where this runs through a pipe or culvert), have rights and responsibilities over the management of the land including: a responsibility to let water flow through the land without any obstruction, pollution or diversion which affects the rights of others; keeping banks clear of anything that could cause an obstruction and increase flood risk; maintaining the bed and banks of the watercourse; and keeping structures clear of debris. There is more information on these rights and responsibilities in the Environment Agency guide 'Owning a watercourse' and in Buckinghamshire Council's guidance, "Maintaining a river or stream you own"14..

5.1.6 Local residents

Local residents should find out about any flood risk in the area, sign up for the Environment Agency's free flood warnings, where available and make a written plan of how they will respond to a flood situation. Business owners should also make a flood plan for their business. There are measures that can be taken to reduce the amount of damage caused by flooding and properties at risk should be insured. Local residents can find out if their property is at risk, prepare for flooding, get help during a flood and get help after a flood.

5.2 Emergency responsibilities

The emergency responsibilities of different organisations are outlined in Table 5-1 below. Please note that Parish and Town Councils do not have a legal obligation to respond to emergencies. Whatever service they provide is voluntary and unique to each Parish or Town Council.

Table 5-1: Roles and responsibilities in an emergency, during and after a flood event

Local Authority (Buckinghamshire Council)
Coordinate emergency support within their own functions
Deal with emergencies on 'non main rivers'
Coordinate emergency support from the voluntary sector
Liaise with central and regional government departments
Liaise with essential service providers
Open rest centres

14 https://www.buckinghamshire.gov.uk/environment/flooding-and-flood-risk-management/maintaining-a-river-or-stream-you-own/

Manage the local transport and traffic networks Mobilise trained emergency social workers Provide emergency assistance Deal with environmental health issues, such as contamination and pollution Coordinate the recovery process Manage public health issues Provide advice and management of public health Provide support and advice to individuals Assist with business continuity

Police Force	Utility Providers
Save life Coordination and communication between emergency services and organisations providing support Coordinate the preparation and dissemination	Attend emergencies relating to their services putting life at risk Assess and manage risk of service failure Assist with recovery process, that is, water utilities manage public health considerations

Fire and Rescue Service	Internal Drainage Board
Save life rescuing people and animals Carry out other specialist work, including flood rescue services Where appropriate, assist people where the use of fire service personnel and equipment is relevant	Operate strategic assets to reduce flood risk in partnership with RMAs and public

Ambulance Service	Town and Parish Councils
Save life Provide treatment, stabilisation and care at the scene	Support emergency responders Increase community resilience through support of community emergency plan development

Voluntary Services
Support rest centres Provide practical and emotional support to those affected Support transport and communication Provide administration Provide telephone helpline support

Environment Agency
Issue Flood Warnings and ensure systems display current flooding information Provide information to the public on what they can do before, during and after a flood event Monitor river levels and flows Work with professional partners and stakeholders and respond to requests for flooding information and updates Receive and record details of flooding and related information

Operate water level control structures within its jurisdiction and in line with permissive powers Flood event data collection Arrange and take part in flood event exercises Respond to pollution incidents and advise on disposal Assist with the recovery process, for example, by advising on the disposal of silt, attending flood surgeries

5.3 Existing flood risk management activities

5.3.1 Natural Flood Management (NFM)

Following a 2017 NFM feasibility study, 24 'leaky dams' were installed in the headwaters of the River Leck during summer 2019[15]. The work was commissioned and managed by Buckinghamshire County Council's Strategic Flood Management Team, with landowner engagement, design of options and practical delivery of interventions overseen by the Freshwater Habitats Trust. A topographic survey of the dams was carried out by JBA Consulting in June 2020. In late 2021, a small flood storage area was constructed at Tilehouse Estate.

The leaky dams are designed to allow for temporary, in-channel, flood attenuation. They also provide hydraulic friction, slowing flood flows down. The NFM features are predicted to alleviate peak river flows and help to reduce the risk of flooding in Leckhampstead from lower magnitude, higher frequency flooding. However, evidence of their effectiveness against more extreme floods is limited[16] and therefore we would not expect the NFM scheme to provide a significant reduction in water levels or flows to the village in a large flood event.

5.3.2 Property and community flood resilience

Prior to the December 2020 event, residents of Leckhampstead had invested in a number of community and Property Flood Resilience (PFR) measures which are known to have been deployed during the event. The measures have been funded by residents, with some support from local Heart of Buckinghamshire funding who provided some community supplies.

- Aquasacs - these temporary flood barriers are an alternative to traditional sandbags. They briefly stopped flood water ingress at one property but were subsequently overwhelmed and washed away as river levels rose further.
- Retaining wall and barrier – a double skinned brick wall with a removable barrier was deployed to hold back river water from the rear at one property along Church End. The wall is approximately 1m high, and successfully held back water reaching just one brick course below the top. However, water eventually percolated underneath to reach the rear of the property.
- Flood gate – A flood gate was fitted to the front doorway of one property to protect from flooding from the front on Church End. Water reached approximately 15cm above the doorstep meaning that the flood gate was effective, though water eventually seeped through the front wall.

Following the floods in December 2020, residents have reported implementing or planning to implement further PFR measures. These measures include adding retaining walls, replacing wooden floors with tiles, and installing demountable flood gates.

5.3.3 Flood warning system

Leckhampstead is not covered by the Environment Agency's national flood warning information service, which mainly covers Main Rivers. There is no national flood warning service for ordinary watercourses or surface water flooding.

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15 https://freshwaterhabitats.org.uk/news/nature-inspires-a-flood-alleviation-solution/

16 Working with natural processes to reduce flood risk - GOV.UK (www.gov.uk)

However, following flooding in 2016 the community instigated its own flood warning system, supported by Buckinghamshire Council and the Environment Agency. A level gauge was installed on the river in the village by a contractor commissioned by the Parish Council, with funding provided by Buckinghamshire Council.

Three river level thresholds are set, at which point flood alerts are sent by SMS to residents who are signed up to receive them. The alerts indicate the current situation and action to be taken. The thresholds are associated with the following impacts:

- 'River level rising' (0.75m)
- 'River at risk of flooding, time to take appropriate precautions' (1m)
- 'River in flood' (1.25m)

This innovative flood warning system is led, owned and maintained by the community itself. While it may not provide long lead times, it does empower residents to take what action they can in the event of rising river levels.

6 Hydrological analysis of the 23rd/24th December 2020 event

6.1 Conditions at the time

At the beginning of the autumn in September 2020, rainfall and catchment soil dryness were about normal for the time of year. However, Storm Alex at the beginning of October brought a significant amount of rain and total rainfall for the month was about three times greater than the monthly average. This led to a decrease in soil moisture deficit (an indication of soil dryness) to below normal levels, indicating that the soil was already wetter than normal for the time of year. Though November was slightly drier than average, a month's worth of rain fell in the period of December up until the event on 23 December. This led to notably low soil moisture deficit (within the 0-10mm band), indicating that the catchment had minimal capacity to hold additional rainfall by the time of the storm event on 23 December.

