Milton Keynes Council

FLOOD RISK INVESTIGATION

Newport Pagnell Section 19 Report

70082487-WSP-FRM-02-RP-CO-0001
JANUARY 2022

PUBLIC

Milton Keynes Council

FLOOD RISK INVESTIGATION

Newport Pagnell Section 19 Report

TYPE OF DOCUMENT (VERSION) PUBLIC

PROJECT NO. 70082487

OUR REF. NO. 70082487-WSP-FRM-02-RP-CO-0001

DATE: JANUARY 2022

WSP

4th Floor
6 Devonshire Square
London
EC2M 4YE

Phone: +44 20 7337 1700

Fax: +44 20 7337 1701

WSP.com

QUALITY CONTROL

Issue/revision	First issue	Revision 1	Revision 2
Date	06/10/2021	06/12/2021	26/01/2022
Prepared by	Jyoti Vaswani	Jyoti Vaswani	Jyoti Vaswani
Checked by	Soledad Berbel Roman	Soledad Berbel Roman	Soledad Berbel Roman
Authorised by	Louise Markose	Louise Markose	Louise Markose
Project number	70082487	70082487	70082487
Report number	70082487-WSP-FRM-02-RP-CO-0001	70082487-WSP-FRM-02-RP-CO-0001	70082487-WSP-FRM-02-RP-CO-0001

CONTENTS

1 INTRODUCTION 4

1.1 BACKGROUND 4
1.2 RISK MANAGEMENT AUTHORITIES 4
1.3 DATA COLLECTION 5
1.4 CONSULTATION WITH STAKEHOLDERS 6
1.4.2. ANGLIAN WATER SERVICES 6
1.4.4. ENVIRONMENT AGENCY 6
1.4.6. INTERNAL DRAINAGE BOARD 6
1.4.8. BUCKINGHAMSHIRE FIRE & RESCUE SERVICE 6
1.4.10. CANAL AND RIVER TRUST 6
1.4.12. PARKS TRUST 6
1.5 SITE VISIT 7

2 CONTEXT AND SETTING 10

2.1 SUMMARY OF EVENT 10
2.2 SITE LOCATION 11
2.3 MILTON KEYNES BALANCING LAKES 13
2.4 TOPOGRAPHY 14
2.5 GEOLOGY 15
2.6 FLOOD RISK 16
2.6.1. FLUVIAL FLOOD RISK 16
2.6.3. SURFACE WATER FLOOD RISK 16
2.6.5. GROUNDWATER FLOOD RISK 16
2.6.9. DRAINAGE 17
2.7 RECORDED FLOOD INCIDENTS 18

3 RAINFALL ANALYSIS 20

3.1 RAIN GAUGE ANALYSIS 20
3.2 RIVER GAUGE ANALYSIS 21
4 FLOODING DESCRIPTION AND MECHANISM 26
5 FLOOD RESPONSE 28
6 CONCLUSIONS AND FURTHER WORK 29
6.1 MAIN FINDINGS 29
6.2 RECOMMENDATIONS AND FURTHER WORK 29
6.2.2. RECOMMENDATIONS FOR COMMUNITIES AND RESIDENTS 29
6.2.3. RECOMMENDATIONS FOR LEAD LOCAL FLOOD AUTHORITY 30
6.2.4. RECOMMENDATIONS FOR THE ENVIRONMENT AGENCY 30
6.2.5. RECOMMENDATIONS FOR ANGLIAN WATER 30

TABLES

Table 1-1 - Risk Management Authorities relevant to this S19 4
Table 2-1 – Summary of Primary Control Rules for the Operation of Willen and Caldecote Lakes. Source: Milton Keynes Drainage Study, Volume 3: Modelling, Table 5.3, March 2000 14

FIGURES

Figure 1-1 - Sluice/control feature for Willen Balancing Lake (owned and managed by Anglian Water). 7
Figure 1-2 – Sandbags present outside property on Mill Street which experienced flooding during the flood event. 8
Figure 1-3 - Section of the River Great Ouse near The Mill House, Mill Street. 8
Figure 1-4 – Kerb on Priory Street 9
Figure 1-5 – Priory Street 9
Figure 2-1 - Newport Pagnell in 1899. Source: Milton Keynes Heritage 12
Figure 2-2 - Newport Pagnell in 1924. Source: Francis Frith 13

Figure 2-3 – Extract of Cranfield Soil and AgriFood Institute map 15

Figure 2-4 - Susceptibility to groundwater flooding. Source: Milton Keynes Council Local Flood Risk Management Strategy, AECOM 2016 17

Figure 2-5 – Tickford street flooding, 1908. Source: © Pinterest 2021 19

Figure 3-1 - 15min rainfall (mm) recorded at Birchmoor E22231 21

Figure 3-2 - Location of river gauges at Newport Pagnell 22

Figure 3-3 – Long term gauged daily flow at the Bedford Ouse at Newport Pagnell Total gauging station. 23

Figure 3-4 - Comparison of water levels for the April 1998 and December 2020 flood events from Newport Pagnell Cemetery river gauge. Source: Environment Agency (EA) - Newport Pagnell winter flooding initial analysis (May 2021) 24

Figure 3-5 - River flows from river gauges between Bletchley and Newport Pagnell (Bletchley Willen and Boughton) 24

Figure 3-6 - River flows from river gauges at Newport Pagnell (Newport Pagnell Main, Newport Pagnell Mill and Newport Pagnell Total) 24

APPENDICES

APPENDIX A

APPENDIX B

APPENDIX C

APPENDIX D

APPENDIX E

1 INTRODUCTION

1.1 BACKGROUND

1.1.1. WSP UK Ltd (WSP) have been commissioned by the Milton Keynes Council (MKC) Flood and Water Management Team to investigate significant flooding in the town of Newport Pagnell between the 23rd/24th December 2020.

1.1.2. A Section 19 investigation under the Flood and Water Management Act (FWMA) 2010 has been completed for Newport Pagnell to investigate the mechanisms, causes and sources of flooding that occurred.

1.2 RISK MANAGEMENT AUTHORITIES

1.2.1. A summary of Risk Management Authorities (RMA) as defined under the FWMA for Newport Pagnell along with their responsibilities is provided in Table 1-1.

Table 1-1 - Risk Management Authorities relevant to this S19

Risk Management Authority	Flood Risk Function
Milton Keynes Council - LLFA	Lead Local Flood Authority (LLFA), responsible for undertaking an investigation of the 23rd/24th December flood event, ensuring co-operation between the Risk Management Authorities in this area and leading the development of emergency planning and recovery after the flood, particularly when the main source of flooding is surface water. Can carry out flood risk management works on minor watercourses (outside the IDB District) Works in partnership with other Risk Management Authorities to ensure risks are managed effectively.
Anglian Water Services	Responsible for ensuring the appropriate level of resilience to flooding and maintenance of the foul and surface water sewerage assets, as well as management of the balancing lakes within the study area.
Environment Agency	The Environment Agency has a strategic overview of all sources of flooding and coastal erosion (as defined in the Flood and Water Management Act 2010). It is also responsible for flood and coastal erosion risk management activities on main rivers and the coast, regulating reservoir safety, and working in partnership with the Met Office to provide flood forecasts and warnings. It must also look for opportunities to maintain and improve the environment for people and wildlife while carrying out all of its duties.
Internal Drainage Board (IDB) (Buckingham and River Ouzel)	Responsible for managing water levels in low-lying areas as well as supervising land drainage and flood defences works on

Risk Management Authority	Flood Risk Function
	ordinary watercourses (for example Boughton Brook and Tongwell Brook) inside the Boards district. The IDB act as the Agent for Lead Local Flood Authority on Consenting and Enforcement matters.
Buckinghamshire Fire & Rescue Service	Local fire and rescue service responsible for attending emergency events within Milton Keynes.
Milton Keynes Council	The Local Planning Authority and the Authority who; • Can carry out flood risk management works on minor watercourses (outside the IDB District); and • Works in partnership with LLFAs and other Risk Management Authorities to ensure risks are managed effectively.
Canal and River Trust	Canal and River Trust is responsible for 2,000 miles of navigable canals and rivers (including the River Ouse), together with bridges, tunnels, aqueducts, docks and reservoirs, along with museums and archive collections.
The Park's Trust	The Parks Trust owns and maintains approximately 2,500 hectares of land in Milton Keynes. They own a considerable amount of land within the valley floodplain of the River Great Ouse and the River Ouzel at Newport Pagnell. They hold and operate this land in accordance with their purpose as a charity, which is to provide and maintain parks and green spaces for use by the public.

1.2.2. It is considered that the above RMAs have exercised or are proposing to exercise those functions in response to the flood. The LLFA have exercised their flood risk management function by investigating reported incidents of flooding through the commissioning of this S19 Flood Investigation Report.

1.3 DATA COLLECTION

1.3.1. As part of this investigation WSP has undertaken data collection activities with a variety of key stakeholders including the Environment Agency (EA), Anglian Water (AW), The Park's Trust, Canal & River Trust, the Internal Drainage Board (IDB), Buckinghamshire Fire & Rescue Service (BFRS) and MKC. This is being undertaken to obtain key data regarding the flood event between the 23rd/24th December 2020, including but not limited to pre and post flood recovery actions, maintenance regimes and local flood risk issues associated with assets that may have contributed to the events.

1.3.2. Data obtained to date and further details regarding this can be seen in Table 1, Table 2 and Table 3 in Appendix A.

1.4 CONSULTATION WITH STAKEHOLDERS

1.4.1. The following key stakeholders have been consulted as they all have flood risk functions that are prevalent to the 23rd/24th December 2020 flooding event.

1.4.2. ANGLIAN WATER SERVICES

1.4.3. Anglian Water provided information and datasets listed in Appendix A as well as verbal feedback within a call on 22nd June 2021 and on 13th January 2022. In the call the functioning and maintenance regimes of balancing lakes and river gauges were discussed, as well as the current studies that there are being undertaken to understand the capacity of their system in conjunction with the river catchment.

1.4.4. ENVIRONMENT AGENCY

1.4.5. The Environment Agency's East Anglia Area Partnerships and Strategic Overview (PSO) team (Great Ouse catchment) have been consulted and have provided a spectrum of data including rainfall and river gauge data. A list of the information assessed from the Environment Agency can be found in Appendix A.

1.4.6. INTERNAL DRAINAGE BOARD

1.4.7. The Buckingham and River Ouzel IDB have been consulted and further information on historical records of flooding as well as IDB assets have been provided. The IDB confirmed that no information of the study flood event was available. Further information of the data provided by the IDB can be found in Appendix A.

1.4.8. BUCKINGHAMSHIRE FIRE & RESCUE SERVICE

1.4.9. The local fire rescue service (Buckinghamshire Fire and Rescue Service) has been consulted. BFRS provided the incidents attended by their crews between at the time of the December 2020 flood event. A list of the information provided can be found in Appendix A.

1.4.10. CANAL AND RIVER TRUST

1.4.11. The Canal and River Trust provided a letter which detailed the water level in the pond (canal pound bounded to the north by the Cosgrove Lock 21 at E 479491 N 242259, and to the south by the Fenny Stratford Lock 22 at E 488356 N 234371) on 23rd and 24th December 2020. During the flood event the water level in the pond was maintained at between 69mm and 170mm head over the control weir level set at 71.68m AOD (normal water level is between -50mm and +150mm of the control weir crest). Further information can be found in Appendix A.

1.4.12. PARKS TRUST

1.4.13. The Park's Trust have been consulted. In this consultation The Park Trust clarified their role within Milton Keynes mainly as a riparian owner maintaining riverside trees, other vegetation and habitats in accordance with good practice. It was also highlighted that they own and maintain a number of local estate sustainable urban drainage systems, overall in estates developed within the past 10 years. A list of the data provided by Parks Trust can be found in Appendix A.

1.5 SITE VISIT

1.5.1. A site visit was conducted on 8th June to Newport Pagnell. On the day of the visit the weather was dry, hot and sunny. The days preceding the site visit the weather was generally dry.

1.5.2. The main aim of the site visit was to:

- Gain an understanding of the catchment of the River Ouzel and River Great Ouse within this location by identifying structures of the watercourses, flow paths and the setting of the watercourse in its catchment.
- Gain an understanding of and an appreciation of the local areas by walking along streets where properties were reported as flooded to understand the scale of flooding experienced during the 23rd/24th December 2020 and associated flooding mechanisms.
- Undertake liaison with the local residents regarding the aforementioned flood events as well as local ward councillors including Jane Carr (ward councillor for Newport Pagnell South).

1.5.3. The following key observations were noted:

Figure 1-1 - Sluice/control feature for Willen Balancing Lake (owned and managed by Anglian Water).

Figure 1-2 – Sandbags present outside property on Mill Street which experienced flooding during the flood event.

Figure 1-3 - Section of the River Great Ouse near The Mill House, Mill Street.

1.5.4. The River Great Ouse was reported to have had high water levels during the flood events of interest, with these reaching the back gardens of several properties. Newport Pagnell Main Gauging Station and Newport Pagnell Mill Gauging Station are located on this reach, both owned and maintained by the Environment Agency.

Figure 1-4 – Kerb on Priory Street

1.5.5. Flooding impacted a number of properties on Priory Street during the flood events of interest. Evidence of low kerbs and potential flow path next to a property that was flooded on December 24th 2020.

Figure 1-5 – Priory Street

1.5.6. During the flood event of interest witnesses reported surface water sewer surcharging from the drains at Priory Street.

2 CONTEXT AND SETTING

2.1 SUMMARY OF EVENT

2.1.1. As stated by the Environment Agency[1], December 2020 was a very wet month with a total rainfall of 108mm (195% of the Long-Term Average (LTA) rainfall) across East Anglia. December 2020 was the second wettest December in this area since the record started in 1981. The consistently above average rainfall in the River Great Ouse catchment during October, November and December 2020 saturated the catchment and contributed to the extreme high-water levels recorded in all the river gauges along the Great River Ouse between Buckingham and Newport Pagnell. These extreme river flows and high-water levels from the River Great Ouse were the main source of flooding in Newport Pagnell and surrounding areas during Christmas Eve of 2020.

