Milton Keynes Council

FLOOD RISK INVESTIGATION

Newport Pagnell Section 19 Report

70082487-WSP-FRM-02-RP-CO-0001
OCTOBER 2021

PUBLIC

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CONTENTS

TABLES

FIGURES

APPENDICES

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	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.
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	Responsible for managing the risk of flooding from main rivers, reservoirs, estuaries and the sea and responsible of developing long-term approaches to FCERM.
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 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. AW provided information and datasets listed in Appendix A as well as verbal feedback within a call on 22nd June 2021. 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 EA's River Great Ouse catchment team have been consulted and have provided a spectrum of data including rainfall and river gauge data. A list of the information assessed from the EA 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) have 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 AW).

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 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 Gauaging Station are located on this reach, both owned and maintained by the EA.

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 EA[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 and River Ouzel catchments during October, November and December 2020 saturated the catchment and contributed to the 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 EA 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 with Bletchley recording a maximum flow of 27.7m^3/s on 24th December, with a drop in river flow evident in the downstream Willen gauge at 17.9 m^3/s. Further investigation is required to understand the trend in 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 is Birchmoor located between Apsley Guise and Woburn (approximately 11.4km south-east of Newport Pagnell), recording 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, is 57.3mm for December. Rainfall in Newport Pagnell through December 2020 was 44% higher than the December average. Consequently, highway drains, drainage ditches and the local sewer network were unable to cope with the continuous and high volume of rainfall. The significantly above average rainfall in combination with the high flows from both the River Ouse and River Ouzel stressed highway drains, drainage ditches and the local sewer network exacerbating the flooding issues in this area.

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 reported unclear to flooding being internal/external. The approximate locations of the reported flood incidents are shown in Appendix B. The EA recorded 15 properties as flooded.

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

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

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**Error! Bookmark not defined.**. 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