6.2 Event rainfall

The graph below shows the rain that fell during the event. HYRAD radar data shows that rainfall started slowly at about 8:30am on 23 of December becoming more intense at 9:30am.

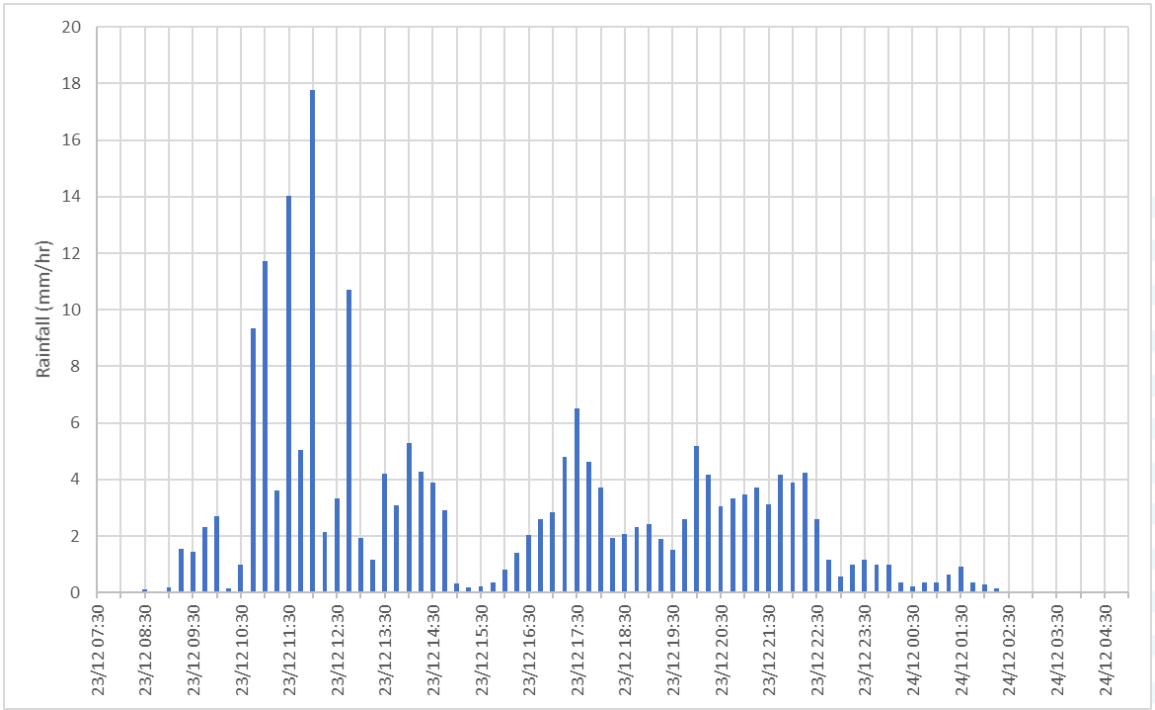

Figure 6-1 Hyrad (radar) rainfall data for the Leckhampstead area

The main body of the storm event happened in two waves. The first, and more intense, wave of rainfall occurred between about 09:30 and 15:00, with the main peak at around 12:00. The second wave occurred between 15:30 and 00:00 of 23/24 December, with the peaks occurring around 17:30 and 20:00.

The rainfall event ended at about 02:00 on 24 December with an approximate total of 52mm recorded by radar over the preceding 19 hours. There is a raingauge at Foxcote, north east of Buckingham, and 2.5km south-west of Leckhampstead. This gauge reported a much lower total of only 28mm, but previous studies indicate that this gauge under-records due to overshadowing, which is also supported by far greater rainfall totals being

recorded for the December 2020 event by the radar data and a daily storage raingauge just south of Biddlesden (62mm), located 7.3km west of Leckhampstead.

HYRAD observed radar rainfall data from the Met Office shows that for the majority of the event the storm passed in a northerly direction across the catchment. After about 5pm, as the weather system turned, the storm passed in a southerly direction.

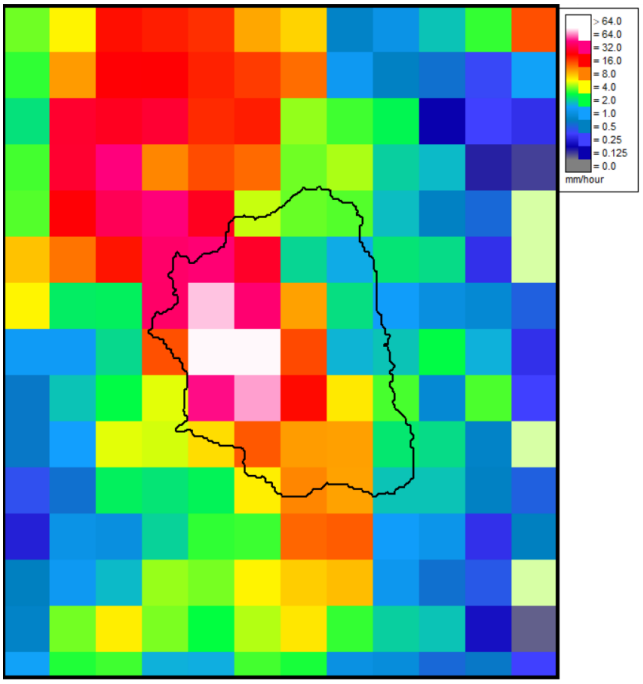

Figure 6-2 Hyrad (radar) rainfall for the Leckhampstead area at 12pm on 23rd December 2020

Figure 6-2 shows the HYRAD observed radar rainfall for the Leckhampstead catchment (black boundary line in the centre of the image). Colours show rainfall rate at the time shown.

Table 6-1: Rainfall totals in the Leckhampstead area on 23/24th December

Rain gauge	Distance from Leckhampstead**	19-hour total on 23/24 December	Grid reference
Foxcote*	4.9km	28mm	471278, 235758
Leckhampstead catchment average (HYRAD)**	-	52mm	462203, 237828

*possible under-recording at Foxcote due to overshadowing effects

**distance from centre of Leckhampstead catchment

6.3 Rainfall return period estimation

The rainfall in the 23/24 December storm event had a 7% chance of occurring in any one year (return period of 13 years).

This is based on the HYRAD radar rainfall total for Leckhampstead itself, which was considered to be more reliable than the catchment average based on the rain gauge data

due to the poor data quality at Foxcote gauge and the distance of the gauge from the village.

This return period is not especially extreme, but the rainfall occurred in combination with soil that was already completely saturated from the notably high rainfall over the preceding month, meaning the catchment was very sensitive and quick to respond to the heavy rainfall. If the same rainfall event had occurred when the soil was drier, it is unlikely that such a large flood would have resulted.

6.4 Leckhampstead level gauge

A community-monitored gauge is set up on the bridge of the River Leck running through Leckhampstead by St Mary's Church, which recorded the levels of the December 2020 flood event. Figure 6-3 below shows the flood hydrograph of the event on the River Leck in this location. The gauge records a peak at 15:30 on 23 December 2020, and does not return to base level for 30 hours. The hydrograph shows that river levels rose and peaked rapidly within a few hours, with a slower falling limb which includes some fluctuations.