2.1.2. The nearest river gauges located on the River Great Ouse at Newport Pagnell owned by the Environment Agency are; Newport Pagnell Main, Newport Pagnell Mill, Newport Pagnell Cemetery and Newport Pagnell Total. Further river gauges investigated for the purposes of this study were Bletchley and Willen located on the River Ouzel and Boughton located on Boughton Brook. River flow data from Bletchley, Willen and Boughton river gauges were investigated. Although river flows indicate an attenuation downstream of the River Ouzel on the 25th December, it is unclear if it is in response to the balancing lakes or due to the effect of floodplain mitigation. Further investigation is recommended to be carried out in the multi-agency capacity study to fully understand the interaction between surface water and fluvial flows and the role of the balancing lakes in this location. River flow data for Newport Pagnell (Newport Pagnell Main, Newport Pagnell Mill and Newport Pagnell Total) river gauges were investigated with Newport Pagnell Total recording a maximum flow of 133m^3/s on the 25th December. It should be noted that all three gauges had some missing flow data around the time of the flood event.

2.1.3. The nearest rain gauge at Birchmoor located between Apsley Guise and Woburn (approximately 11.4km south-east of Newport Pagnell), recorded an average monthly rainfall for December 2020 of approximately 89.6mm. According to the Met Office[2] the average rainfall for Woburn climate station, the nearest climate station to Newport Pagnell, was 57.3mm for December. Although the rainfall gauges did not capture an extreme rainfall intensity at Newport Pagnell, the combination of surface water runoff generated by the continuous rainfall and the extreme water levels in the River Great Ouse overloaded highway drains, drainage ditches and the local sewer network making these systems unable to cope.

2.1.4. Approximately 15 properties throughout Newport Pagnell are reported to have been flooded by a combination of sewage, surface water runoff and fluvial flooding. 10 out of the total 15 properties were reported to be flooded internally with 2 properties reported to be flooded externally and 3

[1] Environment Agency Fact Sheet December 2020 Flooding.
[2] https://www.metoffice.gov.uk/research/climate/maps-and-data/uk-climate-averages/gcpxfm7hf

reported unclear to flooding being internal/external. The approximate locations of the reported flood incidents are shown in Appendix B.

2.1.5. Flood incident data from Anglian Water was not provided at the time of writing.

2.2 SITE LOCATION

2.2.1. Newport Pagnell is located within the local authority of Milton Keynes, at the north-eastern corner of the Milton Keynes urban area. The town sits to the west of the confluence of the River Great Ouse and the River Ouzel. To the south and west lies Milton Keynes which is separated from Newport Pagnell by the line of the M1 motorway and the line of the A422 and A509 dual carriageways.

2.2.2. As shown in Figure 2-1 the High Street has always been a hub for the residents of Newport Pagnell as well as there being considerable residential development within the town, as depicted from 1899[3]. Figure 2-2 shows Newport Pagnell in 1924 where the flow path of the River Ouzel is the same as present day. For the River Great Ouse just upstream of the confluence with the River Ouzel there is one flow path of the River Great Ouse to the north of Mill Street, however present day at this location there are two extensions of the River Great Ouse before the confluence suggesting the river has been diverted here since 1899.

[3] https://www.mkheritage.org.uk/archive/nph/pdf/npmap1899.pdf

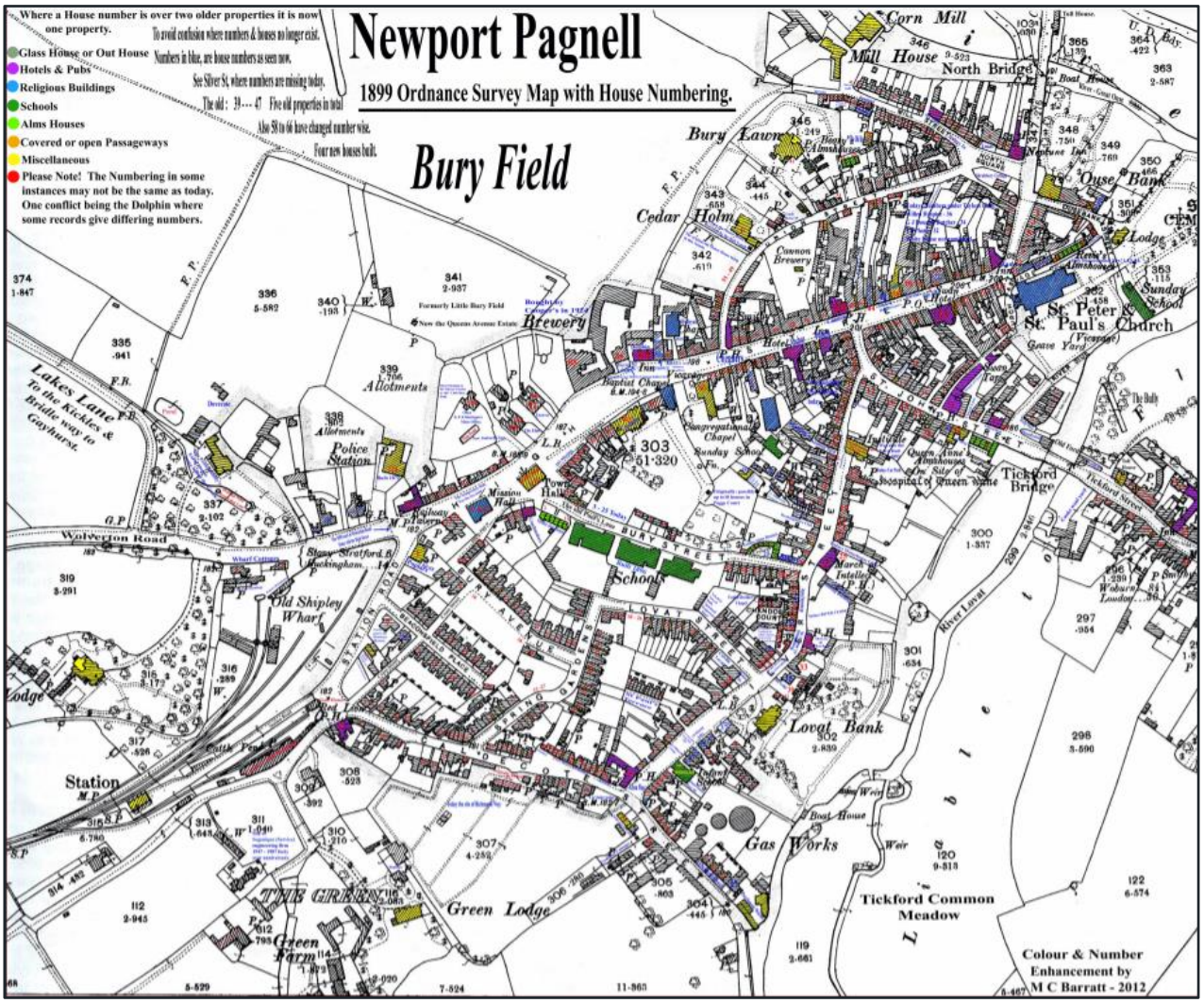


Figure 2-1 - Newport Pagnell in 1899. Source: Milton Keynes Heritage

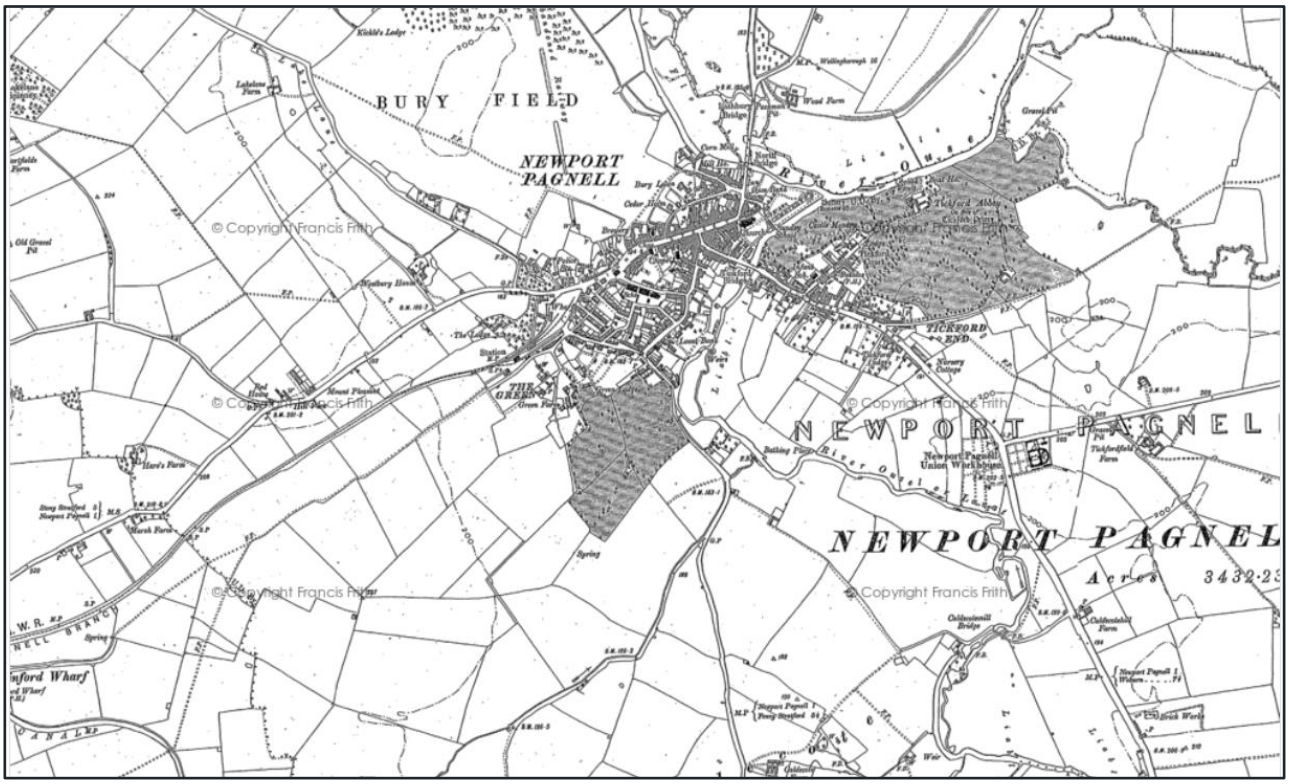


Figure 2-2 - Newport Pagnell in 1924. Source: Francis Frith

2.3 MILTON KEYNES BALANCING LAKES

2.3.1. Anglian Water own and are responsible for the maintenance of the balancing lakes located within Milton Keynes; those of particular interest are Willen Lake and Caldecotte Lake. The purpose of the balancing lakes is to provide storage to compensate for increased runoff and the loss of existing floodplain storage along the Ouzel as a result of the development of Milton Keynes. Therefore, the lakes were implemented to manage the excess of surface water and fluvial flows generated by the development of Milton Keynes, but they are not designed to alleviate flooding or reduce flood flow from the rest of the catchment. The balancing lake structures are maintained as part of the Reservoirs Act 1975. The operation of the balancing lakes is automated, and the lakes will only operate if the appropriate triggers are met. The system can be overrun and operate manually in case of a system failure. Under these circumstances, the Environment Agency might provide advice to Anglian Water if requested.

2.3.2. The gates are controlled automatically and operate on either Ouse mode or Ouzel mode. A summary of these modes is provided in the below table. They are open and closed twice a year under the supervision of a reservoir engineer to ensure the correct operation of these assets. There are also monthly visual inspections on all the balancing lakes to identify any sight of leakage, overgrown vegetation, blockages in screens, etc. The maintenance works identified a problem in Willen North sluice in September 2020 which was resolved as part of the asset's operation maintenance and therefore prior to the December 2020 flood event.

Table 2-1 – Summary of Primary Control Rules for the Operation of Willen and Caldecote Lakes. Source: Milton Keynes Drainage Study, Volume 3: Modelling, Table 5.3, March 2000

Mode Criteria	Description	Mode			
		Ouzel 1	Ouzel 2	Ouzel 3	Ouse 4
A	Ouzel outflow (without control) at confluence greater than 11.5m^3/s	Satisfied	Satisfied		
B	Ouzel outflow (without control) at confluence greater than 1.6 time that at Waterhall (Bletchley gauge)	Satisfied		Satisfied	
C	Ouse flow greater than 40m^3/s	Satisfied			Satisfied
D	Ouse flow greater than 50m^3/s				
E	Either gate up		Satisfied	Satisfied	
F	Ouzel outflow (without control) not greater than 11.5m^3/s				Satisfied
G	Ouzel outflow (without control) not greater than 1.6 times that at Waterhall (Bletchley gauge)				Satisfied

2.3.3. In consultation with Anglian Water, they have confirmed the gates at both Caldecotte and Willen balancing lakes were operating as designed during the December 2020 flood event. Anglian Water manually intervened to raise the gates in Willen lake to divert flows into the lake on the 25th December since they did not trigger automatically based on the water level thresholds reached at the river gauges at Bletchley and measured river outflows. This is due to the fact that rainfall in the River Ouzel catchment was not as intense as rainfall in the upper catchment of the River Great Ouse as shown later in this report. Therefore, river flows and water levels in the River Ouzel were not high enough to trigger the system.

2.4 TOPOGRAPHY

2.4.1. The centre of Newport Pagnell occupies a raised promontory of land defined by the confluence of the River Great Ouse and River Ouzel. The highest point is reached at the parish church with an elevation of approximately 63m AOD. From here, the ground drops sharply away to the River Great Ouse at North Bridge with an elevation of 58 m AOD and to the Tickford Bridge at 56 m AOD.

2.5 GEOLOGY

2.5.1. The land within the study area is defined by the Cranfield Soil and AgriFood Institute (CSAI)[4] as Soilscape 8- “Slightly acid loamy and clayey soils with impeded drainage” and SoilScape 20 - “Loamy and clayey floodplain soils with naturally high groundwater”. Another characteristic of Soilscape 20 is “Water” is also present and depicts the water bodies located within Newport Pagnell. The area is also heavily urbanised with a high proportion of impermeable surfaces likely to increase runoff volumes.