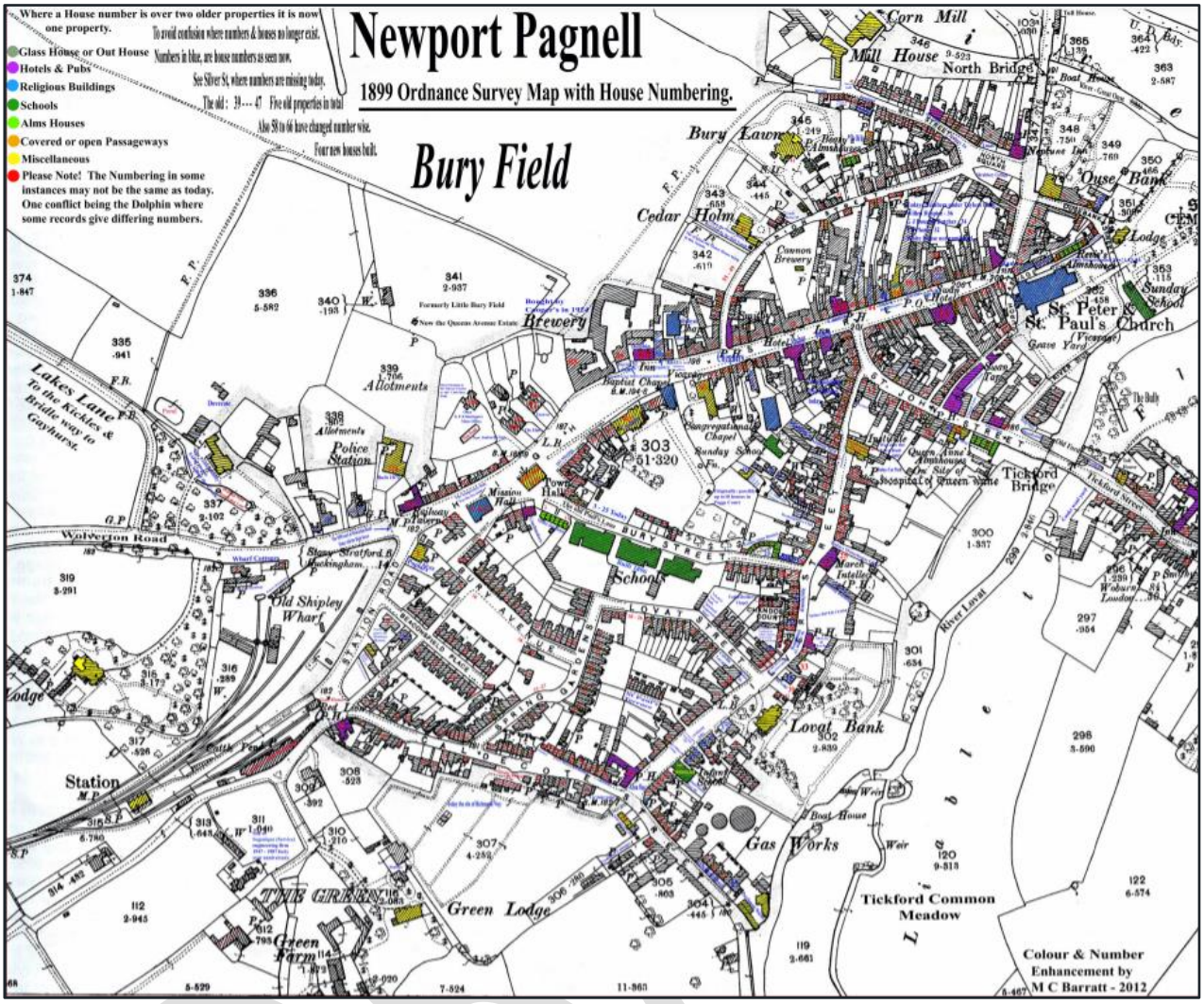

Figure 2-1 - Newport Pagnell in 1899. Source: Milton Keynes Heritage

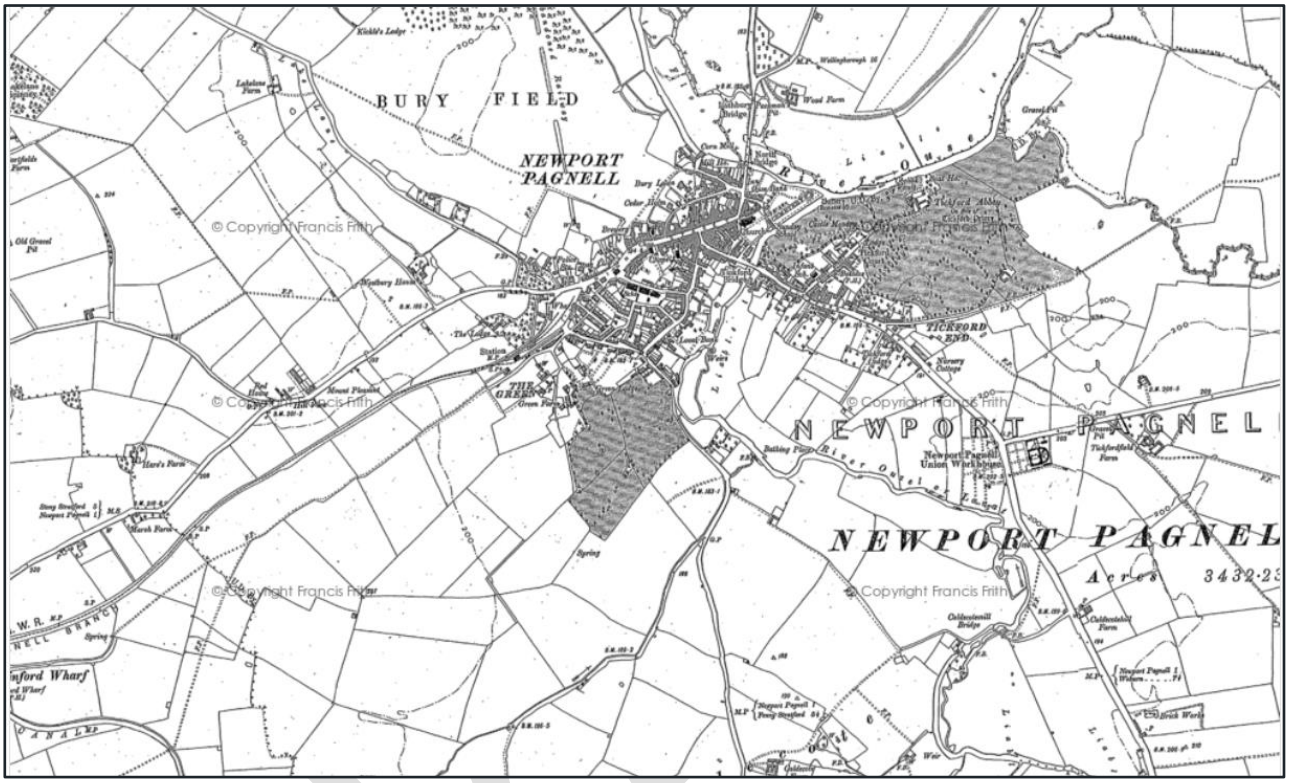

Figure 2-2 - Newport Pagnell in 1924. Source: Francis Frith

2.3 MILTON KEYNES BALANCING LAKES

2.3.1. AW 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 River Ouzel as a result of the development of Milton Keynes. The balancing lake structures are maintained as part of the Reservoirs Act 1975.