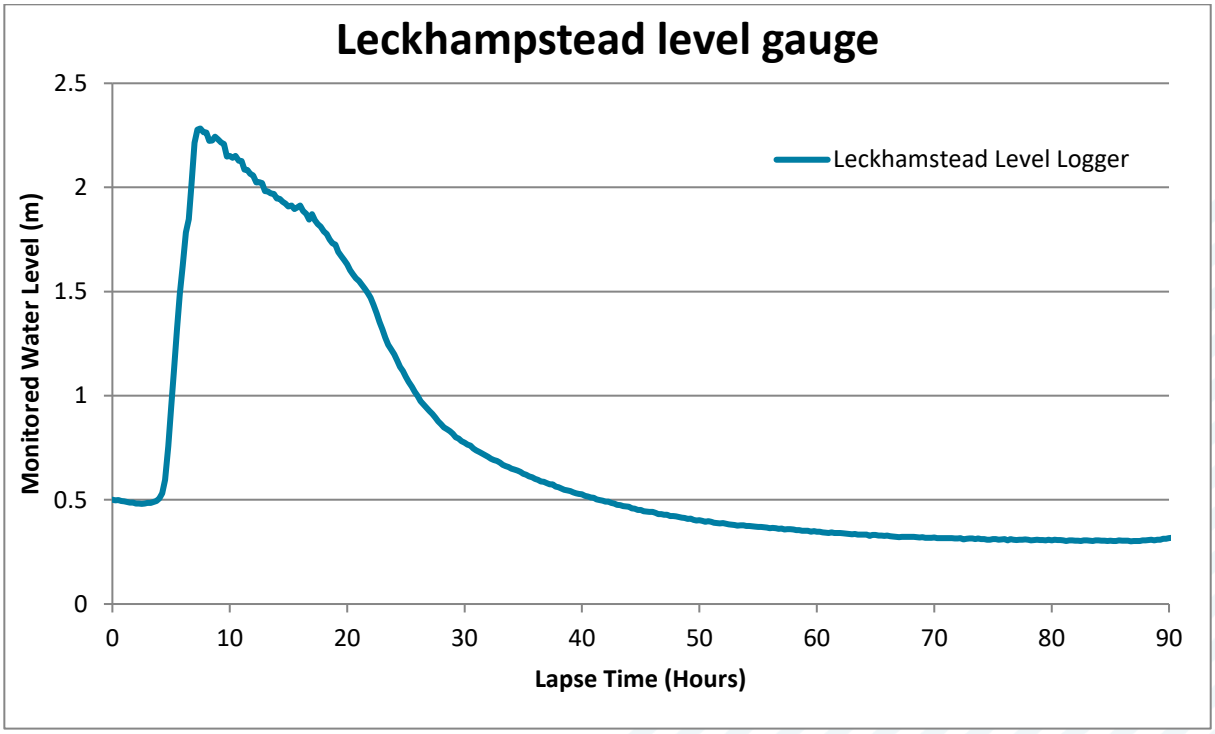

Figure 6-3 Level hydrograph for the Leckhampstead level gauge, 23 December 2020

6.5 Flow return period estimation

The relationship between level and flow at the level gauge location in the hydraulic model (was used to estimate the likely flows during the event. The recorded stage is higher than the peak stage for the 1% annual chance 'design event'. It is therefore likely that the flows during the event had a greater than 1% annual chance of occurring.

7 Incident response

Several authorities including Thames Valley Police, Buckinghamshire Council, the Environment Agency and Buckinghamshire Highways (previously Transport for Buckinghamshire) responded to flooding in Leckhampstead. However, the responses were mostly limited to generic alerts about flooding in the wider area.

Buckinghamshire Fire and Rescue Service attended during the event but were unable to reach the village due to flood water blocking access at the bridge. They aided flood recovery the following day by pumping out a flooded cellar.

The Parish Council's level gauge was successfully activated and alerted residents of the rapidly rising flood waters.

A timeline of the incident response is given in Table 7-1. Residents also responded to the flooding by taking practical steps such as moving furniture upstairs and deploying the PFR measures discussed in section 5.3.2, though as the responses occurred at unknown times over the course of the event they have been included as one entry at the top of the timeline.

Table 7-1: Timeline of incident response

Date	Time	Activity/event	Agency
23/12/2020	Pre and during event	PFR deployed	Residents
23/12/2020	10:29	Thames Valley Police issued an alert for people to avoid the area due to flooding	Thames Valley Police
23/12/2020	12:45	Village river gauge alert: "River level rising"	Leckhampstead Parish Council
23/12/2020	13:15	Village river gauge alert: "River at risk of flooding, time to take appropriate precautions"	Leckhampstead Parish Council
23/12/2020	13:30	Village river gauge alert: "River in Flood"	Leckhampstead Parish Council
23/12/2020	14:00	Church End road becomes impassable	Not applicable
23/12/2020	15:30	River gauge records a peak of 2.28m	Not applicable
23/12/2020	19:00 (approx.)	Fire service attended but could not get past the bridge due to flood water	Buckinghamshire Fire and Rescue Service
23/12/2020	20:58	Buckinghamshire Council issued a tweet, indirectly mentioning flooding at Leckhampstead: "The roads between Leckhampstead and Wicken, Leckhampstead and Thornborough, and the road between the A422 and Thornton are also at risk of being flooded."	Buckinghamshire Council
24/12/2020	Morning	Floodwaters recede	Not applicable

24/12/2020	Unknown	Fire service attended and pumped out the cellar of a house in the village.	Buckinghamshire Fire and Rescue Service

8 Source-pathway-receptor analysis

The Source-Pathway-Receptor model is a concept that can provide an understanding of all aspects of flood hazard. It breaks a flood incident down into three elements:

- Source - the origin of flood water
- Pathway - a route or means by which a receptor can be affected by flooding
- Receptor - something that can be adversely affected by flooding (e.g. people, property, infrastructure)

We analysed all of the information available to determine the main sources of the flood water, the pathways it took and the main receptors. These are summarised in Figure 8-1 below and described in the following sections.