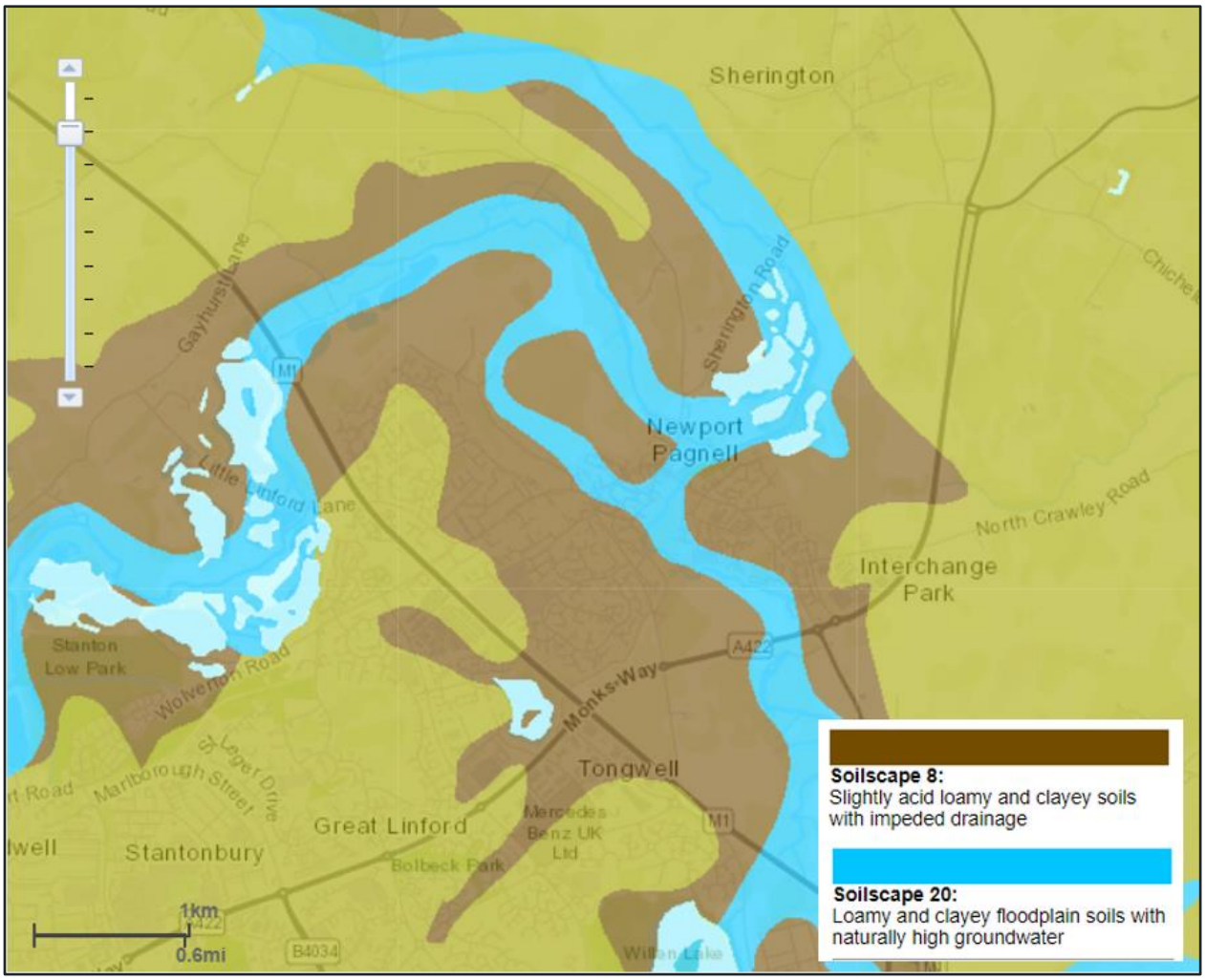


Figure 2-3 – Extract of Cranfield Soil and AgriFood Institute map

[4] Soil Types – Cranfield University, Source: http://www.landis.org.uk/soilscapes/, Last accessed: 27/07/2021

2.5.2. A review of the British Geological Survey (BGS)[5] maps indicate that the majority of the underlying soils of the town centre comprises of Petersborough Member (Mudstone), Kellaways Formation (Sandstone, siltstone and mudstone), Cornbrash Formation (Limestone), Blisworth Limestone Formation (Limestone), Great Oolite Group (Limestone, argillaceous rocks and subordinate sandstone, interbedded) and Wellingborough Limestone Member (Limestone and mudstone, interbedded). The majority of the underlying bedrock geology is limestone and mudstone which does not have a high permeability. Due to underlying geology having a low porosity significant rainfall in this area is unlikely to infiltrate significantly into the ground and will instead runoff over land, especially in heavy rainfall events.

2.6 FLOOD RISK

2.6.1. FLUVIAL FLOOD RISK

2.6.2. Appendix C shows an extract from the Environment Agency's Flood Risk Map for Planning[6] which identifies that most of the properties reported as flooded in Priory Street and Silver Street are within Flood Zone 2 [7]classified at 'Medium Probability of Flooding' and Flood Zone 3 [8]classified at 'High Probability of Flooding' include properties on Lathbury Bridge and Sherington Road.

2.6.3. SURFACE WATER FLOOD RISK

2.6.4. The Environment Agency's Long Term Flood Risk Map[9] within Appendix C identifies the properties reported as flooded in Priory Street and Silver Street as being at 'Low Risk'[12] 'Medium Risk[10]' and 'High Risk[11]' of flooding from surface water, with estimated water depths 300-900mm in the street in front of the properties. Properties flooded in Lathbury Bridge and Mill Street are located in an area classified as 'Low Risk[12]' of flooding from surface water.

2.6.5. GROUNDWATER FLOOD RISK

2.6.6. In regard to groundwater, the BGS Areas Susceptible to Groundwater Flooding map shown in Figure 2-4 identifies areas within Newport Pagnell which are classified as 'Potential for groundwater

[5] BGS Geology of Britain Viewer, Source: https://mapapps.bgs.ac.uk/geologyofbritain3d/, Last accessed: 27/07/2021
[6] EA Flood Risk Map for Planning. Source: https://flood-map-for-planning.service.gov.uk/confirm-location?easting=487583&northing=243709&placeOrPostcode=MK16%200EN; Last accessed: 27/07/2021
[7] Flood Zone 2: Land having between a 1% and 0.1% annual probability of river (fluvial) flooding (between 1 in 100 return period and 1 in 1000 return period) in any given year; or land having between a 0.5% and 0.1% annual probability (between 1 in 200 return period and 1 in 1000 return period) of sea (tidal) flooding.
[8] Flood Zone 3: land assessed as having a 1% or greater annual probability of fluvial flooding (1 in 100 return period or greater) in any given year or 0.5% or greater annual probability of sea flooding (1 in 200 return period or greater) in any year, not taking into consideration flood defences.
[9] EA Long term Flood Risk Map. Source: https://flood-warning-information.service.gov.uk/long-term-flood-risk/map?easting=535641&northing=178954&map=SurfaceWater; Last accessed: 27/07/2021
[10] Medium Risk: each year this area has a chance of flooding between 1% and 3.33%.
[11] High Risk: each year this area has a chance of flooding of greater than 3.33%.
[12] Low Risk: each year this area has a chance of flooding between 0.1% and 1%.

flooding to occur at surface' and 'Potential for groundwater flooding of property situated below ground level'. This mapping provides an indication as to where there is the potential for groundwater flooding and should be considered alongside other sources of flooding.

2.6.7. High groundwater level conditions may not always lead to widespread groundwater flooding; however, they have the potential to exacerbate the risk of surface water flooding and flooding from rivers by reducing rainfall infiltration capacity, and to increase the risk of sewer flooding through sewer/groundwater interactions.

2.6.8. With reference to the National Hydrological Summary, rainfall was above average, which served to raise groundwater levels and saturate the catchment. High groundwater levels can cause seepage into the drainage network, therefore reducing its capacity. However, groundwater mapping in this area is uncertain and there may be disturbance to shallow natural soils and geology due to the area being largely urbanised.

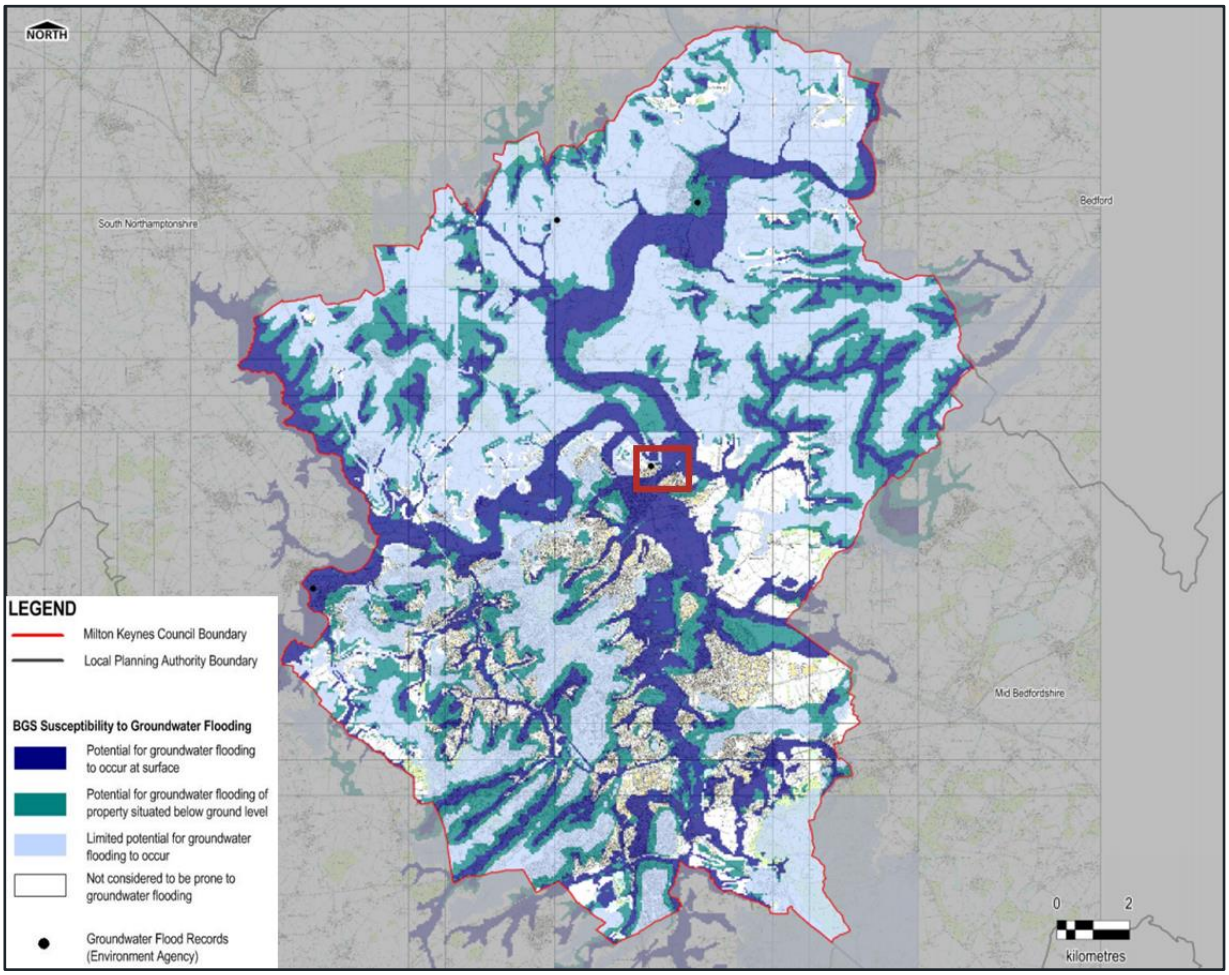


Figure 2-4 - Susceptibility to groundwater flooding. Source: Milton Keynes Council Local Flood Risk Management Strategy, AECOM 2016

2.6.9. DRAINAGE

2.6.10. The surface water drainage system within Newport Pagnell consists of a mixture of public surface water, combined and foul sewers which are owned and maintained by Anglian Water. Highway

drainage, owned and maintained by MKC as the Highway Authority, generally consists of gullies connected to the public surface water and combined sewers. Appendix D shows the locations of the sewers within the problem understanding map.

2.6.11. A call was held with Anglian Water the 22nd of June 2021. During this call, they confirmed that they were not aware of any foul water incident within the area at Newport Pagnell. Anglian Water flooding records were requested during the call however this was not provided at the time of writing this report.

2.6.12. The foul and surface water sewers in Newport Pagnell are complex, with a number of sub-catchments and linkages between these sub-catchments. In general, the foul and surface water sewers in the area to the north of the town comprising St John Street, High Street, Union Street and Mill Street is collected in one sub-catchment. The foul and surface water sewers in Tickford Street and Priory Street form another sub-catchment.

2.6.13. Plans indicate that the surface water sewer network of Tickford Street is connected to Priory Street and ultimately discharging to an outfall[13] in the north east of Priory Street located at 51.24m AOD. During the event, maximum water levels at the River Great Ouse reached 55 mAOD according to the Newport Pagnell Cemetery River Gauge. This means that surface water was unable to discharge into the River Great Ouse overwhelming the surface water sewer system at Priory Street. The capacity of the surface water sewer may have been further reduced due to potential groundwater ingress.

2.6.14. The impact of Cotton Valley overflow was discussed during the consultation with Anglian Water in June 2021. Anglian Water clarified that under normal circumstances the discharge from the site is 2700l/s (2.7m^3/s). However, during the flood event on the 24th December 2020 the treatment flows recorded were about 4600l/s (4.6 m^3/s). Discharges of 4m^3/s is a small percentage of the approximately 100m^3/s recorded in the River Great Ouse during the flood event. It is anticipated a minimal impact on the flood event due to these discharges, however it is recommended Anglian Water to work in partnership with the Environment Agency to investigate the impact of discharge from Cotton Valley on the River Great Ouse flows.