2.3.2. The gates are controlled automatically and operate on either Ouse mode[4] or Ouzel mode[5]. 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. These maintenance works identified a problem in Willen North gate in September 2020 which was resolved as part of the asset's operation maintenance and therefore prior to the December 2020 flood event.

[4] In Ouse mode if a reservoir's volume is greater than 50% of the maximum volume the program will maintain the water level in the reservoir. If the volume of water is less than 50% the program will maintain at least the minimum flow at each reservoir.
[5] In Ouzel mode the program will determine an action to take at Caldecotte and at Willen depending on the flow conditions and reservoir levels at each site. Once in Ouzel mode, the program will perform a series of calculations to determine what action to take at either the Caldecotte outstation or the Willen outstation. The output will be either to maintain the reservoir levels or attempt to achieve ideal flow.

2.3.3. AW is currently undertaken an integrated capacity study which assess the capacity of the balancing lakes and the AW system in conjunction with the river catchment.

2.3.4. Local residents indicated that the Milton Keynes balancing lakes may have contributed to additional flows within the River Ouzel. In consultation with AW they have confirmed the gates at both Caldecotte and Willen balancing lakes were operating as designed. Further investigation into the role of the balancing lakes during the December 2020 flood event is required.

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 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)[6] 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.

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

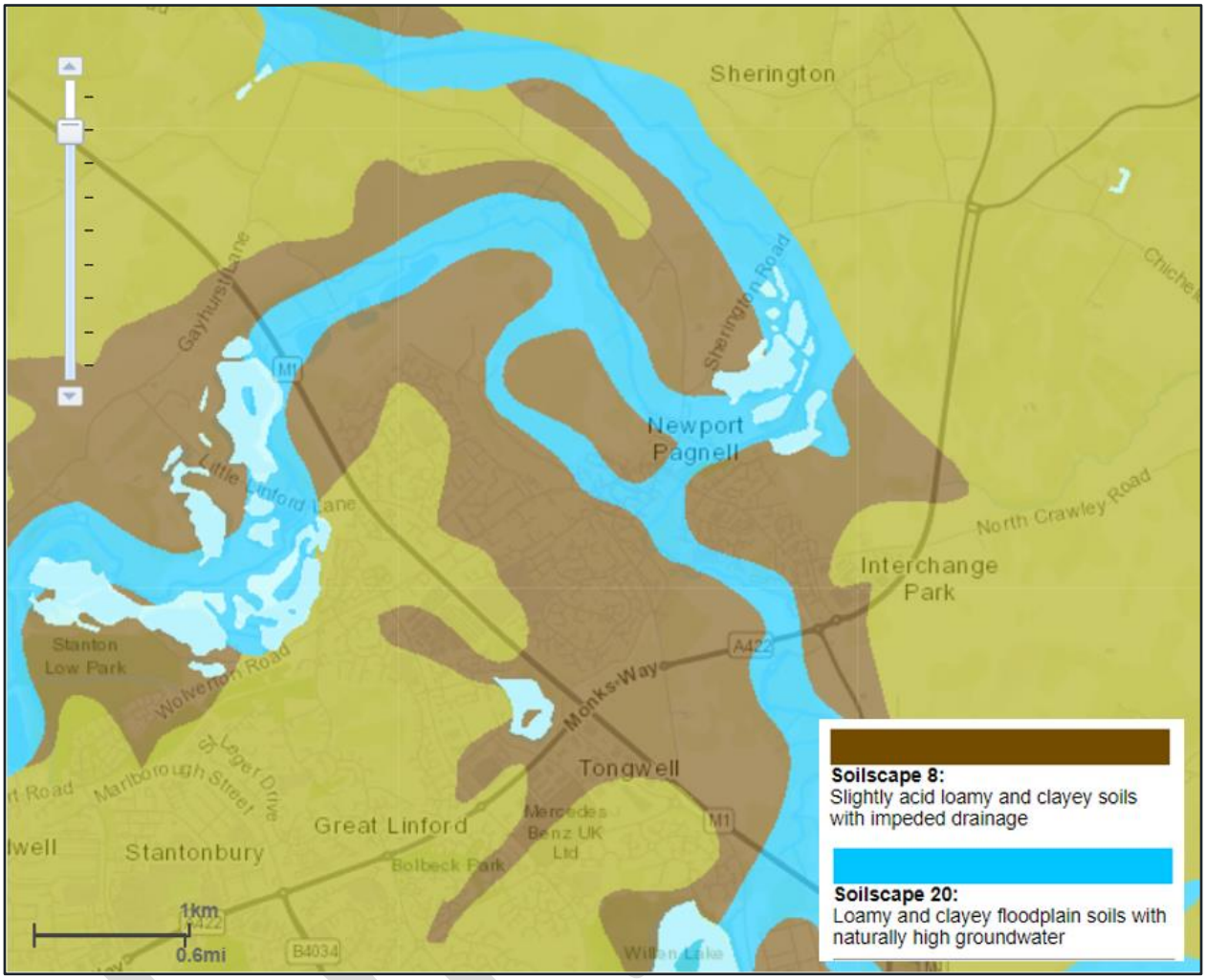

Figure 2-3 – Extract of Cranfield Soil and AgriFood Institute map

2.5.2. A review of the British Geological Survey (BGS)[7] 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.

[7] BGS Geology of Britain Viewer, Source: https://mapapps.bgs.ac.uk/geologyofbritain3d/, Last accessed: 27/07/2021