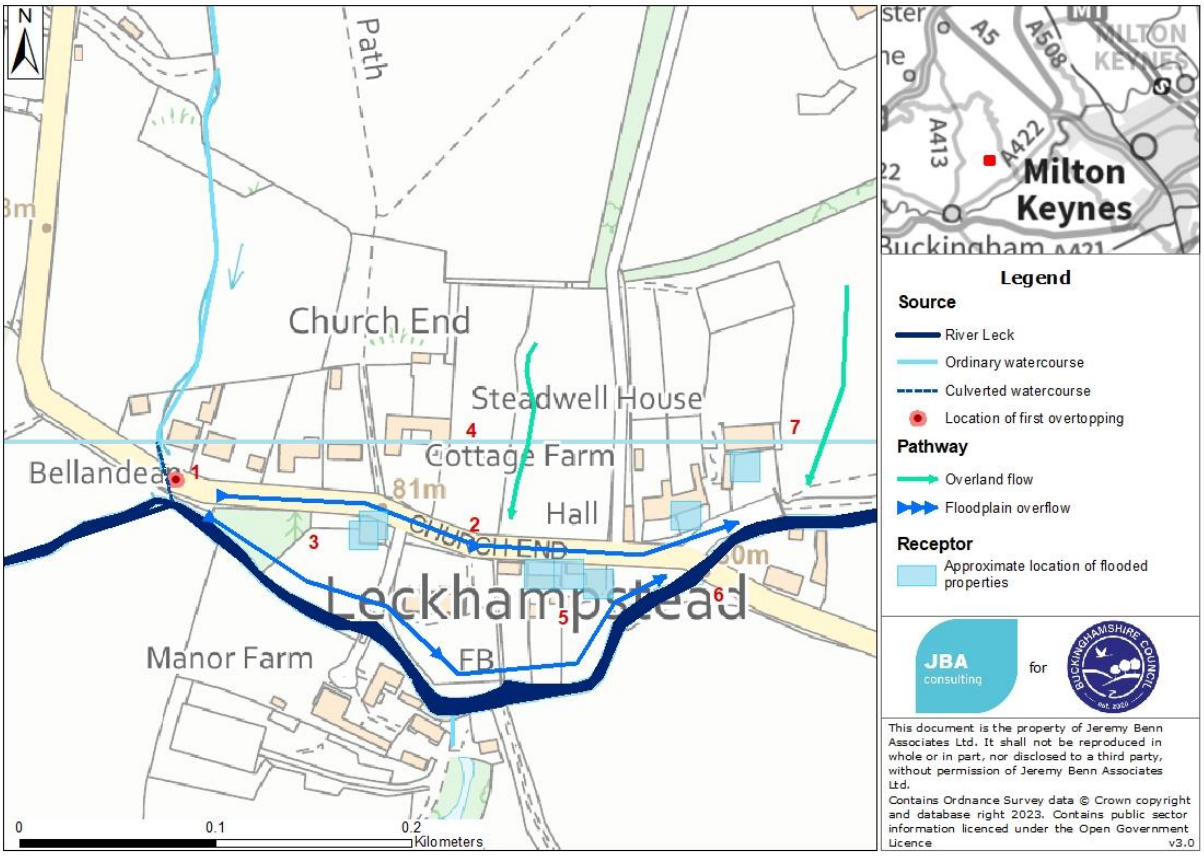

Figure 8-1: Map of sources, pathways and receptors of the 23 December 2020 flood event

8.1 Source

8.1.1 Heavy rainfall

Intense rain fell across the catchment on the morning of 23 December, continuing during the afternoon. Residents reported that this rain had also been falling continuously for the previous three days when it suddenly started running off the saturated fields, leading to the overland flows described below.

Overall, the rainfall lasted 19 hours, with the heaviest rainfall peaking at midday on 23 December and continuing until the early hours of the morning on 24 December. This

indicates a relatively rapid response of the catchment to rainfall and confirms that the catchment was highly saturated at the time of the event.

8.1.2 River Leck

Levels of the River Leck at Church End also rose quickly. The river overtopped its banks on to Church End at location 1 to join with the overland flows which had already pooled on the road, and quickly became unpassable at around 14:00. The rising levels of the river also caused it to encroach on to the rear of the properties along Church End south (3)(5).

8.2 Pathway

8.2.1 Overland flows

Overland flows were observed running off the fields to the north of Church End. The main routes of overland flow paths are shown at locations 4 and 7 in Figure 8-1. These followed ditches and depressions in the fields and channelled surface water flows which contributed to flooding along Church End

This water affected properties immediately surrounding the flow paths (7), and initiated flooding on Church End (2) where the flows pooled and were unable to drain away. This occurred prior to the river flooding at 13:30.

8.2.2 Seasonal watercourse

The seasonal ordinary watercourse tributary of the River Leck and the culvert at location 1 also acted as flow pathways for the field runoff. Large amounts of water were seen channelled along the watercourse, through residents' gardens and the culvert towards the River Leck, contributing to flows in the main Leck.

8.2.3 Road

As well as through residents' gardens, the out-of-bank flow was channelled down Church End as described by residents as a 'secondary river'. At the upstream end of Church End (1) the water was described as being halfway up the fence, downstream the water running along the road was reportedly 75cm deep at the front of the properties (5), and was above the railing at the bridge(6), depicted in the resident photograph below.

Figure 8-2 Floodwaters at Church End bridge (photo credit Tobin Jones)

8.2.4 Floodplain flows

Both Church End itself and the rear gardens of Church End south (adjacent to the river) acted as floodplain flow pathways during the flooding:

- Along Church End, overflow from the River Leck combined with surface water runoff from the fields to the north to create a secondary flow path which encroached on to the front of the adjacent properties (2).
- The rear gardens of Church End south conveyed the out of bank rising river levels to create a wide stretch of water, which in places reached the rear of the adjoining properties (3)(5) (Figure 8-3).

Figure 8-3: Retaining wall at location 5, looking towards the River Leck. In normal conditions, the river is confined to the far end of the garden near the hedgerow. (photo credit Yvonne Gurney)

8.3 Receptor

8.3.1 Properties

A total of seven residential properties were flooded internally, and several properties reported submitting significant insurance claims. The internal flooding was reported to be 10-12cm deep at location 3 and 10-15cm deep at location 5 (reference Figure 8-1). Externally, the floodwater reached 1m high at location 3, and a similar height to the top of a retaining wall at location 5. Significant internal and external flooding was also reported to properties around location 7.

8.3.2 Infrastructure

Roads in to and out of the village became impassable from 14:00 until late evening. This was due to the deep, fast flowing nature of the flood water on the main access route. The flooding meant that during the December 2020 event emergency services were unable to reach the village. Residents note that this is a regular occurrence, with access to the village cut off approximately four or five times per year due to water overtopping the bridge.

Figure 8-4: Water flowing fast down Church End at 16:30 on 23 December 2020 (photo credit: Yvonne Gurney)

8.3.3 People

Flood depths on Church End were significant enough to cause danger to people. One residents noted that they had to wade across the road thigh-deep to get their pets to safety. The regularity of the village being cut off combined with the vulnerable demographic of an elder population in the village results in a significant risk to life.

The hazard rating of the River Leck during the observed 23 December 2020 event was estimated at values falling in to both the 'Danger for most' and 'Danger for all' categories on the road around the River Leck bridge downstream of the village.

Residents have described the impacts of the flooding as traumatic, worrying and stressful, and some have described a feeling of dread as flood alerts are issued. The issuing of flood alerts also necessitates the moving of cars out of the village, and there is a degree of worry regarding home insurance claims and premiums.

After the flood two residents directly reported having to move out of their homes whilst repairs were carried out, though it is understood that the actual number was higher. For all those affected by the flooding there were significant clean-up costs and disruption.