2.7 RECORDED FLOOD INCIDENTS

2.7.1. There are a number of historic flood events that have been occurred in Newport Pagnell prior to the event on the 24th December 2020. Figure 2-5 shows flooding at Tickford Street on 1908. Newport Pagnell was affected by the 1947 flood event with flooding recorded in Tickford Street, Silver Street, Caldecotte Street and Priory Street to a maximum depth of approximately 1.0m, as well as Lakes Lane and Willen Road with the latter recording a maximum depth of approximately 0.75m. The peak water level reported at the Newport Pagnell cemetery gauge was 55.12m AOD. In 1992 a flood event resulted in 9 residential and 6 industrial premises recording flooding, with a further 101 residential and 3 industrial properties suffering access disruption. After the 1998 flood 78 residential properties and one non-residential property were reported as flooded. Of the 78 residential

[13] Assuming this outfall does not have a flap included.

properties, 72 were located in Lakes Lane. The peak water level reported at the Newport Pagnell cemetery gauge was 55.12m AOD, reportedly the same as the peak level recorded for the 1947 flood event.

2.7.2. More recently, in July 2007 Buckinghamshire experienced flooding originating from the River Great Ouse. A Section 19 report was previously undertaken by MKC in response to a flood event in May 2018 resulting in the internal flooding of 15 properties. It should also be noted that in the process of writing this report flooding was reported in Newport Pagnell on 18th June 2021. A summary of maximum flows and maximum water levels recorded in the river gauges during these historical flood events has been provided in Appendix E.

Figure 2-5 – Tickford street flooding, 1908. Source: © Pinterest 2021

3 RAINFALL ANALYSIS

3.1 RAIN GAUGE ANALYSIS

3.1.1. Figure 3-1 shows measurements from rain gauge Birchmoor (E22231) which indicates a particularly wet month of December with persistent rain during the month. As stated by the Environment Agency[1] December 2020 was a very wet month with a total rainfall average of 108mm across East Anglia and it was the second wettest December in the River Great Ouse area since records began in 1981. Subsequently, the rainfall during the 23rd of December fell onto an already saturated catchment, exacerbating flooding issues. Tributaries of the River Great Ouse and upper parts of the catchment including Buckingham, responded with very high river levels at Newport Pagnell.

3.1.2. In addition, the Environment Agency[1] provided the Soil Moisture Deficit (SMD), which is the difference between the amount of water present in the soil and the amount of water the soil has the capacity to hold. This data shows that by the end of December the SMD was on average at 3mm across the East of England. This was 'below normal', whereby a low SMD means heavy rainfall is less likely to infiltrate the ground and more likely to run off into watercourses, indicating the impact of the intense rainfall experienced.

3.1.3. Reports received regarding the December flood event indicate that the flooding started on the morning of the 24th of December. The closest rainfall gauge to Newport Pagnell (Station E22231) located at approximately 11.4km, recorded 89.6mm of rainfall between 1st December and 31st December with a total of 19 mm rainfall recorded at the gauge on the 23rd and 24th December. Rain gauges in the upper River Great Ouse recorded higher rainfall intensities. For example, Brackley rain gauge recorded 53 mm rainfall on the 23rd and 24th December. The high intensity rainfall in the River Great Ouse upper catchment impacted flooding in Newport Pagnell.

3.1.4. Rainfall around the county is recorded by a series of rain gauges operated by the Environment Agency. These report the rainfall depth recorded over either a 15-minute interval or a day. To assess the rarity of the rainfall that fell the Flood Estimation Handbook[14] (FEH) web service Event Rarity Calculator was utilised. This provides the Annual Exceedance Probability (AEP) for the rainfall, which is the likelihood of rainfall of this depth or more falling in a year in that location. For instance, a rainfall event with an AEP of 1% means that rainfall of this depth or greater would only have a 1% chance of occurring in any one year in that location. This is also known as a '1 in 100 year' event. The Event Rarity Calculator assessed the recorded rainfall, however the maximum rainfall depths experienced over the time of the flood event did not derive a return period. Although the magnitude of the rainfall event recorded at this gauge was not particularly significant, the intense rainfall in the River Great Ouse upper catchment and the low SMD and high saturated catchment due to the persistent rain during the previous months were the main source of flooding at Newport Pagnell.

[14] FEH is the standard tool in the UK to estimate rainfall and river flow return periods. It is used by the Environment Agency and all professional hydrologists to estimate rainfall and rainfall return periods.

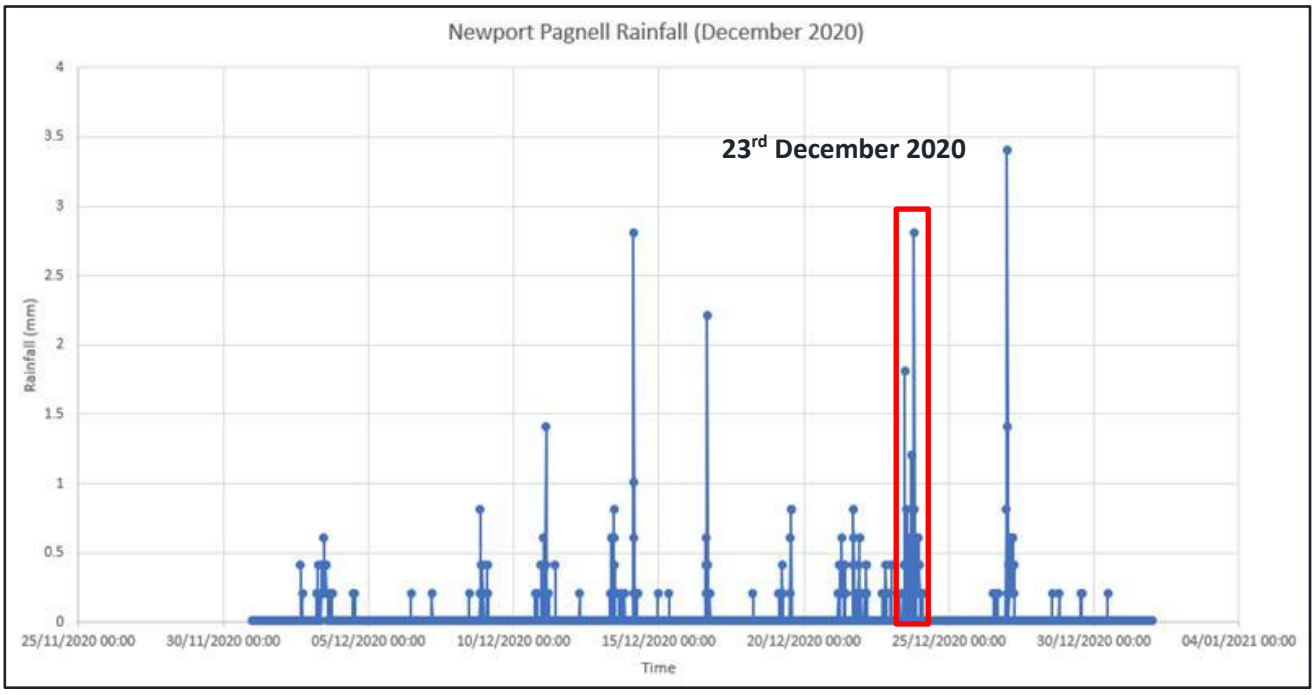


Figure 3-1 - 15min rainfall (mm) recorded at Birchmoor E22231

3.2 RIVER GAUGE ANALYSIS

3.2.1. There are several river gauges along the River Great Ouse and the River Ouzel. There are four river gauges located within Newport Pagnell on the River Great Ouse; Newport Pagnell Main, Newport Pagnell Mill, Newport Pagnell Cemetery and Newport Pagnell Total (see Figure 3-2).

Figure 3-2 - Location of river gauges at Newport Pagnell

3.2.2. Data obtained from the National River Flow Archive (NRFA)[15] for the 24th of December 2020 at the Bedford Ouse at Newport Pagnell Total flow gauge is shown in Figure 3-3. This figure clearly indicates a steep rise in river flows on the 24th of December as a result of the heavy rainfall from approximately 20th December. A sharp peak of flow on the River Great Ouse is evident with estimated values above 100m^3/s resulting from the heavy rainfall. This graph also indicates a discontinuity in the river flow data from 24th December 2020 to 13th January 2021. It might indicate that the dip tube within the river gauge was flooded during this event stopping the operation of the gauge.

[15] NRFA data are quality controlled before archival and release. Near real-time data are from the Environment Agency's Hydrology API and consist of checked and un-checked data. More information, including on quality flags for near real-time data is available in the API documentation.

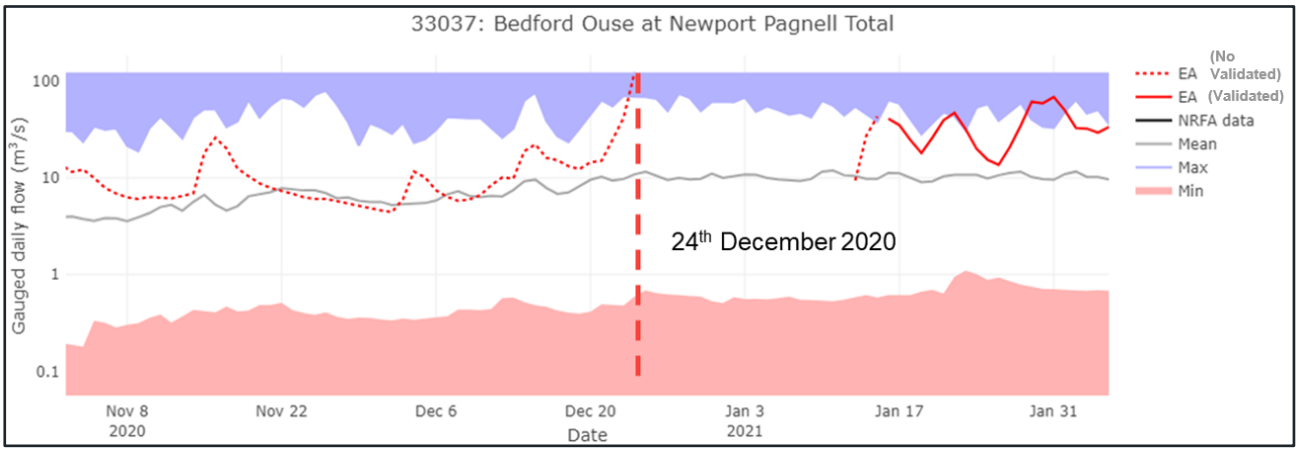


Figure 3-3 – Long term gauged daily flow at the Bedford Ouse at Newport Pagnell Total gauging station.

Key: Red and blue envelopes represent lowest and highest flows on each day over the period of record. Source: National River Flow Archive (NRFA)

3.2.3. Figure 3-4 shows water levels for the River Great Ouse for both the April 1998 and December 2020 flood events. The graph indicates that the December 2020 flood (orange line) had a much higher initial water level than April 1998 (blue line). Water levels were already at approximately 54.25mAOD prior to the main rainfall event on the 23rd December. The difference in initial water levels between 1998 and 2020 is 1.75m due to a smaller rainfall event that took place a week before this flood event. This initial high-water level could have played an important role in the magnitude of the December 2020 flood event, where river levels reached record river levels above 55m AOD in this location.

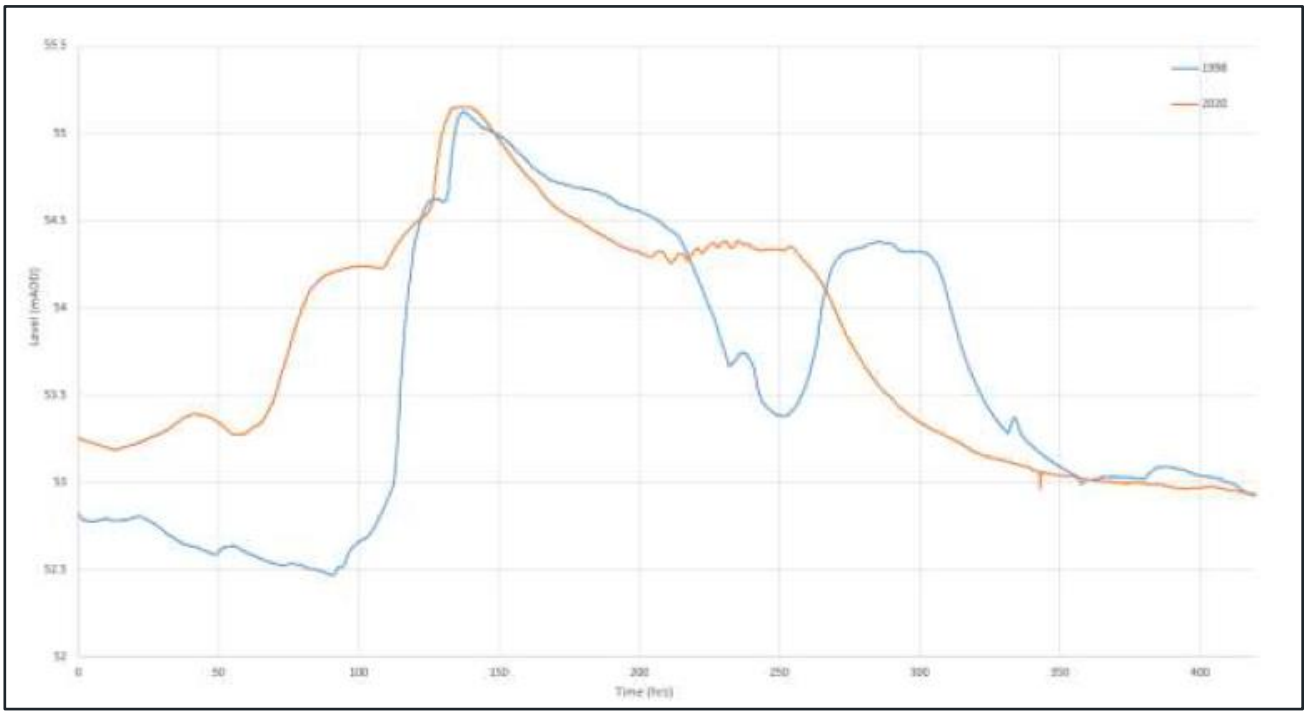


Figure 3-4 - Comparison of water levels for the April 1998 and December 2020 flood events from Newport Pagnell Cemetery river gauge. Source: Environment Agency (EA) - Newport Pagnell winter flooding initial analysis (May 2021)

3.2.4. A study of the river flows has been performed for the River Great Ouse at Newport Pagnell and for the River Ouzel and Boughton Brook between Bletchley and Newport Pagnell.