2.6 FLOOD RISK

2.6.1. FLUVIAL FLOOD RISK

2.6.2. Appendix C shows an extract from the EA's Flood Risk Map for Planning[8] which identifies that most of the properties reported as flooded in Priory Street and Silver Street are within Flood Zone 2 [9]classified at 'Medium Probability of Flooding' and Flood Zone 3 [10]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 EA's Long Term Flood Risk Map[11] within Appendix C identifies the properties reported as flooded in Priory Street and Silver Street as being at 'Low Risk'[14] 'Medium Risk[12]' and 'High Risk[13]' 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[14]' 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 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

[8] 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
[9] 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.
[10] 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.
[11] 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
[12] Medium Risk: each year this area has a chance of flooding between 1% and 3.33%.
[13] High Risk: each year this area has a chance of flooding of greater than 3.33%.
[14] Low Risk: each year this area has a chance of flooding between 0.1% and 1%.

area is uncertain and there may be disturbance to shallow natural soils and geology due to the area being largely urbanised.

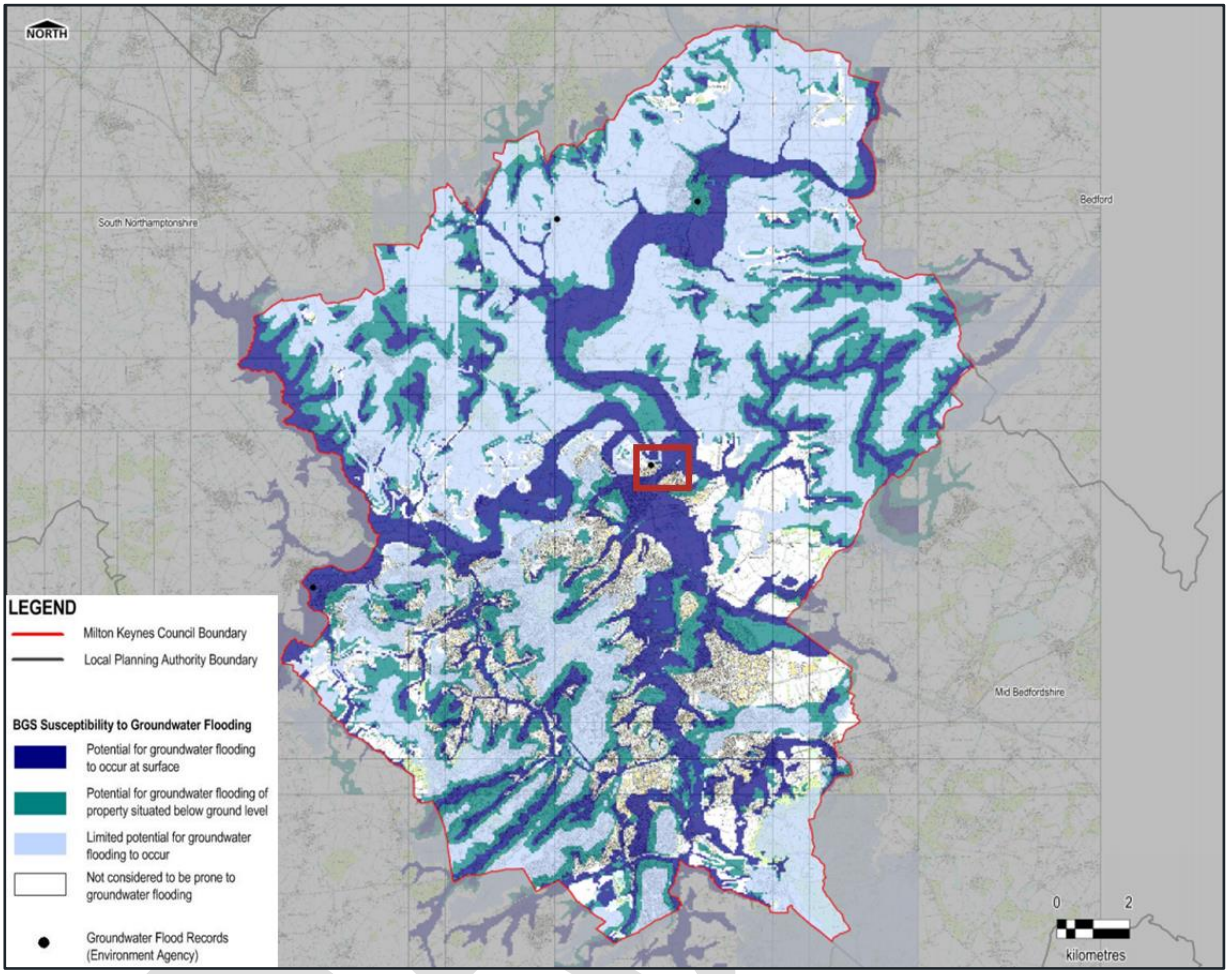

Figure 2-4 - Susceptibility to groundwater flooding. Source: Milton Keynes Council Local Flood Risk Management Strategy, AECOM 2016

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 AW. 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 AW the 22nd of June. During this call, they confirmed that they were not aware of any foul water incident within the area at Newport Pagnell. AW 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[15] 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 AW. AW 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 AW to undertake a sensitivity test within the hydraulic model to better understand the impact of these discharges.

