JBA consulting

Winchester Section 19 Investigation

Final Report

June 2021

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Hampshire County Council

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Revision History

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Contract

This report describes work commissioned by Hampshire County Council, by an email dated 17 November 2020, Hampshire County Council's representative for the contract was Sarah Reghif. Peter Rook and Ed Hartwell of JBA Consulting and Ade Salako of Satius Consulting carried out this work.

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Purpose

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Acknowledgements

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Executive summary

Background

Where a significant flood event has occurred, Hampshire County Council (HCC) as the Lead Local Flood Authority must, to the extent that it considers it necessary or appropriate, conduct a formal flood investigation under Section 19 of the Flood and Water Management Act 2010. The aim of this investigation is to determine the causes of the flooding that occurred in Winchester on 27 August 2020 and identify which authorities have relevant responsibilities, and whether they have or are proposing to respond. The results of the investigation will be published and the relevant risk management authorities notified.

Hampshire County Council has appointed JBA Consulting and Satius Consulting to undertake the Section 19 investigation on its behalf.

27 August 2020 flooding

Surface water flooding was experienced across Winchester on 27 August 2020, affecting a number of areas including the High Street, Stockbridge Road, Cranworth Road, Andover Road and parts of Harestock. This flooding triggered HCC's criteria to undertake a Section 19 investigation as over twenty residential and commercial properties were flooded internally across Winchester, including flooding a significant number in the High Street. The flooding also affected significant lengths of the public highway.

Sources of information

A wide range of different data has been compiled as part of the Section 19 Investigation, this has been used to understand the causes of flooding in Winchester and to establish the context of the area. Data initially provided for the study included open source data such as the Risk of Flooding from Surface Water (RoFSW) mapping, flood incident and asset data from Risk Management Authorities and video (CCTV) footage provided by Winchester City Council from the event. Additional data including hydrometric datasets and survey data from stakeholder engagement was collected as part of the investigation.

Flood investigation

JBA undertook the following activities to assist in determining factors that may have contributed to the surface water flooding on 27 August 2020:

- Online stakeholder engagement surveys;
- Site visit to flood affected areas of Winchester;
- Meetings with Risk Management Authorities;
- Analysis of the storm event rarity;
- Analysis of groundwater levels and river levels during the event; and
- Review of asset condition and design.

Evidence collected during the stakeholder engagement exercise indicated that surface water flooding receded relatively quickly. This indicates that surface water flooding was the result of an exceedance of the design capacity of surface water drainage systems and was unlikely to be the result of blockages. The investigation also concluded that groundwater levels and river levels in the River Itchen were unlikely to have had an impact on the hydraulic capacity of surface water drainage systems.

Due to the rapid onset of the flooding, there was an emergency response with 21 properties across the city receiving emergency assistance from Hampshire Fire and Rescue Service. However, Hampshire County Council, as both the Lead Local Flood Authority (LLFA) and Highway Authority, and Winchester City Council took a number of actions following the event, including clearing the High Street, emergency maintenance on highway drainage systems, and commissioning the Section 19 investigation.

Analysis of rainfall rarity on 27 August determined that the storm event was between a **1 in 29 and a 1 in 42-year event**. This is a more extreme event than highway drainage systems are typically designed for[1], and more extreme than what surface water sewer systems are typically designed for[2].

Source-pathway-receptor model of flooding

Data from a wide range of sources was compiled from the event, using this data, three main areas of interest were identified for further analysis using source-pathway-receptor models. The source-pathway-receptor models aim to identify the sources of flooding in each of these areas, map the flow routes and pathways which conveyed flood water, and identify the receptors affected by flooding, including estimated flood depths and the impacts of flooding to those receptors. The aim of this assessment was to build a conceptual model of the flooding that occurred in order to identify appropriate recommendations. Photographs and CCTV footage from the event has been used alongside these models for reference.

Mapping was undertaken to determine the source of flooding, the pathways where water flowed and the receptors which were affected by the flooding. This determined that the source of surface water flooding in Winchester was intense rainfall on 27 August 2020. The pathway was via roads, which can act as key conveyance routes in an urban setting. The water routed to the low points where it caused internal property flooding, at the High Street, Cranworth Road and a number of areas in Harestock. The rapid onset of flooding was exacerbated by the steep topography of Winchester, the density of development and high proportion of impermeable surfaces within the city.