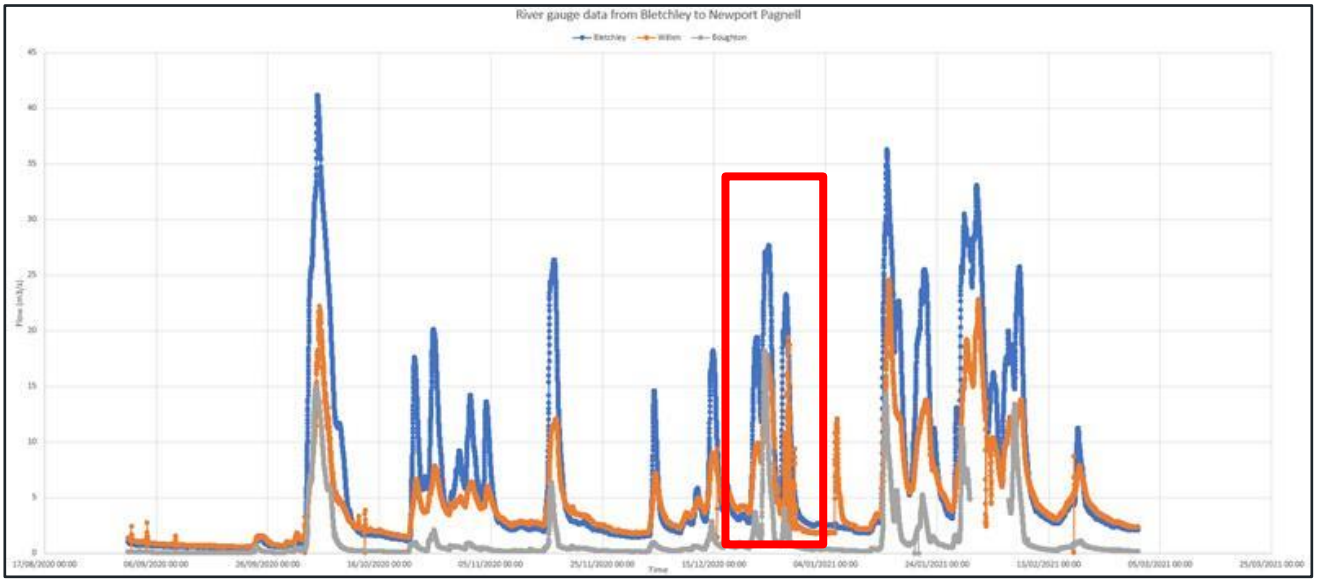


Figure 3-5 - River flows from river gauges between Bletchley and Newport Pagnell (Bletchley Willen and Boughton)

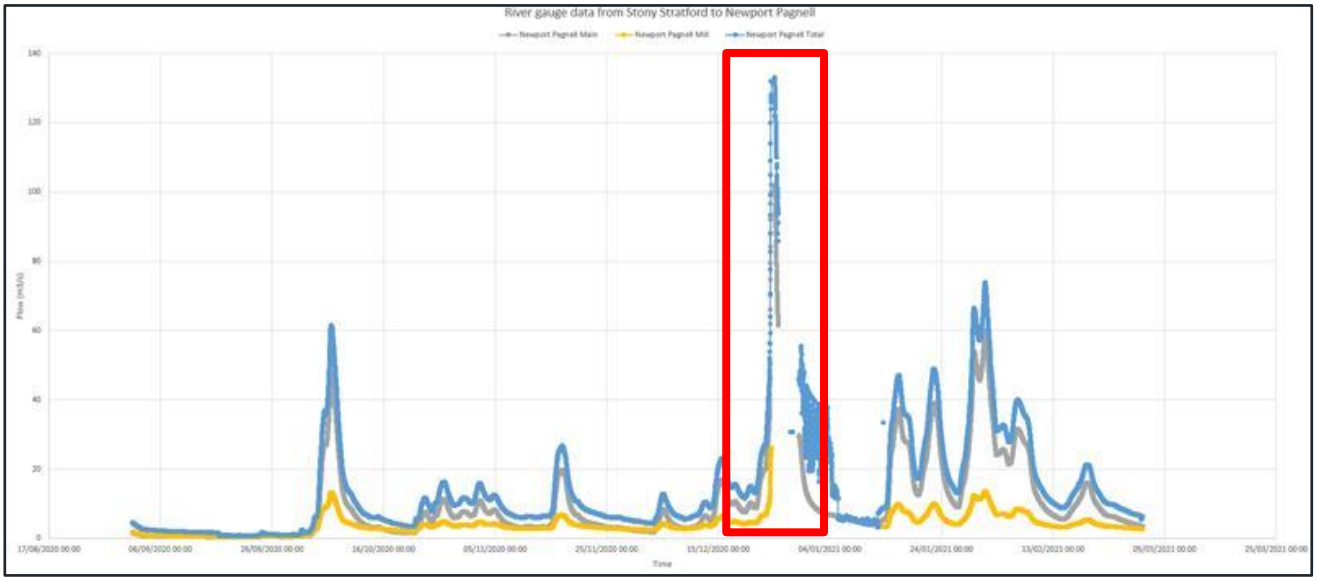


Figure 3-6 - River flows from river gauges at Newport Pagnell (Newport Pagnell Main, Newport Pagnell Mill and Newport Pagnell Total)

3.2.5. As mentioned previously, both Caldecotte and Willen balancing lakes operated as designed during the December flood event. On the 25th December it was decided to manually operate the lakes since

thresholds at Willen and Bletchely river guages were not triggered due to the absence of relatively high water levels in the River Ouzel. Figure 3-5 indicates that the flow of the River Ouzel from Bletchley to Newport Pagnell although peaked on the 23rd of December recording a maximum flow of 27.7m3/s at the Bletchley gauge, this was not high enough to trigger the Ouzel mode at the balancing lakes as indicated in Table 2-1. A drop in river flow is observed on the 25th December downstream Willen river gauge when the decision was made to manually operate the gates. This drop in the river flows might be reflecting the adjustment of the flows in this location. Therefore, although the balancing lakes worked as designed, there could be a role for them to be used to manage flood flows in the wider catchment which is recommended to be investigated further. Also, this data suggest that Bletchley gauge consistently recorded higher water levels than Willen gauge which could suggest that water was attenuated in the floodplain and that there could be an opportunity to explore this further to manage fluvial flooding in the future. This is something that could be investigated in the lake capacity partnership project.

3.2.6. Figure 3-6 indicates the flows within Newport Pagnell (Newport Pagnell Main, Newport Pagnell Mill and Newport Pagnell Total gauging stations). The graph shows that the flows in the River Great Ouse peaked around the time of the flood event with Newport Pagnell Total river gauge recording a flow of 133m^3/s on 24th December and therefore activating the balancing lakes in the Ouse mode (see Table 2-1). This historically high recorded peak flow in the Newport Pagnell gauges was a direct consequence of high intensity rainfall in the upper catchment of the River Great Ouse leading to a saturated catchment and quick response from the River Great Ouse. It should be noted that all three gauges had some missing flow data around the time of the flood event. Flow data for the Stony Stratford and Haversham river gauges were not available and therefore a trend in river flows for the River Great Ouse could not be assessed.

4 FLOODING DESCRIPTION AND MECHANISM

4.1.1. The flood event that occurred during the 24th December was mainly due to the extreme high-water levels recorded in the River Great Ouse. It was exacerbated by the incapacity of the drainage network to drain surface water and potential groundwater ingress. Intense rainfall in the upper catchment of the River Great Ouse during the 23rd of December over an already saturated catchment due to a wet month of December led the response of the watercourses and high-water levels within the River Great Ouse and River Ouzel. As stated by the Environment Agency[1] the Soil Moisture Deficit (SMD), which is the difference between the amount of water present in the soil and the amount of water the soil has the capacity to hold, was on average at 3mm across the East of England at the end of December. This was 'below normal', whereby a low SMD means heavy rainfall is less likely to infiltrate the ground and more likely to run off into watercourses, indicating the impact of the intense rainfall experienced. Potential reduced capacity of surface water sewer due to high water levels of the River Great Ouse near the outfalls as well as potential high groundwater levels exacerbated flooding at Priory Street. A total of 15 properties were reported to have flooded (10 internally, 2 externally and 3 unclear). Correspondence with local residents at Mill Street and the Toll House affected by the flood incident indicated that river levels at the River Great Ouse quickly increased overtopping its banks and inundating properties. A resident from Toll House reported that a retaining wall was breached due to the high-water levels reached in the river at approximately 10.30am on 24th December 2020. Figures A and B in Appendix D show the extent of the flooding at the Toll House and Figure C shows river levels of the River Great Ouse at Northampton Road Bridge.

4.1.2. The River Ouzel, which flows through the centre of Newport Pagnell overtopped its banks downstream of Tickford Bridge, flooding properties at River Side Street on the northern bank and Tickford Street on the southern bank. It was due to the difficulty of the River Ouzel to discharge into the River Great Ouse. Environment Agency flood defences retained flood water within the floodplain (Castle Meadow) protecting properties situated behind flood defences. Although flood defences performed adequately and protected properties from the high-water levels at the River Ouzel at this location due to the difficulty to discharge into the River Great Ouse, several properties at Priory Street were flooded. Figure F in Appendix D shows flooding at Priory Street from the roundabout at Tickford Street. Local residents at Priory Street reported that the local drainage drains and gullies were surcharging causing surface water to pond and accumulate. Properties that flooded externally recorded flood water depths up to approximately 30cm. It is understood to be caused by the incapacity of the surface water drainage system to discharge into the River Ouzel causing surcharging of drains and surface water flooding to the low ground sections at Priory Street. The flood event on 18th June 2021 impacting Newport Pagnell indicated surface water drainage capacity issues on Priory Street (refer to Figure E in Appendix D) and potential high groundwater levels at Castle Meadow (refer to Figure D in Appendix D) that have the capacity to exacerbate flooding in this area of Newport Pagnell.

4.1.3. The discharges from the Cotton Valley overflow were higher during the flood event (4600l/s (4.6 m^3/s) compared to normal circumstances (2700l/s (2.7m^3/s). Although overall it is considered that this would result in a small percentage increase of peak river flows and therefore an anticipated minimal impact to the flood event due to these discharges, it is recommended Anglian Water to work

in partnership with the Environment Agency to undertake a sensitivity test and investigate the impact of discharge from Cotton Valley on flows within the River Great Ouse.

4.1.4. New developments present within the area of Newport Pagnell (for example Aston Martin and Salmons Yard) have the potential to impact flood risk in the area, however, further investigation would be required to assess the flood mitigation measures implemented in these developments such as Sustainable Drainage Systems (SuDS) and their impact within the catchment.

4.1.5. Buckinghamshire Fire & Rescue Service attended the flood event on the 23rd and 24th of December. The police also attended the event and put a road closure in place for Priory Street as a result of the flooding.

4.1.6. The Canal and River Trust have advised that for the Milton Keynes trough pound (bounded to the north by the Cosgrove Lock 21 and to the south by the Fenny Stratford Lock 22) on 23rd and 24th December 2020 the water level in the pound was maintained at between 69mm and 170mm head over the control weir. Normal water level is between -50mm and +150mm of the control weir crest, i.e., 71.18m AOD and 73.18m AOD. Therefore, although the water level on the 23rd and 24th of December was above normal this was still held within the pound which has a control weir crest of 71.68m AOD.

4.1.7. It should be noted that although the 1998 flood event is often used as a benchmark by which other floods are measured and compared for the River Great Ouse, this was classified as a summer flood event which is characterised by dry summer months experiencing a sudden intense rainfall compared to the December 2020 flood event which was characterised as a winter flood event experiencing rainfall over a prolonged period of time. The 1998 flood event was estimated as a 1 in 125-year event[16].

16 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/295146/geho0807bnaz-e-e.pdf

5 FLOOD RESPONSE

5.1.1. Buckinghamshire Fire & Rescue Service attended two properties in Newport Pagnell on 23rd December and one property on 24th December, with the incident type for all four calls cited as flooding.

5.1.2. Anglian Water maintained 'full-incident' mode 24/7 over 12 weeks, from 23rd December 2020 to 12th March 2021 across Milton Keynes. This response from Anglian Water to the flood events over 23rd and 24th December 2020 included 400 dedicated technicians and 500 volunteer shifts. Approximately 120 tankers were deployed to prioritise tankering water from pumping stations in order to help local residents. Anglian Water recorded unprecedented volumes of contacts from concerned local residents; 30,000 jobs were raised, and 80,000 incoming calls were received. Anglian Water undertook meetings with the regional MP's and local authority representatives, as well as working closely with the Environment Agency to agree temporary local enforcement positions.

5.1.3. The following locations are covered within the Environment Agency's Newport Pagnell flood warning area; Mill Street, Tickford End, Willen Road, Lakes Lane, Westbury Lane, Wolverton Road, High Street, Station Road, Glenwoods, roads off Alexandra Drive and Blakelands. The first flood warning was issued on 24th December 2020 at 08.35am indicating rising river levels at the Newport Pagnell Cemetery river gauge. Further flood warnings were issued on 24th December (15.32pm, 23.18pm), 25th December (12.12pm), 26th December (00.02am, 08.32am and 19.40pm), and 27th December 2020 (07.55am)[17].