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 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. Figure 2-6 below shows a manhole on Priory Street surcharging and Figure 2-7 shows potential groundwater emerging from the ground at Castle Meadow.

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

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

Figure 2-6 – Surcharging manhole on Priory Street, June 2021.

Figure 2-7 - Potential groundwater emerging from the ground at Castle Meadow, June 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 EA[1] December 2020 was a very wet month with a total 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 very quickly leading to high river levels at Newport Pagnell.

3.1.2. In addition, the EA[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.

3.1.4. Rainfall around the county is recorded by a series of rain gauges operated by the EA. 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[16] (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 low SMD and high saturated catchment due to the persistent rain during the previous months aggravated flooding at Newport Pagnell.

[16] 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.

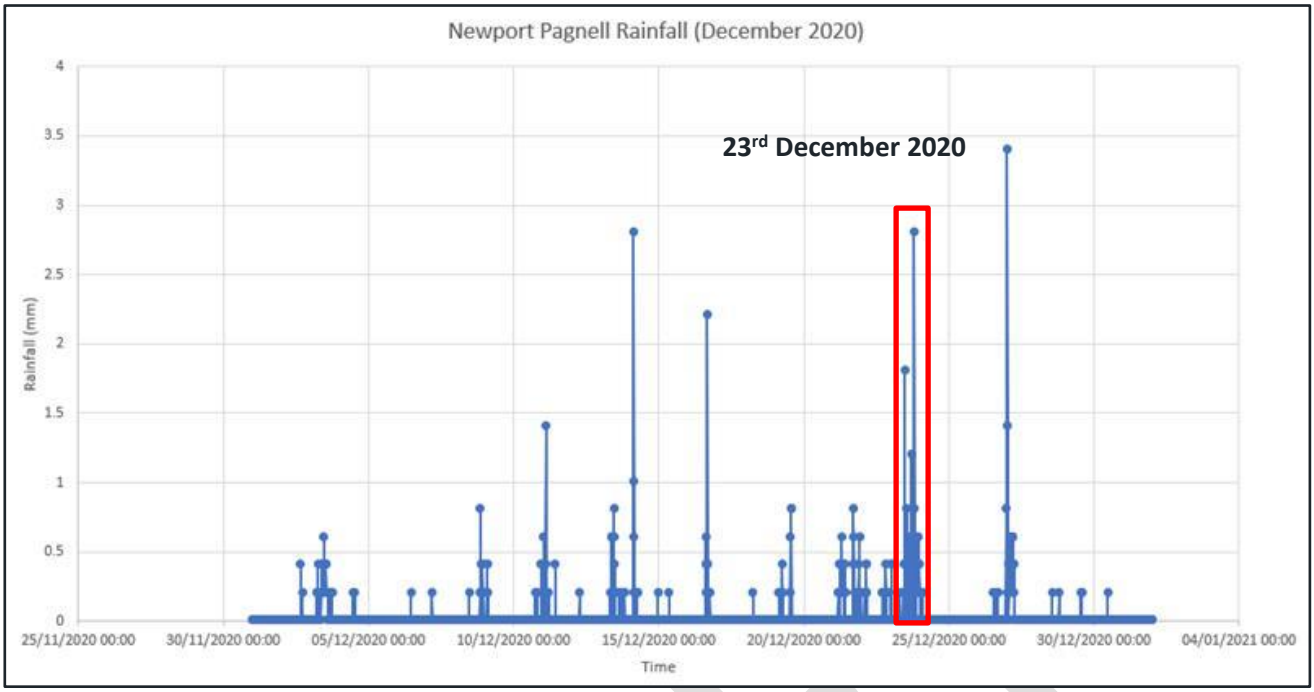

Figure 3-1 - 15min rainfall (mm) recorded at Birchmoor E22231

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. River gauge analysis has been based on gauging station data that has not been validated yet (data validated available until the 30/09/2020), which means that the outcomes from this analysis may change in future assessments.