Conclusions

The flooding that occurred on 27 August 2020 impacted up to 70 residential and commercial properties throughout Winchester, these were primarily located in the High Street, Cranworth Road and Harestock.

The source of this flooding was surface water runoff during an intense rainfall event, as a result the highway drainage systems could not reasonably be expected to manage surface water flows associated with this event. Furthermore, the rapid drain-down following the flooding suggests that these drainage systems were functioning and that these systems suffered a hydraulic overload due to the volume of water rather than from a blockage.

This runoff was rapidly conveyed as high velocity sheet flow on the public highway, which was exacerbated due to the steep topography and high degree of urbanisation and impermeable surfaces in the city. Surface water flowed through and pooled in low spots such as the Broadway and Cranworth Road, where the depth of water was sufficient to cause internal property flooding.

Recommendations

Flooding occurred as the rainfall intensity exceeded the design standard for highway drainage[1]. As such, the collection system could not keep up with the rate of runoff. To increase the future resilience in the drainage system at Winchester High Street and in Harestock, there may be opportunities to retrofit Sustainable Drainage Systems (SuDS).

Source-pathway-receptor mapping identified that space in Winchester is limited due to the high degree of urbanisation. The use of source control techniques such as rain gardens,

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1 CIRIA C635 (2006) 'Designing for exceedance – good practice' (Table 3.1)

2 Sewers for Adoption 8 (draft): https://www.water.org.uk/wp-content/uploads/2018/10/SfA-8-Master-2.pdf

tree pits and permeable paving are advised as space is limited in the High Street. By freeing up capacity in existing surface water drainage systems, these drainage systems would be more able to manage surface water flows though not of the intensity experienced on 27 August. They would also reduce the overall impermeable area, provide interception storage for smaller events and improve amenity and biodiversity in the area. Due to the high degree of urbanisation in Winchester, there may be limited space to incorporate large volumes of surface water storage such as basins. However, in Harestock it may also be possible to utilise larger SuDS features such as basins.

Where it is not possible to manage the source of flooding, or utilise pathways to manage flood waters, the use of Property Flood Resilience (PFR) techniques are suggested due to its potential to improve the resilience to a number of residential and commercial properties. PFR can provide effective products and measures, at an individual property level, to reduce the impact of future floods, by either aiming to limit water entry (resistance) or by adapting the internal fabric of the property to limit damage (resilience).

Meetings with the Highway Authority identified a number of instances where the Highway Authority was not aware of the presence of assets. This could lead to potential issues with lack of maintenance exacerbating or causing flooding issues if left unaddressed. As a result, it is recommended that the Highway Authority undertakes additional mapping of highway drainage assets to ensure that the location of all drainage assets and maintenance requirements are known. The site visit on 11 January noted a number of gullies in the High Street and Harestock areas that appeared to be blocked with silt, more frequent cleansing in specific areas such as the High Street could improve their performance and reduce residual flood risk. However, based on the estimated magnitude of the event it is unlikely this would have had a significant impact on the flooding that occurred.

The source-pathway-receptor mapping identified a number of areas where the Risk of Flooding from Surface Water mapping inaccurately represented surface water flood risk. A review and 'health check' on existing surface water mapping would indicate where these inaccuracies are and would allow the LLFA and other Risk Management Authorities (RMA) to better understand flood risk in Winchester.

It has been established there was limited time for emergency responders to mobilise a response to the flooding at the time of the event. It may also be possible to set up a surface water flood forecasting system for Winchester, this would enable emergency responders to mobilise more quickly and for asset managers to undertake pre-emptive maintenance work in advance of potential flooding.