[17] https://floodassist.co.uk/flood-warnings/flood-area-info/buckinghamshire/052fwfmonewpag2/area-close-to-the-river-great-ouse-and-river-ouzel-at-newport-pagnell

6 CONCLUSIONS AND FURTHER WORK

6.1 MAIN FINDINGS

6.1.1. The flood incident that occurred during the 24th December was the result of a combination of river, surface water and groundwater flooding. Intense rainfall in the upper catchment of the River Great Ouse during the 23rd of December fell on to an unusually saturated catchment, as reported by the Environment Agency, which likely lead to more surface water runoff than would be expected if the catchment was dry and groundwater was at normal levels. Surface water flood risk mapping and groundwater vulnerability mapping highlight that this is an area at risk.

6.1.2. The nearest rainfall gauge is located at 11.4km from Newport Pagnell, hence it is unlikely to have recorded the peak of the event. The rainfall analysis using this gauge primarily indicates no evidence of an intense rainfall event for Newport Pagnell prior to the flood event. However, as highlighted in this report, high intensity rainfall in the upper catchment of the River Great Ouse resulted in high peak flows travelling downstream and causing flooding at Newport Pagnell.

6.1.3. It is understood that high water levels of the River Great Ouse caused flooding in the northern area of Newport Pagnell. High water levels of the River Ouzel due to backwater caused flooding in some properties located at River Side street and next to Tickford Bridge.

6.1.4. It is understood that highway drains and the local surface water sewer network were also unable to cope with the volume of rainfall runoff and high groundwater levels and river levels resulting in ponding within Priory Street.

6.1.5. Our investigation identified that the following factors may have also contributed to flooding:

- It is possible that more recent developments have incrementally increased the impermeable area in this location and contributed to incremental increases in rainfall runoff which increase flood risk, however this cannot be quantified at this stage. Further analysis would be required to identify the flood risk impact of developments.
- Insufficient maintenance of Highway Authority or Anglian Water Service assets has increased the extent of surface water ponding in the street and resulted in flooding to local properties with a low threshold.
- No control or attenuation of urban runoff, thus exacerbating flooding on Priory Street.

6.2 RECOMMENDATIONS AND FURTHER WORK

6.2.1. Recommendations and further work are suggested for the following key stakeholders.

6.2.2. RECOMMENDATIONS FOR COMMUNITIES AND RESIDENTS

- Produce a comprehensive community flood plan with the cooperation of all drainage system owners of surrounding properties.
- Prepare Household Emergency Plans for any vulnerable properties in the area.
- Review riparian ownership responsibilities regarding ditches and culverts in the area and take appropriate action.

- Collaboration with Milton Keynes Council[18] regarding any Highways maintenance.
- Improve coordination between Community Flood Group, Emergency Planning Team, Environment Agency and other flood management authorities.

6.2.3. RECOMMENDATIONS FOR LEAD LOCAL FLOOD AUTHORITY

- Work with the Environment Agency and other flood management authorities to support the community in the preparation of a Community Flood Plan.
  The LLFA is currently leading a partnership project between Anglian Water and the Environment Agency to undertake an integrated capacity study which assess the capacity of the balancing lakes and the Anglian Water system in conjunction with the river catchment.
- Facilitate collaboration between key stakeholders to enhance current understanding of flood risk and flood mitigation measures at Newport Pagnell, in order to determine any potential improvement opportunities and constraints.
- Better understanding of the capacity of the local drainage systems, in partnership with Anglian Water, to determine any potential improvement opportunities and capacity issues.

6.2.4. RECOMMENDATIONS FOR THE ENVIRONMENT AGENCY

- Carry out a review and investigate options to improve the resilience of Newport Pagnell Main, Mill and Cemetery river gauges.
- Work in partnership with Milton Keynes Council and Anglian Water to develop a Lake Capacity study to assess the condition and performance of the strategic drainage network of Milton Keynes, including all of the original lakes. This study should investigate the possibility of using the Milton Keynes balancing lakes beyond their original design to manage future flooding.
- Work in partnership with Anglian Water and Milton Keynes Council to review flood incident management procedures in relation to the balancing lakes and take the opportunity to make any improvements identified and incorporate a strategic maintenance plan.
- Work in partnership with Anglian Water to investigate the impact of discharge from Cotton Valley Sewage Treatment Works on the River Great Ouse flows.
- Consider further flood mitigation measures for Newport Pagnell.
- Monitor high flows in the area and determine a criteria for the activation of the balancing lakes with the Thames Valley Resilience Forum due to the current degree of uncertainty of automatic operation documented on the drainage strategy undertaken in 2002.

6.2.5. RECOMMENDATIONS FOR ANGLIAN WATER

- Undertake a sensitivity analysis of the Cotton Valley overflow to gain a better understanding of the impact of the discharges during the December 2020 flood event and potential impacts to flooding in Priory Street.

[18] https://www.milton-keynes.gov.uk/pay-report-apply/report-it

- Liaison with the Environment Agency to develop an integrated catchment model to gain a better understanding of the fluvial interaction of the River Great Ouse and River Ouzel impact on the sewer network capacity within Newport Pagnell.
- Liaison between Anglian Water, Environment Agency and MKC to optimise the operation mode of the balancing lakes within Newport Pagnell for future flood management within this area.
- Recommendation to include the potential impacts of new developments in this area on the foul and surface water sewer network capacity.
- Undertake CCTV survey in critical areas to identify potential blockages or defects in the surface sewer network.
- Support the Environment Agency and relevant risk management authorities within Milton Keynes to explore existing procedures and opportunities regarding the strategic drainage network.

Appendix A

APPENDIX A

MKC S19 Newport Pagnell

Dataset	Owner	Received?	Date	Comments
15 minute Rainfall data	Environment Agency	Y	22/07/2021	
River flow data	Environment Agency	Y	22/07/2021	
River gauge data	Environment Agency	Y	22/07/2021	
Any additional gauging station data for gauges within the Borough of Milton Keynes owned by the Environment Agency for last 10 to 15 years including the following gauges outside of Milton Keynes; River Tove at Cappenham Bridge and the River Great Ouse at Thornborough	Environment Agency	Y	22/07/2021	Received river gauage data for stations surrounding Milton Keynes
Operation and maintenance regimes for the gauging stations	Environment Agency	N		
Any information and data regarding the magnitude of the following flooding events occurring across the borough of Milton Keynes; 4th October 2020, 24th December 2020, 15th January 2021 and 30th January 2021	Environment Agency	N		
The location and information regarding the EA flood alleviation schemes	Environment Agency	Y	22/07/2021	
GIS shapefiles of any supplementary modelling that is not currently represented on the Flood Maps available online	Environment Agency	N		
A copy of Chapter 11 of the Ouzel Flood Scheme document (1987)	Environment Agency	N		They do not hold a copy of this
Catchment changes within Milton Keynes	Environment Agency	N		
List of the hydraulic capacities of all structures upstream of the confluence of the river Ouzel and the river Ouse at Newport Pagnell	Environment Agency	N		
Information pertaining to the balancing lakes associated with Milton Keynes	Environment Agency	Y	10/08/2021	210810 105745 - Naomi Chatfield-Smith - FW EAn 2021 216430 - EA Data - Final response to
Gauging station locations	Environment Agency	Y	07/06/2021	
Winter 20-21 Flooded Properties Working Spreadsheet EXTERNAL.xlsx	Environment Agency	Y	07/06/2021	
Water Situation Reports for Partners	Environment Agency	Y	07/06/2021	
Any supplementary modelling	Environment Agency	Y	22/07/2021	Products 5, 6 and 7
Asset register	Environment Agency	N		
Functional floodplain	Environment Agency	N		
Newport Pagnell community briefing May 2021.pdf	Environment Agency	Y	14/05/2021	
Newport Pagnell winter flooding initial analysis May 2021.pdf	Environment Agency	Y	14/05/2021	
MK Assets (GIS files)	Environment Agency	Y	22/07/2021	
MK operating procedures MKY-04-001.pdf	Environment Agency	Y	22/07/2021	
Recorded Flood Event Outlines 216430 (Newport Pagnell).pdf	Environment Agency	Y	22/07/2021	
2020 10 23 October Flooding Letter EA - FINAL.PDF	Environment Agency	Y	19/04/2021	
8433-1 2020 11 12 Reply.pdf	Environment Agency	Y	19/04/2021	
Clip Map Layers (GIS files)	Environment Agency	Y	22/06/2021	
Detailed River Network (GIS files)	Environment Agency	Y	22/06/2021	
Flood Alert Areas (GIS files)	Environment Agency	Y	22/06/2021	
Flood Map For Planning (Rivers and Sea) (GIS files)	Environment Agency	Y	22/06/2021	
Flood Risk Areas (GIS files)	Environment Agency	Y	22/06/2021	
Flood Warning Areas (GIS files)	Environment Agency	Y	22/06/2021	
Flood_Storage_Areas (GIS files)	Environment Agency	Y	22/06/2021	
Flood_Zone_2 (GIS files)	Environment Agency	Y	22/06/2021	
Groundwater Vulverability (GIS files)	Environment Agency	Y	22/06/2021	
Historic Flood Map (GIS files)	Environment Agency	Y	22/06/2021	
Indicative Flood Risk Areas (GIS files)	Environment Agency	Y	22/06/2021	
Indicative_Flood_Risk Areas_PDF	Environment Agency	Y	22/06/2021	
NRD (GIS files)	Environment Agency	Y	22/06/2021	
RFCC_Boundaries (GIS files)	Environment Agency	Y	22/06/2021	
Risk of Flooding from Surface Water (Basic) (GIS files)	Environment Agency	Y	22/06/2021	
Spatial_Flood_Defences (GIS files)	Environment Agency	Y	22/06/2021	
Statutory Main River Map (GIS files)	Environment Agency	Y	22/06/2021	
Water Situation Summaries	Environment Agency	Y	22/06/2021	
Milton Keynes Lakes Operation (Sept 2004).pdf	Environment Agency	Y	10/08/2021	

Master map	MKC	N		
Administrative areas	MKC	N		
IDB area	MKC	Y	22/06/2021	
Anglian water management area	MKC	N		
Areas Susceptible to Groundwater Flooding	MKC	N		
Location MKC flood defences/flood alleviation schemes	MKC	N		
Drainage Asset register & condition (including information on railway culvert referenced in SFRA)	MKC	N		
MKC Highways - flood Events	MKC	N		
Natural Flood Management (NFM) work summary	MKC	N		
Number and locations of property affected during flood event	MKC	Y	19/03/2021	

Any photos that were provided by local residents and confirmation if these can be used in the report.	MKC	Y	11/06/2021	
Activities that were completed before, during or after – including clean-up activities and removal of blockages etc.	MKC	N		
Are there are any activities that should have been undertaken in advance of the event, such as installation of property flood gates.	MKC	N		
Consultation undertaken with other RMAs.	MKC	N		
Any known data gaps that may be a risk for completion of the S19 report or ability to draw conclusions.	MKC	N		
Fire brigade data	MKC	N		
Landscaping	MKC	N		
Great Ouse December 2020 summary.pdf	MKC	Y	19/03/2021	
Milton Keynes Drainage Study - Vol 3 Modelling.pdf	MKC	Y	29/03/2021	
Balancing Lakes locations and areas	MKC	Y	19/04/2021	
Balancing Lakes Activation Emails	MKC	Y	24/06/2021	
FEH2013 Return period 24122020 for 491679-253579.pdf	MKC	Y	15/06/2021	
MAP Rain - Gauging Station E21493.pdf	MKC	Y	15/06/2021	
MAP Rain - Gauging Station E22088.pdf	MKC	Y	15/06/2021	
MAP Rain - Gauging Station E60701.pdf	MKC	Y	15/06/2021	
Flood Log emails	MKC	Y	24/06/2021	
Flood Triggers emails	MKC	Y	24/06/2021	
Newport Pagnell emails	MKC	Y	24/06/2021	
Boundary Map (GIS files)	MKC	Y	22/06/2021	
Flood Data 2016 (GIS files)	MKC	Y	22/06/2021	
Flood Data 2018 (GIS files)	MKC	Y	22/06/2021	
MKC Lakes (GIS files)	MKC	Y	22/06/2021	
Highways (MKC sourced) (GIS files)	MKC	Y	22/06/2021	
Landscaping (MKC sourced) (GIS files)	MKC	Y	22/06/2021	
Parks Trust (MKC sourced) (GIS files)	MKC	Y	22/06/2021	
MKC watercourses (GIS files)	MKC	Y	22/06/2021	
Scrutiny Meeting files	MKC	Y	06/08/2021	
Flood Alleviation works completed in Newport Pagnell following the flooding in 2008 (00206B45AF2B210331111037.pdf)	MKC	Y	16/08/2021	
Flood Schemes in Newport Pagnell (00206B45AF2B210331111027.pdf)	MKC	Y	16/08/2021	
KaarbonTech Report Card Prospect Road Vehicle Over.pdf	MKC Highways	Y	12/08/2021	
KaarbonTech Report Cards Prospect Road.pdf	MKC Highways	Y	12/08/2021	

DG5 register	Anglian Water	N		
Information on Anglian Water balancing lakes	Anglian Water	Y	22/06/2021	Covered in Wet Weather Incident - increased data sharing-20210622_083906-Meeting Recording.mp4.
Information on Anglian Water pumping stations	Anglian Water	Y	22/06/2021	Covered in Wet Weather Incident - increased data sharing-20210622_083906-Meeting Recording.mp4.
All rain gauging station data for gauges within the Borough of Milton Keynes owned by the Anglian Water for last 10 to 15 years	Anglian Water	N		
Historic flooding records	Anglian Water	N		
Any information and data regarding the magnitude of the following flooding events occurring across the borough of Milton Keynes; 4th October 2020, 24th December 2020, 15th January 2021 and 30th January 2021	Anglian Water	Y	22/06/2021	Covered in Wet Weather Incident - increased data sharing-20210622_083906-Meeting Recording.mp4.
Local flood risk issues associated with assets	Anglian Water	Y	22/06/2021	Covered in Wet Weather Incident - increased data sharing-20210622_083906-Meeting Recording.mp4.
Wet Weather Incident - increased data sharing email	Anglian Water	Y	15/05/2021	
Wet Weather Incident - increased data sharing-20210622_083906-Meeting Recording.mp4	Anglian Water	Y	22/06/2021	
Audio files between AW and local community (audio_only.m4a and zoom_0.mp4)	Anglian Water	Y	06/08/2021	
AW_WW_EXPORT_MK (GIS files)	Anglian Water	Y	22/06/2021	
ouzel fds.pdf	Anglian Water	Y	10/08/2021	