3.2.3. Data obtained from the National River Flow Archive (NRFA)[17] 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.

[17] 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.

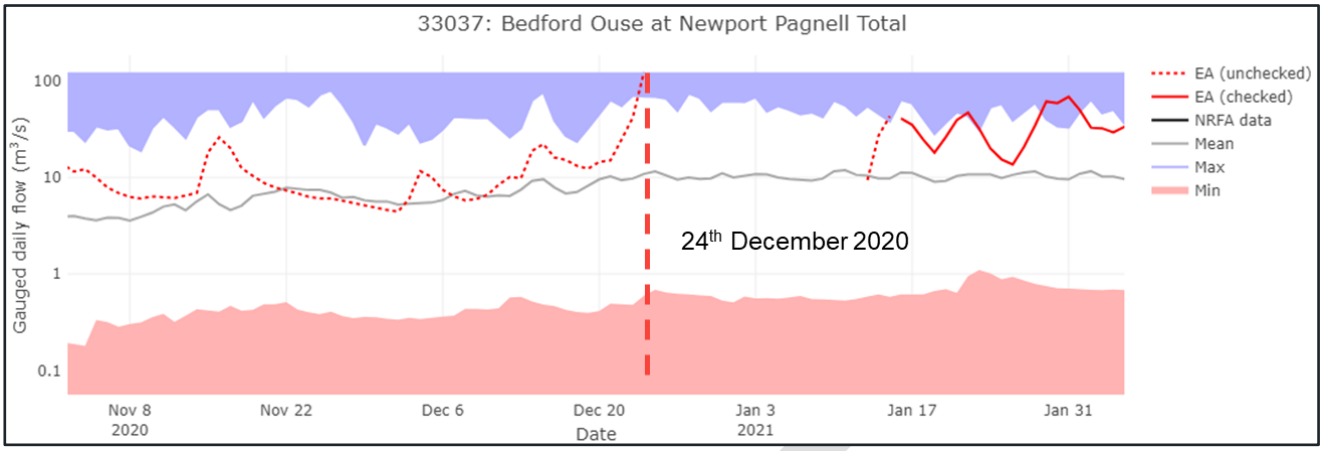

Figure 3-3 – Long term gauged daily flow at the Bedford Ouse at Newport Pagnell Total gauging station.

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

3.2.4. Figure 3-4 shows water levels for the 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. 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.