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Abbreviations

AEP	Annual Exceedance Probability
BGS	British Geological Society
BST	British Summer Time
CCTV	Closed Circuit Television
DTM	Digital Terrain Model
EA	Environment Agency
FEH	Flood Estimation Handbook
GIS	Geographic Information Systems
GMT	Greenwich Mean Time
HCC	Hampshire County Council
JBA	Jeremy Benn Associates
LFRMS	Local Flood Risk Management Strategy
LIDAR	Light Detection and Ranging
LLFA	Lead Local Flood Authority
m AOD	metres Above Ordnance Datum
NGR	National Grid Reference
PFR	Property Flood Resilience
RMA	Risk Management Authority
RoFSW	Risk of Flooding from Surface Water
SAAR	Standard Average Annual Rainfall
SuDS	Sustainable Drainage Systems
SW	Southern Water
WCC	Winchester City Council

1 Introduction

1.1 Criteria for a Section 19 Investigation

Where a significant flood event has occurred and the responsibility for managing the future risk is unclear, Hampshire County Council (HCC), as the Lead Local Flood Authority, may conduct a formal flood investigation under **Section 19** of the Flood and Water Management Act 2010[3].

It is for the Lead Local Flood Authority (LLFA) to determine what is considered to be 'significant flooding' in its area and whether a formal investigation is necessary or appropriate. HCC has set out the criteria in which it defines 'significant flooding' and will undertake a Section 19 investigation in its **Flood Investigation Guidance**[4] document:

- Flooding that affects 20 or more residential properties internally in one flood event within the same location.
- Flooding that affects significant lengths of public highway and lasts for a period of three hours or more from the onset of flooding.

The aim of this investigation is to identify which Risk Management Authorities (RMAs) have responsibilities and whether they have responded to, or are intending to respond to, the flooding that occurred. The results of the investigation will be published.

1.2 Flooding on 27 August 2020

Surface water flooding was experienced across Winchester on 27 August 2020, affecting a number of areas including the High Street (Figure 1-1), Stockbridge Road, Cranworth Road, Andover Road and parts of Harestock. This flooding triggered HCC's criteria to undertake a Section 19 Investigation as over 20 residential properties were flooded internally across Winchester. The flooding caused internal flooding to a number of commercial properties in the High Street. The flooding also affected significant lengths of the public highway.

3 Flood and Water Management Act 2010 Section 19 (accessed 03 February 2021): https://www.legislation.gov.uk/ukpga/2010/29/section/19

4 HCC Flood Investigation Guidance: https://documents.hants.gov.uk/flood-water-management/FloodInvestigationsguidance.pdf (accessed December 2020)

Figure 1-1: Flooding to Winchester High Street on 27 August 2020[5]

1.3 Approach to the Section 19 Investigation

The aim of this investigation was to identify which Risk Management Authority has relevant flood risk management functions and whether they have responded to the flooding that occurred. To meet the objectives of the Section 19 Investigation, our analysis sought to establish the following:

- The sources of flooding in Winchester
- Identify the extent and impacts of flooding
- Understand the likely flood mechanisms (source – pathway – receptor)
- Analyse hydrometric data from the event (including rainfall)
- Determine key factors that influenced the severity / extent of flooding
- Explore and examine potential mitigation measures that could be undertaken to reduce the risk and impacts of a similar event.

The flooding on 27 August affected a number of areas across Winchester including:

- Winchester High Street and adjoining roads;
- Cranworth Road and adjoining roads;
- Harestock including Priors Dean and Buriton Road;

- Stockbridge Road;
- Wordsworth Close and Browning Drive; and
- Sleepers Hill and Wentworth Drive.