Role of the Parks Trust in Milton Keynes	Park Trust	Y	20/04/2021	
Pre and post flood recovery actions and maintenance regimes across Milton Keynes	Park Trust	Y	20/04/2021	
Information on flood defences	Park Trust	Y	20/04/2021	
Milton Keynes Balancing Lakes	Park Trust	Y	20/04/2021	
Parks_Trust_Land_MIlton_Keynes_North_East.JPG	Park Trust	Y	20/04/2021	
Sustainable Urban Drainage Systems managed by The Parks Trust in Milton Keynes.docx	Park Trust	Y	20/04/2021	
1979_Chartered Municipal Engineer Journal_MK Balancing Lakes.pdf	Park Trust	Y	20/04/2021	
2003_Environment Agency Operation of Willen and Caldecotte Lakes.pdf	Park Trust	Y	20/04/2021	

Any information regarding water levels and operation of the structures during the 23rd/24th December 2020 as well as 15th January 2021	Canal & River Trust	Y	06/05/2021	General info on the water levels and operation of the structures
Any relevant information and data regarding the following flooding events occurring across the borough of Milton Keynes; 4th October 2020, 24th December 2020, 15th January 2021 and 30th January 2021	Canal & River Trust	N		They do not have this data
Any information on overtopping and/or breach events during the 23rd/24th December 2020 as well as 15th January 2021	Canal & River Trust	Y	06/05/2021	
Historic flooding records	Canal & River Trust	N		

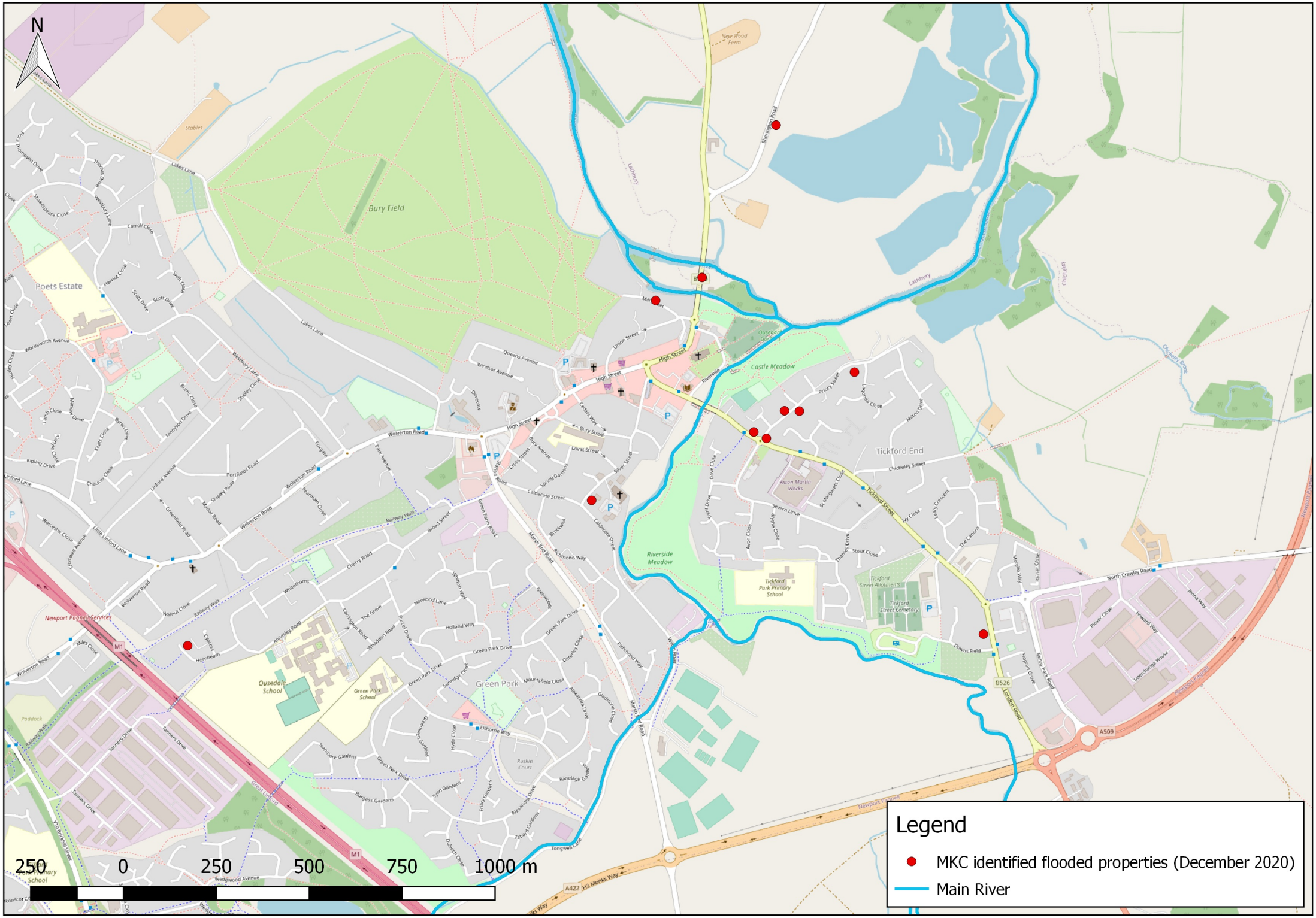
Historical overtopping and/or breach events	Canal & River Trust	Y	06/05/2021	
Records of management and maintenance of the canal and its structures within the three study areas	Canal & River Trust	Y	06/05/2021	
Bridges, canal centreline, outfall discharge points (GIS files)	Canal & River Trust	Y	22/06/2021	

Shapefile GIS layer of the watercourses associated with Newport Pagnell and IDB districts	IDB	Y	04/05/2021	
Historic flooding records	IDB	Y	04/05/2021	
Any relevant information and data regarding the following flooding events occurring across the borough of Milton Keynes; 4th October 2020, 24th December 2020, 15th January 2021 and 30th January 2021	IDB	N		They do not have this data
Records of the Board's Asset management System for the assets located within the above study areas	IDB	N		
IDB Shapefiles	IDB	Y	22/06/2021	
IDB Watercourses	IDB	Y	22/06/2021	

MK Flooding incidents attended Jan 2020 - Mar 2021.xlsx	Fire Brigade	Y	06/07/2021	
Historic flooding records	Fire Brigade	N		