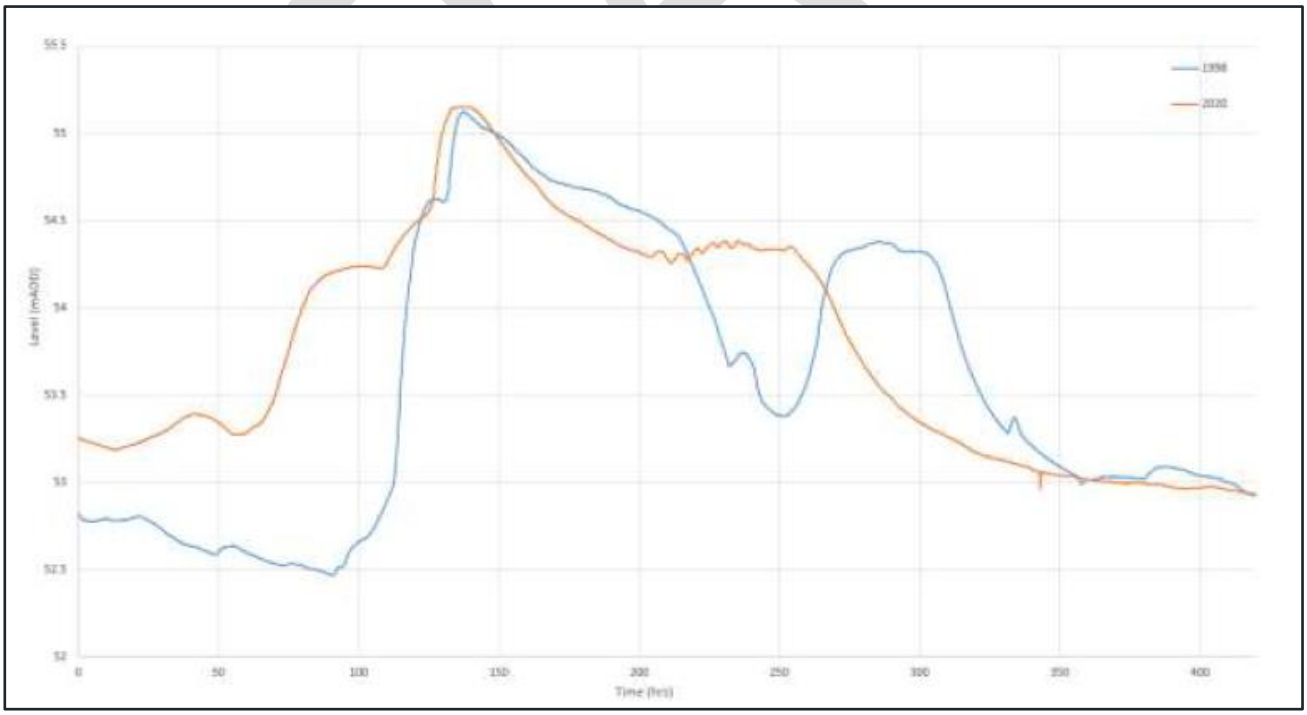

Figure 3-4 - Comparison of water levels for the April 1998 and December 2020 flood events from Newport Pagnell Cemetery river gauge. Source: Environment Agency (EA) - Newport Pagnell winter flooding initial analysis (May 2021)

3.2.5. 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.

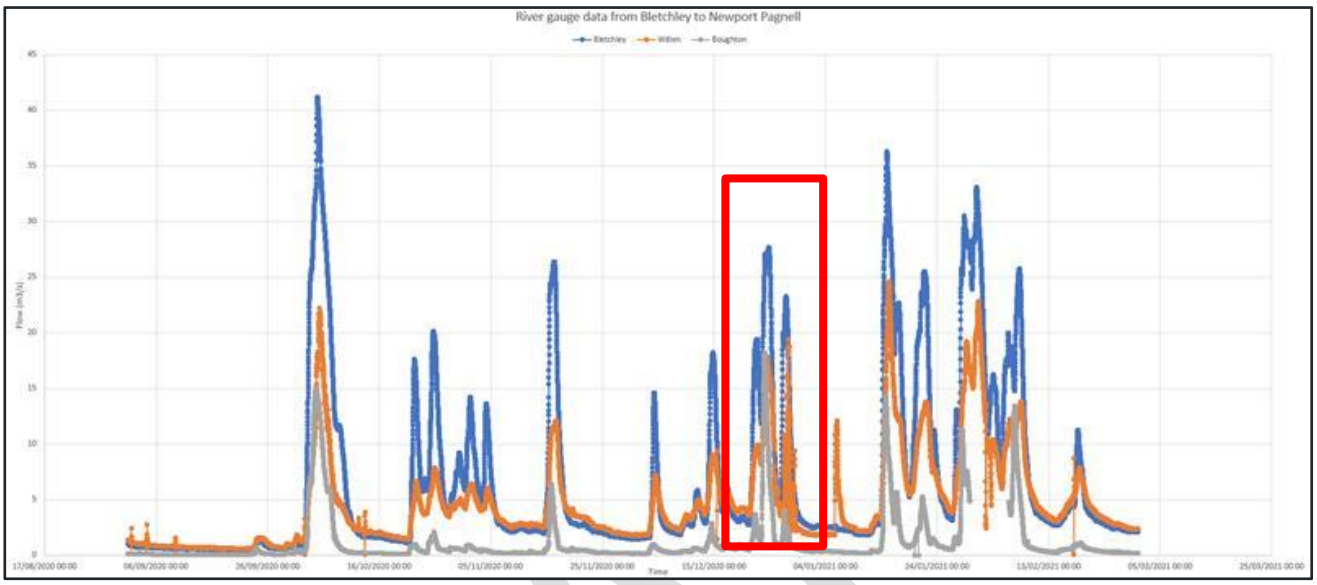

Figure 3-5 - River flows from river gauges between Bletchley and Newport Pagnell (Bletchley Willen and Boughton)