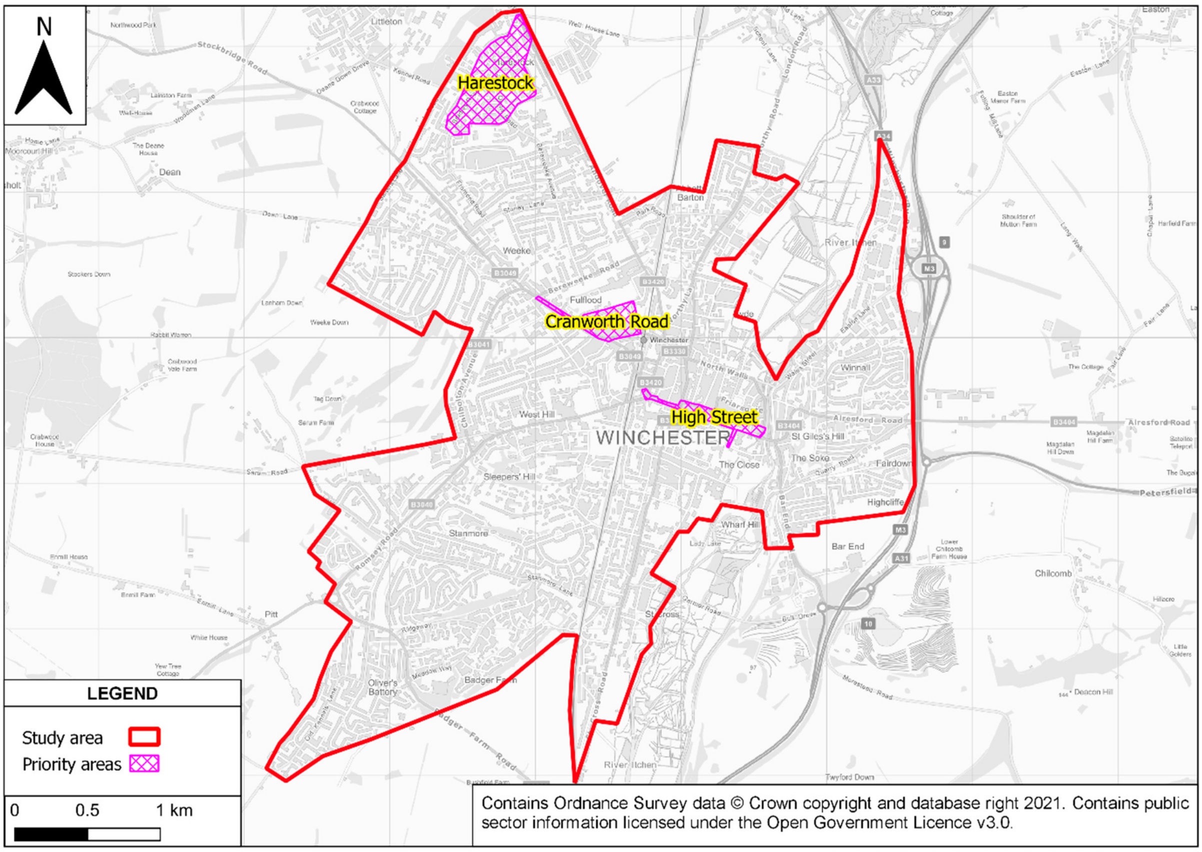
Properties are known to have flooded internally in many of these areas. The Section 19 investigation has identified flood mechanisms for these areas in detail (see section 6 - Source-Pathway-Receptor model), including the source of the flooding, pathways and receptors. Although the Section 19 investigation has primarily focused on these areas, flooding across Winchester on 27 August has been considered as part of the overall investigation.

2 Study area

2.1 Location

The City of Winchester is located in Hampshire, on the edge of the South Downs National Park, as shown in Figure 2-1. The scope of the investigation covered the entirety of Winchester. However three areas of flooding were considered to have affected a greater number of residents, these were the High Street, Cranworth Road and Harestock.