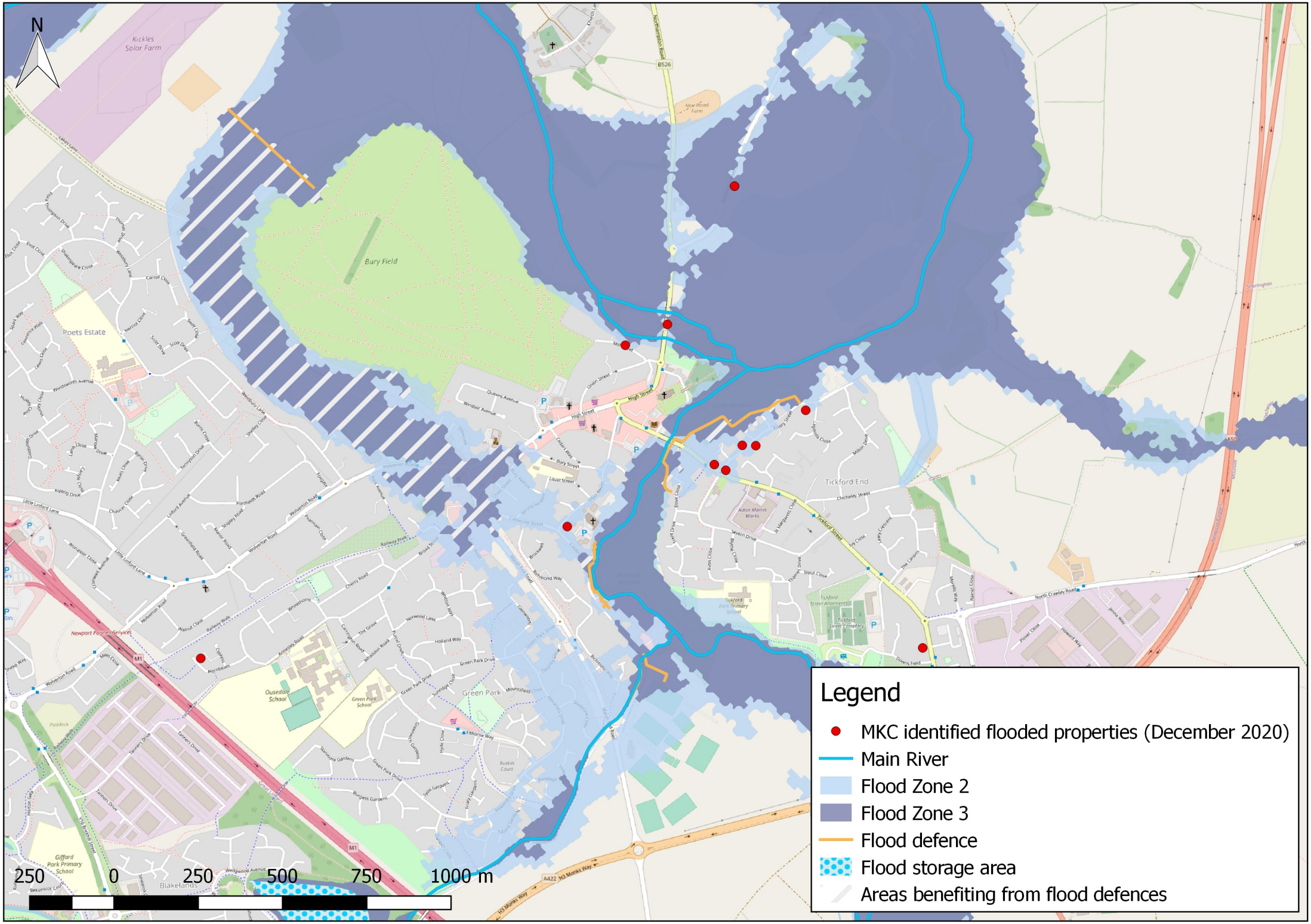
Appendix B

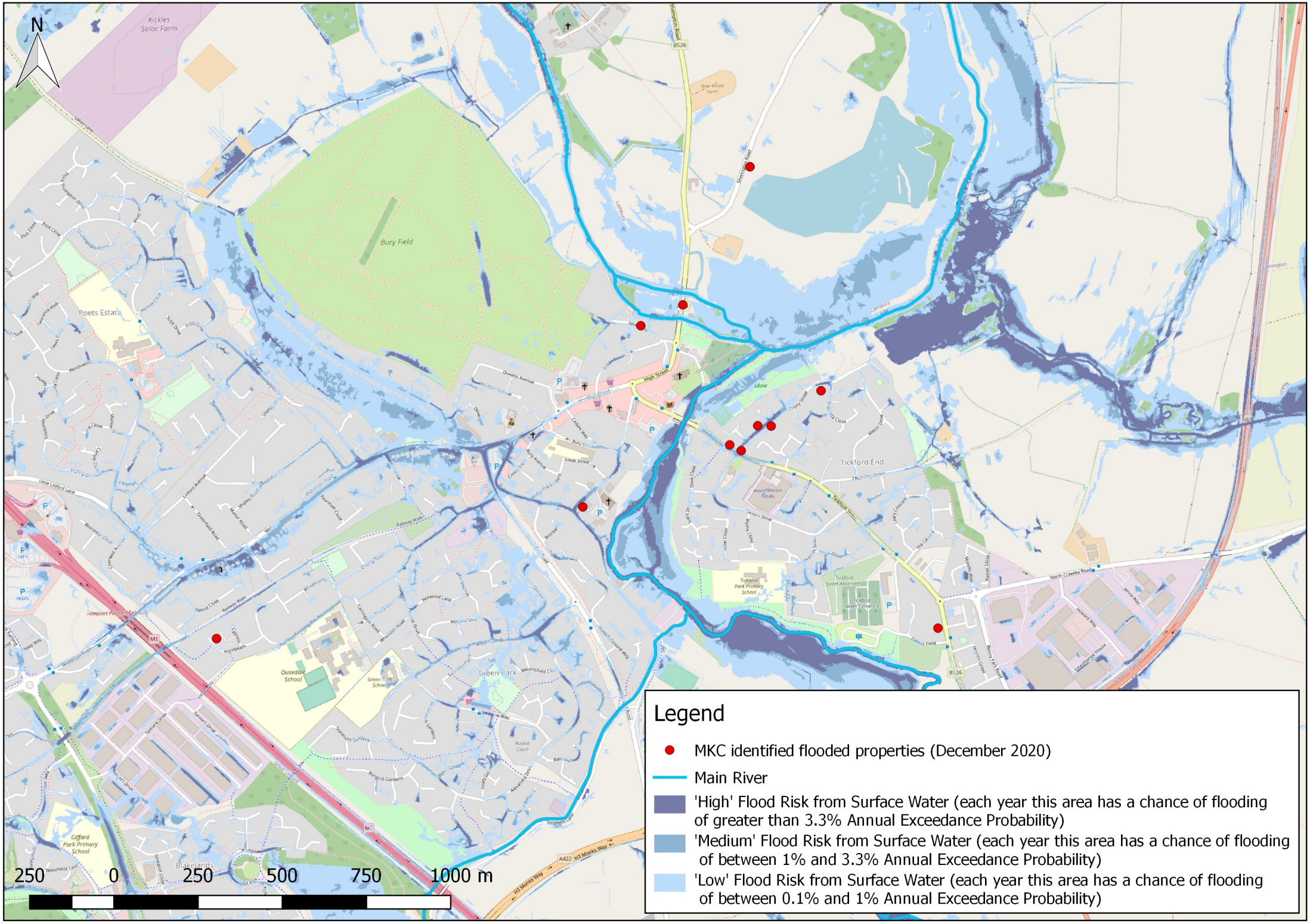
APPENDIX B



Appendix C

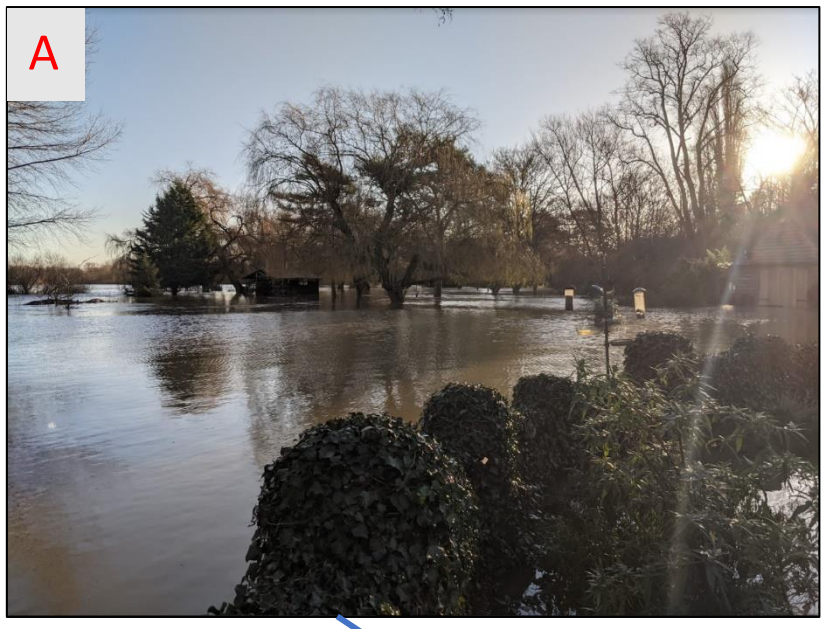
APPENDIX C


N
Kickles Solar Farm
Bury Field
Poets Estate
Tickford End
Green Park
Ousedale School
Green Park School
Gifford Park Primary School
Blakelands
Newport Pagnell Services
M1
A422 H3 Monks Way
B526
Northampton Road
High Street
Tickford Street
Legend
MKC identified flooded properties (December 2020)
Main River
Flood Zone 2
Flood Zone 3
Flood defence
Flood storage area
Areas benefiting from flood defences
250 0 250 500 750 1000 m

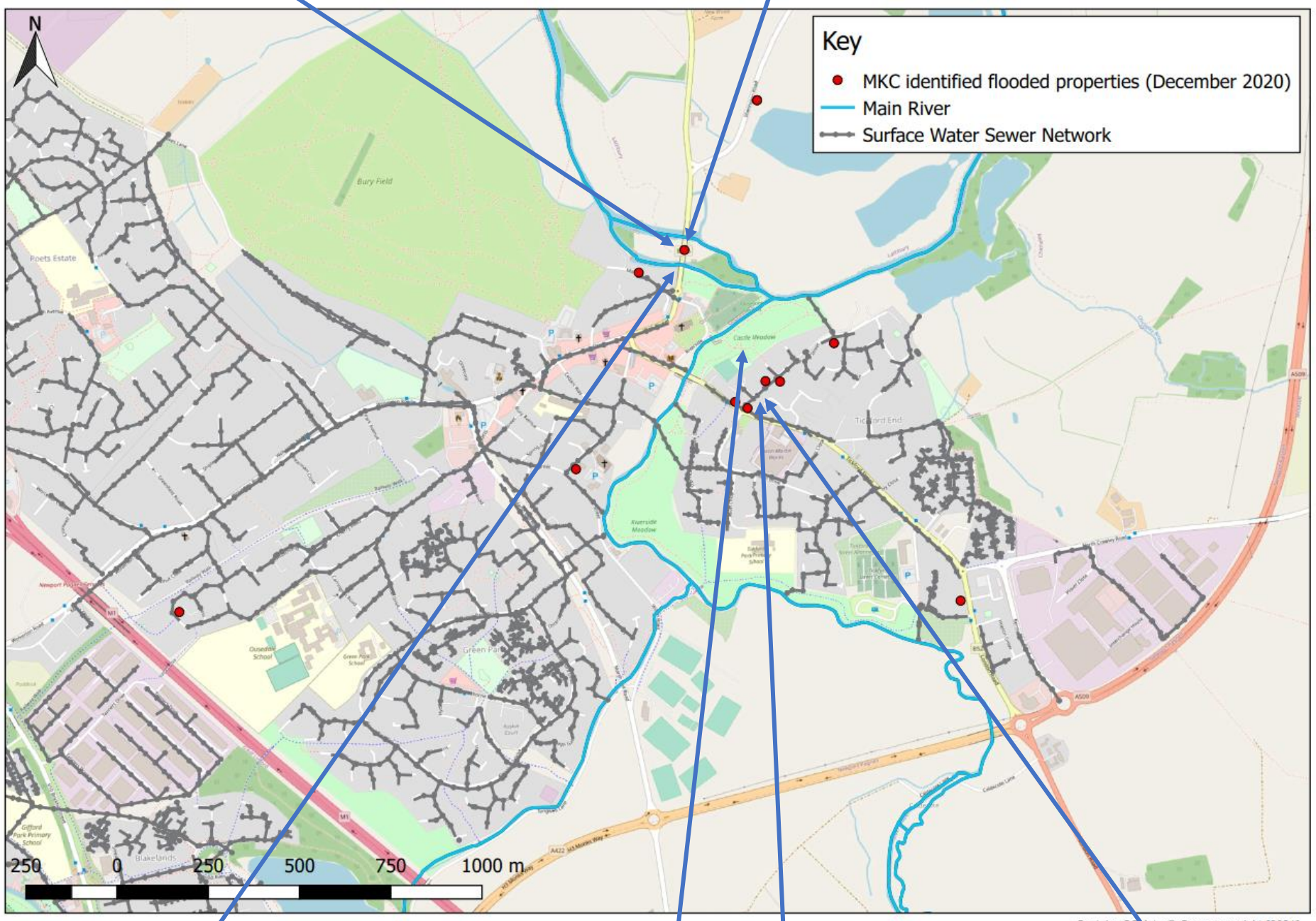

N
Kickles Solar Farm
Bury Field
Poets Estate
Tickford End
Ousedale School
Giffard Park Primary School
Blakelands
Tickford Park Primary School
250 0 250 500 750 1000 m
Legend
MKC identified flooded properties (December 2020)
Main River
'High' Flood Risk from Surface Water (each year this area has a chance of flooding of greater than 3.3% Annual Exceedance Probability)
'Medium' Flood Risk from Surface Water (each year this area has a chance of flooding of between 1% and 3.3% Annual Exceedance Probability)
'Low' Flood Risk from Surface Water (each year this area has a chance of flooding of between 0.1% and 1% Annual Exceedance Probability)

Appendix D

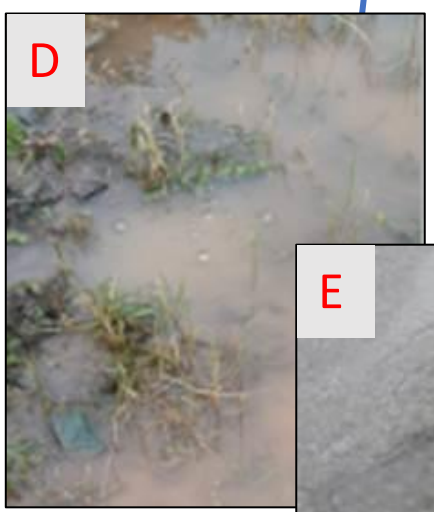
APPENDIX D


A


B


N
Key
MKC identified flooded properties (December 2020)
Main River
Surface Water Sewer Network
250 0 250 500 750 1000 m
Contains OS data © Crown copyright [2021].


C


D


E


F
ROAD
CLOSED

Appendix E

APPENDIX E

	Readings (mean historical water level data, m)													
Date of flooding	Scale of flooding	Waterhall Park (Bletchley) Gauge	Water Eaton Brook Gauge	Broughton Brook Gauge	Caldecotte Spillway Weir	Caldecotte Lake Level	Willen Lake Gauge	Willen Spillway Weir	Willen Lake Level	Newport Pagnell confluence (Total) Gauge	Newport Pagnell Mill Gauge	Newport Pagnell Cemetery Gauge	Lakes in operation	Comments
April, 1998		NA	NA	58.6 (approximate maximum observed water level) 58.4 (approximate maximum modelled water level)	64.5 (approximate maximum observed water level) 65.1 (approximate maximum modelled water level)	65.5 (approximate maximum observed and modelled water level)	NA	58.7 (approximate maximum observed water level) 58.8 (approximate maximum modelled water level)	59.9 (approximate maximum observed water level) 60.1 (approximate maximum modelled water level)	NA	55.5 (approximate maximum observed water level) 55.7 (approximate maximum modelled water level) It shouls be noted the above water levels have been taken at Newport Pagnell Mill/Mill gauging stations.	55.2 (approximate maximum recorded peak level) 55.1 (approximate maximum modelled water level)		
12th December 2012 – 22nd December 2012	Yes, property flooding around Caldecotte Lake Unconfirmed	0.67	84.68	0.39 (note; Stage ok. Flow suspect due to non-modularity.)	No water level data received.	NA	0.66	No water level data received.	NA	No water level data received.	Mean historical water level data not available	Mean historical water level data not available	Yes, Willen Lake in operation. Unclear if Caldecotte in operation	Balancing Lakes in operation
Monday, 13th June 2016	Total of 300 – 400 properties reported to be flooded	0.4	84.60 (note; Manual parallel drift down by 9mm to match dip on 12/05/2016. Manual anchored drift down by 5mm to match dip on 31/08/2016. Net drift down of 14mm)	0.37 (note; Stage good. non-modular fow identified.)		NA	0.52		NA					
Thursday, 16th June 2016		0.38	84.61 (note; Manual parallel drift down by 9mm to match dip on 12/05/2016. Manual anchored drift down by 5mm to match dip on 31/08/2016. Net drift down of 14mm)	0.27		NA	0.49		NA					
27th May 2018	500 properties flooded internally, and a 1000 flooded externally	0.47	84.55	0.31 (note; Parallel shift down by 55mm for the whole period and manually anchored drift up by 3 mm on left side to match dip at start and match shifted stage at 24/07/2018. Field log missing for the visit on 24/07/2018.)		64.01	0.62		58.4					
Sunday, 4th October 2020	1 property in Waterhall Park, flooded for the first time in 20 years	1.79	85.09	1.14 (note; Stage good. non-modular flow identified.)		NA	1.11		NA				Yes, Calecotte Lake in operation	Caldecotte Lake in operation/ Willen not in operation
23rd /24th December 2020	Flooding in rural areas on the 23rd December and flooding in Stony Stratford and Newport Pagnell	1.32	85.12	0.91 (note; Stage good. non-modular flow identified.)		NA	1.03		NA					
14th January 2021	Property in Waterhall Park flooded for the second time in 4 months	1.62	85.08	1.01		NA	1.12		NA					
28th January 2021	No property flooding – high levels in Waterhall park	1.51	84.97	0.85		NA	1.09		NA					
18th June 2021	80 properties flooded. 60 properties flooded in the Bletchley Area	Data doesn't extend to this date.	Data doesn't extend to this date.	Data doesn't extend to this date.		NA	Data doesn't extend to this date.		NA					

		Readings (mean historical flow data, m3/s)											
Date of flooding	Scale of flooding	Waterhall Park (Bletchley) Gauge	Water Eaton Brook Gauge	Broughton Brook Gauge	Caldecotte Lake	Caldecotte Spillway Weir	Willen Lake Gauge	Willen Spillway Weir	Newport Pagnell confluence (Total) Gauge	Newport Pagnell Mill Gauge	Newport Pagnell Cemetery Gauge	Lakes in operation	Comments
April, 1998		34 (approximate maximum flow)	NA	NA	NA	NA	NA	NA	NA	NA	NA		
12th December 2012 – 22nd December 2012	Yes, property flooding around Caldecotte Lake Unconfirmed	6.73	No flow data received.	2.15 (note; Stage OK. Flow suspect due to non-modularity.)	No flow data received.	No flow data received.	5.88	No flow data received.	22.54	Mean historical flow data not available	No flow data received.	Yes, Willen Lake in operation. Unclear if Caldecotte in operation	Balancing Lakes in operation
Monday, 13th June 2016	Total of 300 – 400 properties reported to be flooded	1.57		1.43 (note; Stage good. non-modular fow identified.)			3.07		6.2				
Thursday, 16th June 2016		1.43		0.67			2.7		13.2				
27th May 2018	500 properties flooded internally, and a 1000 flooded externally	2.73		1.03			5.43		5.99				
Sunday, 4th October 2020	1 property in Waterhall Park, flooded for the first time in 20 years	36.9		14.2 (note; Stage good. non-modular flow identified.)			16.8		26.1			Yes, Calecotte Lake in operation	Caldecotte Lake in operation/ Willen not in operation
23rd /24th December 2020	Flooding in rural areas on the 23rd December and flooding in Stony Stratford and Newport Pagnell	22.9		9.9 (note; Stage good. non-modular flow identified.)			14.3		82.4				
14th January 2021	Property in Waterhall Park flooded for the second time in 4 months	31.2		11.3			17.1		27.2				
28th January 2021	No property flooding – high levels in Waterhall park	28.1		8.18			15.8		34.7				
18th June 2021	80 properties flooded. 60 properties flooded in the Bletchley Area	Data doesn't extend to this date.		Data doesn't extend to this date.			Data doesn't extend to this date.		Data doesn't extend to this date.				

4th Floor
6 Devonshire Square
London
EC2M 4YE

wsp.com