8.3.4 Services

There were no local services such as schools, shops or doctors' surgeries affected by the flooding, as Leckhampstead is mostly residential. The floodwater was up to the entrance of St Mary's Church but is not known to have caused any damage.

9 Hydraulic modelling

9.1 Previous hydraulic modelling studies

JBA built two models for Leckhampstead in 2016:

- A catchment model (built using JFlow® software), designed to model the effects of NFM across the upper catchment on flows entering the village.
- A detailed 1D-2D fluvial model for the River Leck (using Flood Modeller-TUFLOW) through Leckhampstead

9.2 Updates to the models

As discussed in Section 5.3.1, twenty-four leaky dams were installed in the headwaters of the River Leck catchment during 2019[17]. A topographic survey of the dams was carried out by JBA Consulting in June 2020 to provide the exact dimensions of the channel and as-built dams.

Following the December 2020 event, JBA were commissioned to model the effect of the as-built NFM features to analyse their likely effect on the flood flows for the River Leck downstream and in Leckhampstead. The models were run with and without NFM structures for the full range of design events, and also using the rainfall for the 23 December 2020 event. Through this, we can assess the impact that the NFM features might have had on reducing the impact of flooding in Leckhampstead on 23 December 2020.

9.3 Results

The 1D-2D fluvial model for the River Leck through Leckhampstead shows that Church End and many of the properties surrounding the river are at risk of flooding from a 1 in 10 annual chance event and upwards. The modelled flood extent for a 1 in 10 annual chance event is displayed in Figure 9-1.

Modelling of the observed event of 23 December 2020 shows that the NFM structures installed in the upper catchment are predicted to have reduced the peak flow by 1% for the flood event, which equates to a very marginal reduction in water levels.

This small effect is to be expected due to the very high magnitude (greater than 1 in 100 annual chance event) of the December 2020 event. As outlined in Section 5.3.1, NFM is known to have limited effectiveness in such large flood events, with greater effectiveness in lower magnitude events. This is supported by our modelling results for lower magnitude design flood events. These demonstrate the same pattern: there is a more significant reduction in flood risk at the 1 in 30 annual chance event, with a reduction in peak flows of approximately 5% and a reduction in peak water levels of between 1 to 10 cm within the village.

Figure 9-2 below shows the difference between flood extents for the modelled baseline 1% annual chance event and the observed event of 2020. The modelled flood extents of each event are largely similar. Although the 1% annual chance flood extent appears slightly greater, while the flood extent from the 2020 event is slightly greater in some locations on Church End Road in the centre of the village.

17 https://freshwaterhabitats.org.uk/news/nature-inspires-a-flood-alleviation-solution/