Figure 2-1: Location map of Winchester identifying the scope of the Section 19



2.2 Topography

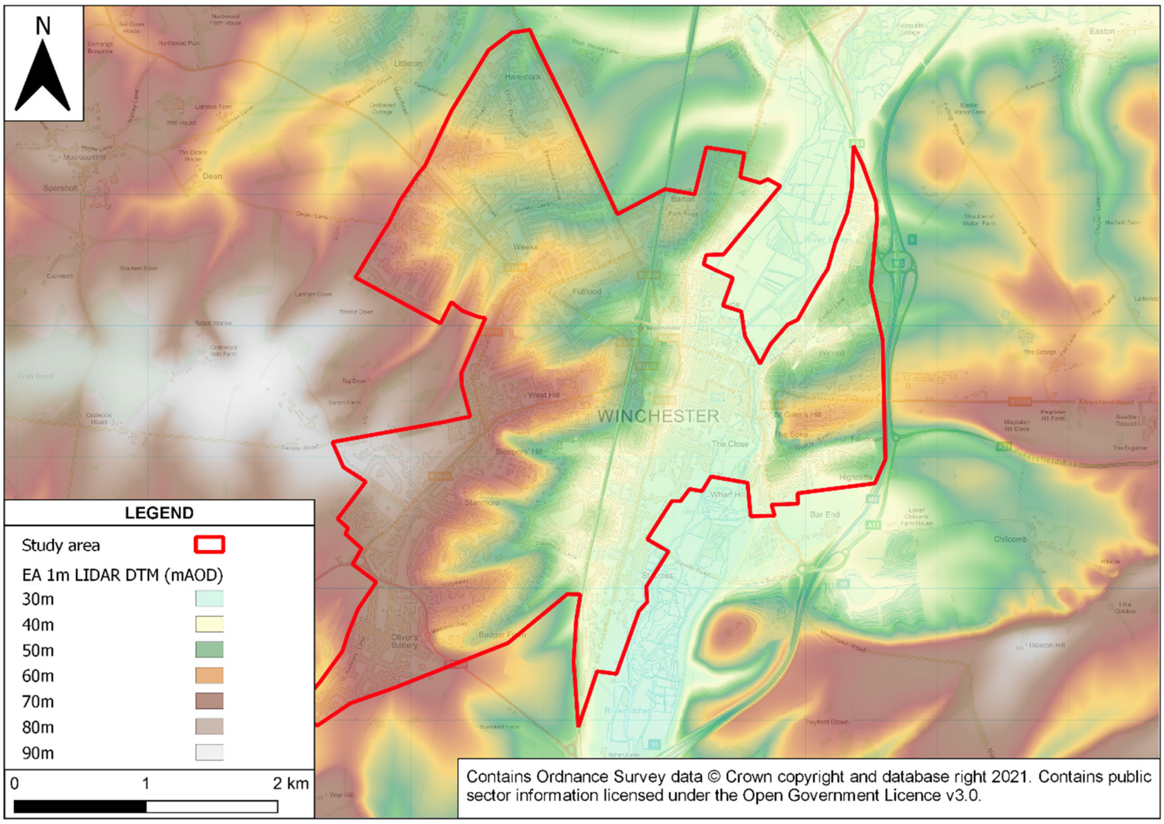
The city of Winchester straddles the River Itchen river valley. It is situated within the South Downs, and as a result there are chalk hills forming higher ground to the east and west of Winchester, as shown in Figure 2-2.

LIDAR (Light Detection and Ranging) data was provided in the form of an elevation model available across the study area at a 1m spatial resolution. The Environment Agency's 1m LIDAR DTM, indicates that elevation values are approximately:

- 35 – 38m AOD towards the west of the High Street, closest to the River Itchen
- 40-55m AOD from the west of the High Street towards the Winchester Railway Station and the West Hill area
- 50m AOD at the lowest point of Cranworth Road
- 60 – 90m AOD in Harestock from East to West.

The steep natural topography of Winchester is believed to have contributed to surface water flooding in the past as a result of runoff from higher to lower areas.

Figure 2-2: EA 1m LIDAR DTM showing the general topography of Winchester and the surrounding area