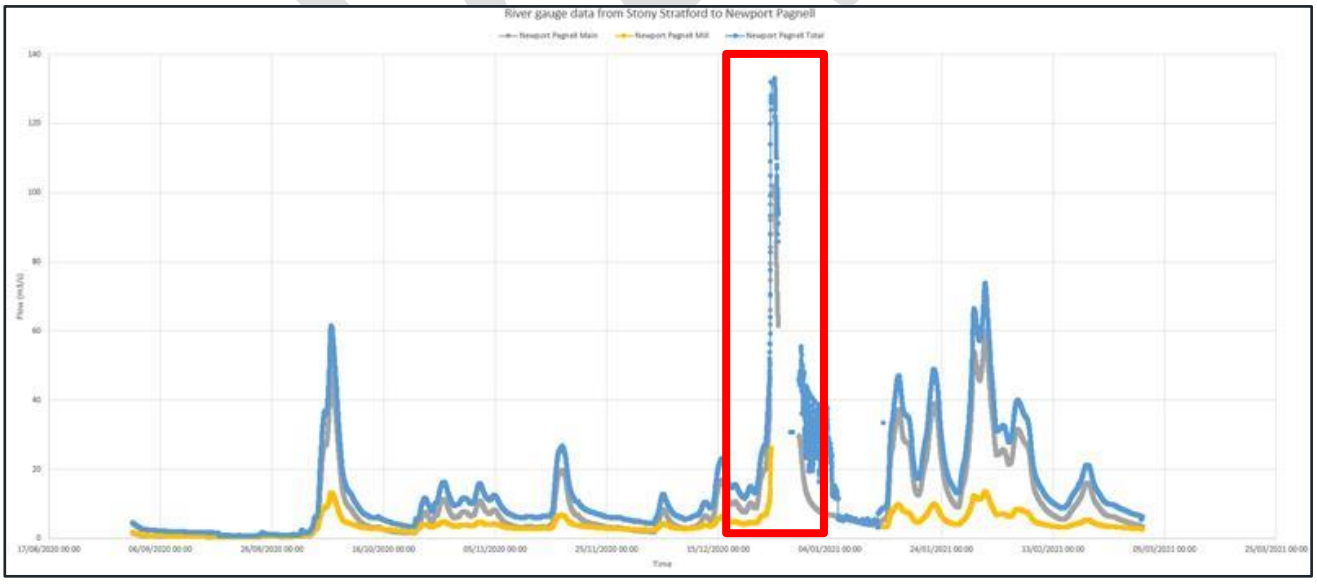

Figure 3-6 - River flows from river gauges at Newport Pagnell (Newport Pagnell Main, Newport Pagnell Mill and Newport Pagnell Total)

3.2.6. 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 an unusually high peak. A drop in river flow is evident at the downstream Willen river gauge

around this time. Further investigation is required to understand the trend in flows and the role of the balancing lakes in this location.

3.2.7. 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 25th December. A potential explanation for this recorded peak flow in the Newport Pagnell gauges may be due to a direct consequence of the 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 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 over an already saturated catchment due to a wet month of December led to a quick response of the watercourses and high-water levels within the River Great Ouse and River Ouzel. As stated by the EA[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 Rod 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. EA flood defences retained flood water within the floodplain (Castle Meadow) protecting properties situated behind flood defences. Although flood defences protected properties from the high-water levels at the River Ouzel, 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 AW to undertake a sensitivity test within the hydraulic model to better understand the impact of these discharges.

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 this impact.

4.1.5. BFRS 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[18].

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

5 FLOOD RESPONSE

5.1.1. BFRS 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. AW maintained 'full-incident' mode 24/7 over 12 weeks, from 23rd December 2020 to 12th March 2021 across Milton Keynes. This response from AW 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. AW logged unprecedented volumes of contacts from concerned local residents; 30,000 jobs were raised and 80,000 incoming calls were received. AW undertook meetings with the regional MP's and local authority representatives, as well as working closely with the EA to agree temporary local enforcement positions.

5.1.3. The following locations are covered within the EA'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)[19].

[19] 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 EA, 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.

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 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 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 AWS 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.

6.1.6. Local residents indicated that the Milton Keynes balancing lakes may not have attenuated the peak flows within River Ouzel although consultation with AW found no supporting evidence.

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[20] regarding any Highways maintenance.
- Improve coordination between Community Flood Group, Emergency Planning Team, EA and other flood management authorities.

6.2.3. RECOMMENDATIONS FOR LEAD LOCAL FLOOD AUTHORITY

- Work with the EA and other flood management authorities to support the community in the preparation of a Community Flood Plan.
- 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 maintenance review of the river gauges located in the River Ouzel and River Great Ouse, associated with Newport Pagnell.
- Liaison with Anglian Water regarding a study to be carried out assessing if there is potential for fluvial flows to be better attenuated in the event of a flood within the balancing lakes associated with Newport Pagnell.
- Discuss the potential for Newport Pagnell to be included within the project area in order to implement further flood mitigation measures.
- Better understanding of the hydrological catchment of the River Great Ouse, River Ouzel and historical catchment changes to analyse impacts on Newport Pagnell.

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.
- Liaison with the Environment Agency to develop an integrated catchment model to gain a better understanding of the fluvial interaction of the River 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.

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

Appendix A

APPENDIX A

Appendix B

APPENDIX B

Appendix C

APPENDIX C

Appendix D

APPENDIX D

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