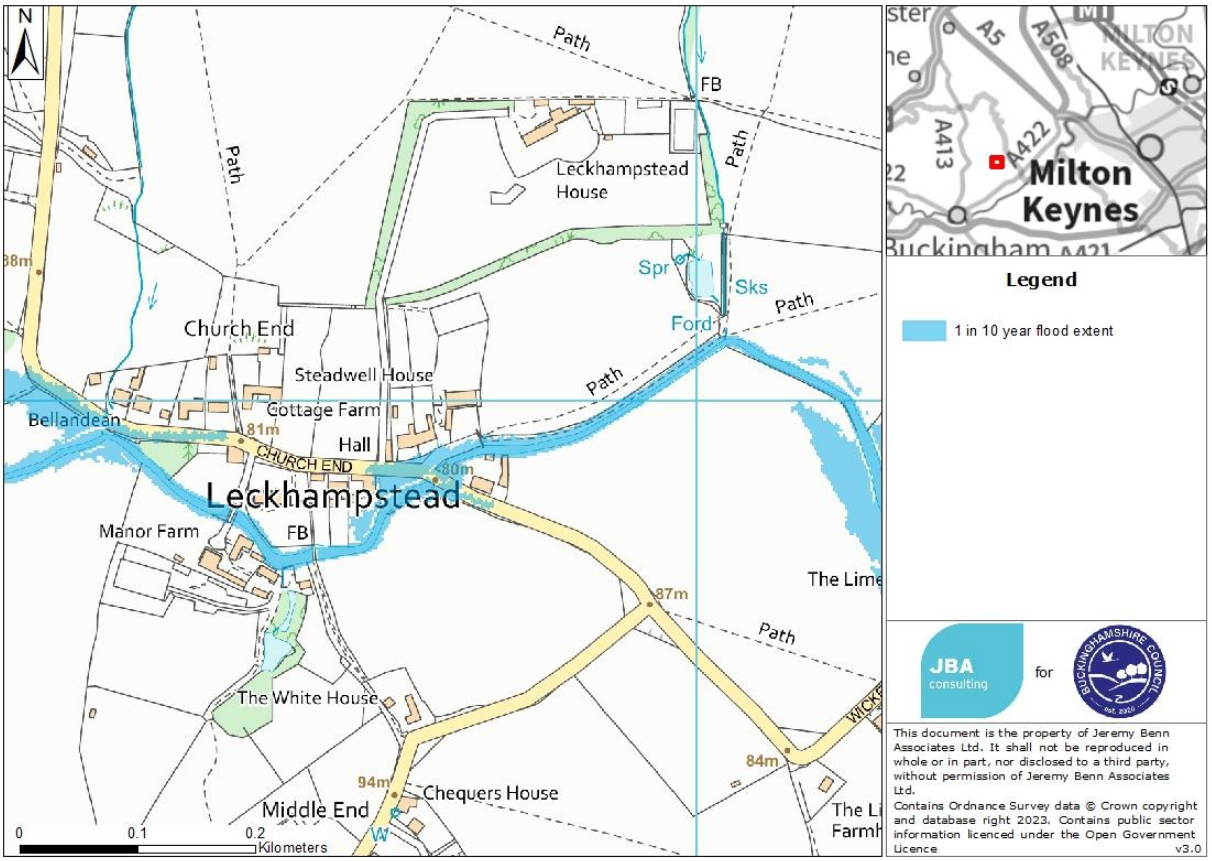

Figure 9-1 Modelled flood extent of a 1 in 10 year flood for the River Leck

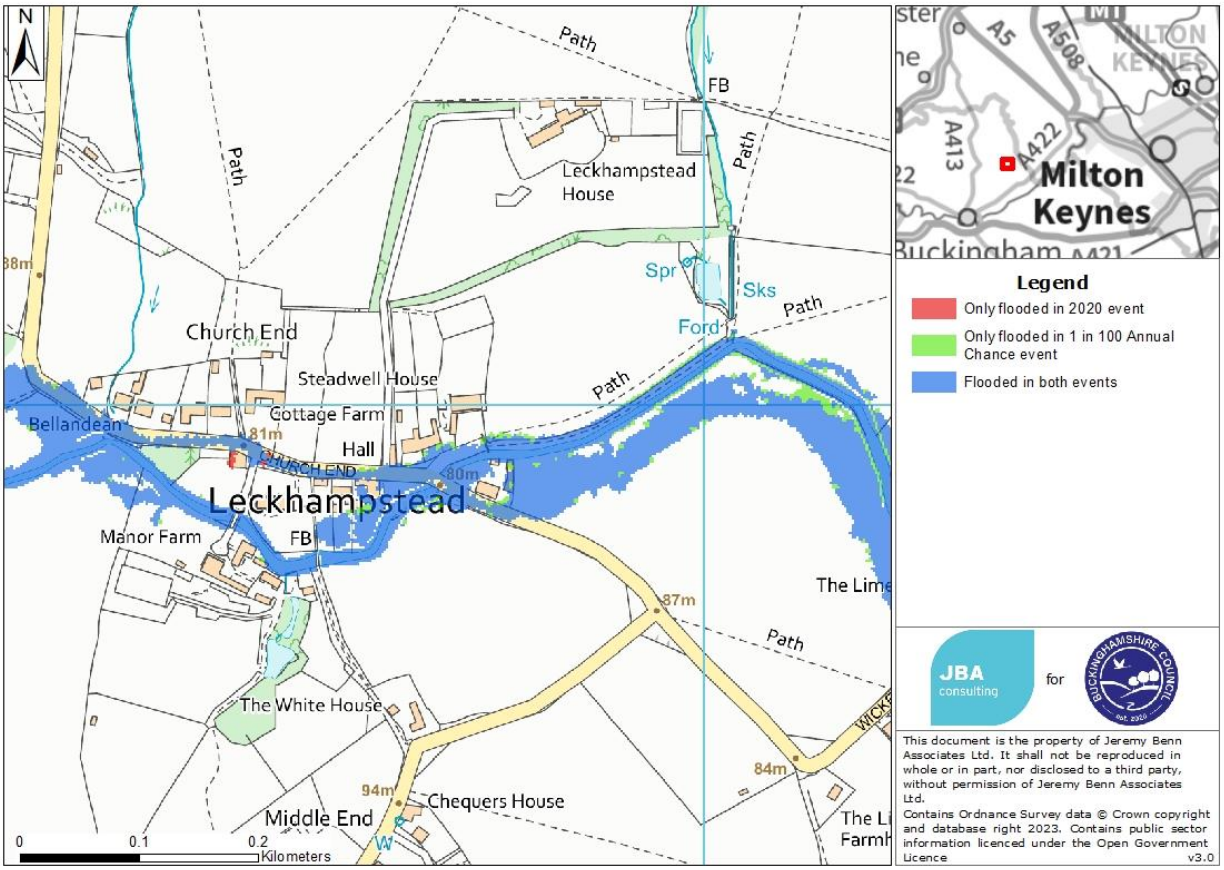

Figure 9-2 1 in 100 annual chance flood event of the River Leck modelling alongside the observed flood event in 2020

10 Discussion and preliminary appraisal

10.1 Introduction

In this section, we consider potential options to mitigate flood risk and reduce damages, taking into account the identified causes and mechanisms of flooding in Leckhampstead.

This includes consideration of measures such as natural flood management, Property Flood Resilience (PFR) (flood doors, barriers etc), community flood resilience and flood alleviation schemes.

We undertook a high-level option appraisal focussing on benefit, practical and viability considerations. We carried out a multi-criteria analysis to compare each option which included consideration of:

- Contribution towards reducing flood risk to property
- Contribution towards reducing flood impacts on people/communities
- Contribution to improving the availability of data, evidence and modelling to support option development or flood incident response
- Deliverability (including construction complexity, access, designations, services, space, land ownership, available materials and expert equipment or advice required)
- Community/resident acceptability
- Contribution towards biodiversity and water quality betterment
- Contribution towards amenity benefits
- Contribution to carbon reduction
- Maintenance requirements
- Approximate timescales
- Relative benefit-cost ratios

The scoring criteria and full results are described in more detail in the Multi-Criteria Analysis in Appendix A. Options were given a relative score and recommendations made for further work to be carried out, or quick-win actions.

Doing nothing or 'Walk away' was the least beneficial option, followed by continuing with a 'business as usual' approach to managing flood risk in Leckhampstead.

It is important to note that whilst JBA and Buckinghamshire Council have liaised with partner organisations regarding this assessment, this is a high-level, preliminary assessment undertaken by and on behalf of Buckinghamshire Council. Therefore, it is for the relevant responsible body or persons to assess these recommendations in terms of their legal obligation, resource implications, priority and the costs and benefits of undertaking such options.

Buckinghamshire Council will monitor progress on recommendations through the Buckinghamshire Strategic Flood Committee, but does not have powers to enforce their delivery by other delivery partners.

10.2 Flood alleviation scheme options

An initial options appraisal undertaken in 2017 examined a range of potential engineered flood alleviation options for the village, including:

- Construction of flood walls
- Modifications to the Church End road bridge
- Construction of large, engineered flood storage areas in the upper catchment

- Reconnection of the floodplain upstream of the village
- Combinations of the above

As context, Buckinghamshire Council as the LLFA do not have any capital budget of their own to draw upon to fund any flood management works on the ground. In order to design and construct flood alleviation schemes, the LLFA must develop a successful business case to bid for funding from central government under the Flood and Coastal Erosion Risk Management Grant in Aid (FCERM GiA) national funding system[18] The first step in this process is an appraisal of the cost-benefit of a range of potential flood alleviation options to determine if any are economically viable. In the case of Leckhampstead, this was undertaken via the initial options appraisal mentioned above from 2017.

The 2017 appraisal assessed the benefits and costs of the engineered alleviation options listed above, but concluded that none of these options would be economically viable as the estimated costs associated with any of the options would be significantly higher than their estimated benefits. As further context, under the national FCERM GiA funding system, benefits are based upon the damages that could be avoided, which are largely dependent on the number of properties that can be protected. As the numbers of properties in Leckhampstead are relatively low compared to many other schemes nationally, the damages that can be avoided - and therefore the benefits that can be delivered - are also relatively small, leading to lower benefits than costs.

(It should be noted that whilst engineering options were found to be unviable, scope was instead identified for delivering lower cost, small scale Natural Flood Management measures to – see Sections 5.3.1, 9.3 and 10.3 for further information).

As part of this Section 19 Flood Investigation, the previous appraisal was reviewed in light of the updated model information, with particular focus on the flood storage options. This review found that, unfortunately, there are still no viable options as the estimated costs greatly outweigh the benefits. Combined with the difficulty of building a low-cost scheme which can reduce flood risk significantly to all of the properties, this means that an engineered scheme for Leckhampstead is unfortunately not economically viable and that it would not be possible to make a successful business case under the current FCERM GiA funding system.

Table 10-1: Recommendations for flood alleviation schemes

Option	Organisation(s) responsible	Multi-criteria analysis score	Recommendation	Timescale
Engineered flood alleviation scheme	Buckinghamshire Council	5	Not Recommended - economically unviable	N/A

10.3 Natural flood management

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18 For further information regarding funding of flood risk management schemes, please see: https://thefloodhub.co.uk/frms-funding-and-delivery/

The LLFA has secured a small amount of Local Levy funding for the financial year 2023-2024 to allow for the construction of additional NFM within the River Leck catchment to enhance the flood risk benefits provided to the village of Leckhampstead. The additional NFM measures to be implemented include leaky dams/debris dams/tree hinge dams in the headwaters, offline flood storage and field corner bunds.