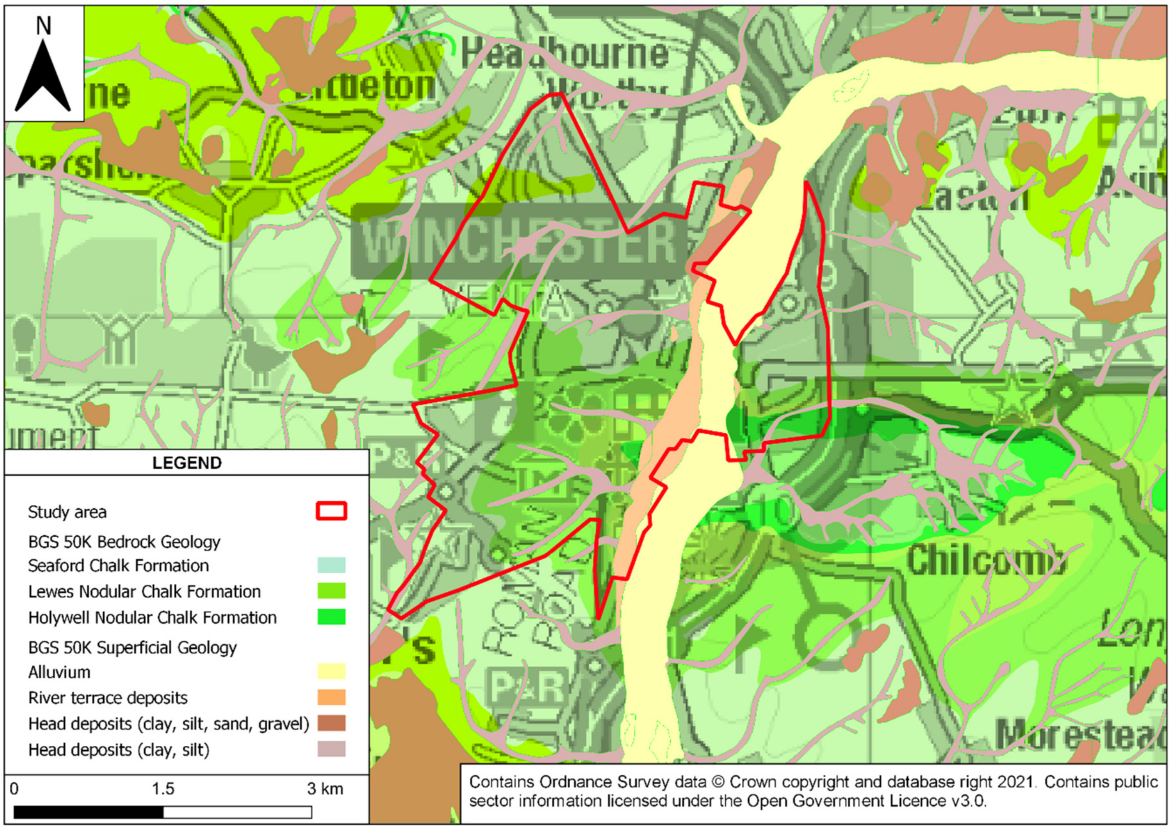


2.3 Geology and soils

British Geological Survey 50k mapping indicates that the entirety of Winchester is underlain by chalk, which is comprised of the Lewes Nodular Chalk Formation, the Seaford Chalk, the New Pit Chalk Formation and the Holywell Nodular Chalk Formation, this provides a generally permeable geological setting, although it is possible that there are lithological sub units within the formation that are less permeable.

Superficial deposits are also prevalent throughout Winchester, mostly associated with the River Itchen floodplain and as a result are mostly located in lower lying areas. These deposits include Alluvium (clay, silt, sand and gravel), River Terrace Deposits (sand and gravel) and Head Deposits (clay, silt, sand and gravel). These deposits have a higher degree of heterogeneity and so permeability in these deposits is likely to be spatially variable.

Figure 2-3: BGS 50k bedrock and superficial geology in Winchester



2.4 Hydrology

The hydrology of Winchester is complex, with the River Itchen passing from north to south, flowing through the town centre of Winchester, before ultimately discharging to the Solent and English Channel at Southampton. The River Itchen flows through the city in a number of channels, with the main channel passing under the City Mill and Bridge Street, east of the Broadway. A secondary channel is culverted under the Broadway and Colebrook Street east of Winchester College.

Flows are also conveyed through the Brook Street Culverts, a series of three 600mm diameter culverts running parallel to Upper, Middle and Lower Brook Street, before converging along the high street and discharging to the watercourse along Colebrook Street. A number of other watercourses are present in Winchester, all of which are part of the River Itchen. These watercourses are mostly designated as Environment Agency main rivers, although smaller ordinary watercourses are also present.

The River Itchen is heavily managed, with sluice gates present at Durngate to control flows along the watercourse. The Itchen is a chalk stream with a significant groundwater baseflow and as a result, flows are not prone to rapid changes as a result of rainfall.