If additional funding becomes available in future, there may be opportunities to build upon and enhance the current NFM in the upper catchment of Leckhampstead. Scaling up the number of NFM interventions across the catchment would scale up the flood risk benefits, and there are significant opportunities for further development of NFM in the Leck catchment.

It is recommended that:

- Regular inspection and maintenance should be allowed for in order to maintain the catchment's resilience to flooding and prevent failure of the structures.
- Future designs should take opportunities to force flow onto the floodplain from the channel through rougher vegetation (such as woodland or buffer strips), or, even better, into areas where it can be stored (such as offline flood storage bunds)

Residents reported that December 2020 was the first time that some of the flooding on Church End could be partially attributed to overland flows from the fields north of Church End, rather than directly from the river. Working with landowners in these areas to manage land in a way that reduces runoff and overland flows where possible as part of any NFM scheme may help to address this source of flooding.

Table 10-2: Recommendations for expansion of NFM scheme

Option	Organisation(s) responsible	Multi-criteria analysis score	Recommendation	Timescale
Expansion of NFM scheme in upper catchment of the River Leck	Buckinghamshire Council	16	In progress	1-5 years

10.4 Property Flood Resilience

Property Flood Resilience (PFR) involves assessing how floodwater enters a property and recommending measures at an individual property level to mitigate potential flooding.

PFR can provide effective products and measures to reduce the impact of future floods in Leckhampstead by either aiming to limit water entry in the first place (resistance) or by adapting the internal fabric of the property to limit damage (resilience) if flooding does occur. Several properties in Leckhampstead have already invested proactively in their own PFR measures.

Resistance measures can include flood doors, flood barriers, automatic airbricks and non-return valves. Resilience measures include raising electrics, using porous plaster, and fitting solid floors or tiled floor coverings instead of carpets.

Although PFR measures are not able to entirely prevent flood water ingress, they aim to limit damage and ensure properties are adapted to cope with the impacts of floods and recover quickly from these disruptive events. Constraints of both resistance and resilience

approaches include funding, resident willingness and the appropriateness of the individual property for installing PFR measures.

PFR can either be taken forward as a community-wide scheme by a lead organisation such as Buckinghamshire Council, or privately by individual property owners. Buckinghamshire Council do have long-term aspirations to lead and deliver PFR more widely across the county in the coming years. However, this would require appropriate staffing and sufficient funding to be secured, and is subject to much uncertainty at present.

Individual property owners at risk of flooding, or those who have experienced flooding previously, may wish to consider installing PFR products and making their properties more resilient on a private basis[19]. Before any products are fitted, an independent PFR survey should be commissioned to identify the points of ingress and recommend appropriate measures[20]. Kitemarked PFR products should be supplied and installed by an approved supplier, to ensure the efficacy and reliability of the PFR measures.

If residents are unable to fund such works individually, the community could look to apply for grant funding from charities that can help with flood recovery (such as Heart of Bucks or the National Lottery Community Fund).

In the period immediately following any flood event, we recommend that residents speak with their insurance companies regarding support with the costs of implementing measures to 'build back better,' helping to better protect properties against future flooding when repairing a property after a flood event.

Table 10-3: Recommendations for property flood resilience

Option	Organisation(s) responsible	Multi-criteria analysis score	Recommendation	Timescale
Investigate opportunities for installing PFR in at risk properties	Property owners/community	13	Recommended	1-5 years

19 The Homeowners' Guide to Flood Resilience' (https://www.knowyourfloodrisk.co.uk/sites/default/files/FloodGuide_ForHomeowners.pdf) aims to inform homeowners about how to reduce flood risk to their homes and the variety of PFR methods available. It also includes contact details for surveyors/providers of Kitemarked flood protection equipment.

The National Flood Forum provide a webpage and guidance leaflet for homeowners on the steps towards installing their own PFR measures, and a tool to provide indicative costs of measures at: https://nationalfloodforum.org.uk/about-flooding/reducing-your-risk/protecting-your-property/

20 The Blue Pages, a directory for flood risk reduction services provided by the National Flood Forum, list a number of companies who may be able to undertake such individual flood risk surveys: https://bluepages.org.uk/listing-category/surveys-building/.

10.5 Community flood resilience

Table 10-4: Recommendations for community resilience

Option	Organisation(s) responsible	Multi-criteria analysis score	Recommendation	Timescale
Community flood resilience e.g. formation of a formal Flood Action Group, home insurance support	Community / Leckhampstead Parish Council	10	Recommended	<1 year

10.5.1 Flood Action Group

A community approach to resilience can significantly increase residents' ability to prepare, respond, and recover from floods in the future, and so reducing the impact of flooding on the community. This could include formalising the current active community members as a Flood Action Group. The National Flood Forum[21] have resources to assist communities with developing such groups to help with preparing for flooding and building their own resilience.

To further inform residents on how to prepare for, respond to and recover from flooding, it is recommended that greater awareness is raised of the existing community Flood Plan. The Flood Action Group could also create a 'flood preparedness' information pack for current and future residents in the area. The pack may contain advice on taking out contents' insurance on belongings, property resistance and resilience measures and a checklist of what to do in the event of a flood. This may help to give reassurance to residents on what can be done in the event of another flood and minimise future loss of belongings and damage to properties.

10.5.2 Home insurance

Residents reported anxiety around the effects of flooding on their home insurance; being able to afford the costs, claim successfully and cover for future flooding. Support and advice on insurance matters to residents in Leckhampstead can be provided through the Flood Re scheme[22] or advice from the National Flood Forum insurance helpline[23].

10.6 Community flood warning review

Warnings were disseminated to residents at 12:45, 13:15 and 13:30. Residents have noted that the timing of the alerts did not allow for them to prepare sufficiently for the event. It should be noted that this was a very fast event, with the hydrological analysis suggesting that the time to peak was approximately 2hrs, and the river rose from a warning level of 0.75m to 'in flood' in 45 minutes.

———————————————————————————————————————

21 National Flood Forum: https://nationalfloodforum.org.uk/working-together/communities/what-is-a-flood-action-group/

22 https://www.floodre.co.uk/flood-resources/

23 https://nationalfloodforum.org.uk/how-we-help/our-services/

To allow residents more time to prepare for the event, consideration could be given to adjusting the warning levels with the support of the warning system supplier. Analysis of the data, lead time and onset of overtopping at the low points since the logger was installed may result in small improvement to the effectiveness of the triggers. However, future events are also likely to be flashy and long lead times are unlikely to be achievable.

Table 10-5: Recommendations for community flood warning review

Option	Organisation(s) responsible	Multi-criteria analysis score	Recommendation	Timescale
Review alert and warning levels of the River Leck gauge	Community / Leckhampstead Parish Council	20	Recommended	<1 year

11 Conclusion and recommendations

11.1 Conclusions

The flooding that occurred in Leckhampstead on 23 and 24 December led to the internal flooding of at least seven properties in Leckhampstead village, resulting in residents being out of their homes for long periods of time following the flooding. There were significant problems with access and egress to the village, and dangerously high and fast-flowing floodwater. Buckinghamshire Council, as the Lead Local Flood Authority for Leckhampstead, has exercised its power to undertake a Section 19 investigation as this fulfilled its criteria of 'significant flooding'.

The total rainfall (53mm within 19 hours) during the storm event had a 7% chance of occurring in any one year (or 1 in 13 annual chance, or return period of 13 years). This is not especially extreme, but given that the soils were already completely saturated from the notably high rainfall over preceding months, the catchment was very sensitive and quick to respond to heavy rainfall. If the same rainfall event had occurred when the soil was drier, it is unlikely that such a large flood would have resulted.

The main sources of flooding to Leckhampstead was due to heavy rain across the catchment causing overland flows on the valley sides, converging with high levels in the nearby River Leck, which later exceeded its banks. The community level gauge on the River Leck peaked at 2.28m, at which point residents reported flood levels of up to 15cm inside properties, and up to 60cm outside properties. At its peak, Church End was described as a river following the road through the village.

It should be noted that due to the depth and velocity of flooding in Leckhampstead, flooding such as the event in December 2020 poses a significant danger to residents, particularly the vulnerable or elderly. This has been reflected in previous years where residents have reported incidents of vehicles requiring rescue near the River Leck bridge.

Warnings set at pre-determined trigger levels were sent out automatically by the community's own flood alert system on the River Leck. Residents reported the flooding to Buckinghamshire Fire and Rescue, but they were unable to attend until floodwaters receded due to the floodwater at the River Leck bridge making the area impassable.

Some individual properties already have some forms of PFR, which were used in the December 2020 event. Aquasacs deployed in the December 2020 event were unsuccessful at mitigating the flooding to properties. Some more robust measures installed by residents, such as a garden retaining wall, were more successful. Introducing similar robust PFR measures to properties at risk could reduce the damage and amount of time residents are out of their homes during flood recovery.

A high-level appraisal of measures to reduce flood risk in Leckhampstead has been undertaken, which includes the consideration of additional NFM measures in the upper catchment, PFR and community resilience. The least beneficial option according to the MCA was 'Walkaway'. The options that scored the highest were as follows:

- Community flood warning review
- Expansion of the NFM scheme in the upper catchment
- Property Flood Resilience
- Community flood resilience e.g. formation of a formal Flood Action Group

11.2 Summary of recommended actions

Recommended actions	Risk Management Authority/Stakeholder
Expansion of NFM scheme in the upper catchment of the River Leck	Buckinghamshire Council
Property Flood Resilience	Community / Buckinghamshire Council
Community flood resilience e.g. formation of a formal Flood Action Group	Community / Leckhampstead Parish Council / Buckinghamshire Council
Review alert and warning levels of the River Leck gauge	Community / Leckhampstead Parish Council

Appendix A Multi-criteria analysis

1	Contribute towards reducing flood risk to property Aligns with OM1A - economic damages	Likely change in internal flood risk to property	
		-2	Increase in flood risk to any property
		-1	N/A
		0	No perceived change
		1	Reduction in flood risk to 1 -10 properties
		2	Reduction in flood risk to 10 - 30 properties
		3	Reduction in flood risk to 30 - 70 properties
		4	Reduction in flood risk to 70-100 properties
		5	Reduction in flood risk to >100 properties
2	Contribute towards reducing flood impacts on people/communities Aligns with OM1B - people related benefits - risk to life, mental health, vehicle damages, evacuation costs	Likely change in flood impacts on people/communities. Encompassing community preparedness and resilience; stress, health, mental health impacts; nuisance flooding (gardens, roads etc); disruption to access and egress; vehicle damages; risk to life and evacuation costs.	
		-2	Major negative change in flood impacts on people/communities
		-1	Minor negative change in flood impacts on people/communities
		0	No perceived change
		1	Minimal positive change in flood impacts on people/communities (e.g. reduction in nuisance flooding)
		2	Minor positive change in flood impacts on people/communities (e.g. reduction in disruption to toilet use)
		3	Minor positive change in flood impacts on people/communities (e.g. improvements to access and egress)
		4	Medium positive change in flood impacts on people/communities (e.g. increasing community flood preparedness and ability to act)
		5	Major positive change in flood impacts on people/communities (e.g. reduction of risk to life and evacuation costs)
3	Contribute to improving the availability of data, evidence and modelling to support option development or flood incident response	This criteria focusses on the benefits of further data collection and evidence studies to support option development	
		0	Does not improve the availability of data, evidence and modelling
		1	
		2	Will provide additional data, evidence or modelling, helpful in development of interventions
		3	
		4	
		5	Improvement to data, evidence and modelling which is essential to the development of a capital scheme
4	Deliverability	Likely deliverability of the intervention considering construction complexity, access, designations, services, space, land ownership, available materials and expert equipment or advice required.	
		-2	Deliverability is at high risk of complexity/constraints
		-1	
		0	Not known/not applicable
		1	
		2	Deliverability is at low risk of complexity/constraints
5	Community / resident acceptability	Community buy in or perceived residents opinion.	
		-2	Community/residents are likely to have objections
		-1	Community/residents may not be receptive
		0	No known objections / constraints
		1	Community/residents are likely to be receptive but may have some constraints
		2	Community/residents are likely to be receptive and have no constraints
6	Contribute towards biodiversity and water quality betterment	Potential for the intervention to provide creation of habitats and river restoration, as well as improving existing water quality.	
		-2	Significant detriment
		-1	Some detriment
		0	No perceived change
		1	Some betterment
		2	Significant betterment
7	Contribute towards amenity benefits	Potential for the intervention to improve the amenity value of the surrounding area.	
		-2	Significant detriment
		-1	Some detriment
		0	No perceived change
		1	Some betterment
		2	Significant betterment
8	Contribute to carbon reduction	Potential for the intervention to contribute towards carbon reduction via sustainable construction techniques or carbon sequestration from increased planting.	
		-2	Significant net carbon increase
		-1	Some net carbon increase
		0	Not known/no effect
		1	Some net carbon reduction
		2	Significant net carbon reduction
9	Maintenance	High level assessment of maintenance requirements.	
		-2	N/A
		-1	High cost/frequency maintenance, requires new and specialised maintenance routines
		0	Not known/no effect
		1	Low-cost maintenance, can be compelted as part of existing maintenance routines
		2	No active maintenance required (passive maintenance designed)
10	Timescale	1	Long term strategic aim (>10yrs to progress, funding route unclear)
		2	
		3	Likely to be able to progress in next 1 - 5 yrs e.g. through FCERM partnership funding programme
		4	
		5	Quick win (<1yr), BC able to fund directly
11	Benefit Cost Ratio (BCR)	High level assessment of benefit to cost ratio	
		-2	Strong negative BCR
		-1	
		0	Equal BCR
		1	
		2	Strong positive BCR

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