2.5 Sewerage

Southern Water sewer maps have been reviewed as part of the investigation, these maps indicate that there is a separate surface water sewer network throughout much of Winchester, including the High Street and Cranworth Road. These public sewers are indicated to discharge surface water runoff to the River Itchen. Highway asset mapping has also been reviewed, this indicates that highway drainage systems typically discharge to the public sewer network, although in areas such as Harestock they discharge through infiltration via soakaways.

2.6 Sources of flood risk

Surface water has been identified as the primary cause of flooding in Winchester on 27 August. However, a number of other sources have been considered to determine whether these may have contributed to the flooding that occurred.

2.6.1 Fluvial flood risk

The River Itchen is heavily managed with multiple sluices to control flows into the city centre, which has previously flooded from fluvial sources in 2014 and in the winter of 2000/ 2001.

Since these events the Environment Agency, Winchester City Council and Hampshire County Council have undertaken in partnership the **Winchester Flood Alleviation Scheme**[6] to address fluvial flood risk. Phase 1 of the scheme was completed in 2016 and is comprised of flood walls, demountable flood barriers, sluice gates and flood bunds. Phase 2 was completed in December 2020 and consists of a series of sluice gates allowing WCC to control flows into the city during extreme events.

It is possible that surface water drainage outfalls into watercourses could have been unable to discharge if they became surcharged due to high river levels. The Section 19 investigation has assessed the possibility of this occurring by analysing river levels based on gauge data before, during and after the event. This analysis can be found in Section 5.5.2.

2.6.2 Groundwater flood risk

High groundwater levels have the ability to impede infiltration of surface water runoff into the ground. They can also impact the ability of surface water drainage systems to discharge runoff, particularly where drainage systems are poorly sealed and maintained or where they discharge through infiltration. A review of groundwater levels at the time of the event has been undertaken in Section 5.5.3.

2.6.3 Surface water drainage systems

The risk of flooding from drainage assets has been considered as part of the investigation, as this has the potential to exacerbate surface water flooding, particularly where assets are poorly maintained or managed. Both the highway drainage system and the surface water sewer network have been considered in Section 5.6 of the investigation.

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6 Winchester Flood Alleviation Scheme: https://www.winchester.gov.uk/projects/14652/flood-alleviation-scheme-durngate-terrace-and-the-trinity-centre

3 Data collection

A wide range of different data has been compiled as part of the Section 19 Investigation, this has been used to understand the causes of flooding in Winchester and to establish the context of the area.

3.1 Open source data

The following datasets have been downloaded from the Defra Data Services Platform (https://environment.data.gov.uk/). The data is all available under the Open Government Licence v3.0.

3.1.1 Flood Map for Planning

The Environment Agency Flood Zones, as shown on the Environment Agency Flood Map for Planning, show areas at risk of flooding from fluvial and tidal sources. The Flood Map for Planning provides the basis for the assessment of flood risk and development suitability.

Flood Zone 2 shows the areas of land that have between a 1% Annual Exceedance Probability (AEP) and 0.1% AEP of river flooding in any given year (and between a 0.5% AEP and 0.1% AEP of flooding from the sea). Flood Zone 3 is defined as land having a 1% AEP or greater of river flooding (or 0.5% AEP or greater annual probability of sea flooding).

The Environment Agency Flood Zones for the River Itchen are based on detailed 1D-2D hydraulic modelling, completed in 2019. The Flood Zones do not take into account the presence of flood defences.

3.1.2 Risk of Flooding from Surface Water

The Risk of Flooding from Surface Water (RoFSW) dataset assesses flood risk as a result of rainfall with the following chance of occurring in any given year (Annual Exceedance Probability).

- 3.3% AEP (1 in 30)
- 1% AEP (1 in 100)
- 0.1% AEP (1 in 1000)

Flood extents, depths of flooding, velocity and hazard are available for each design event.

The RoFSW has been created using the Environment Agency's nationally produced surface water flood mapping and appropriate locally produced mapping from Lead Local Flood Authorities (LLFAs). The RoFSW dataset improves on previous nationally produced surface water mapping as it incorporates new modelling techniques, finer resolution LIDAR data for a larger area (90% urban areas in England and Wales) and combines appropriate mapping from LLFAs.

Although the dataset is more representative of flow routes than previous surface water mapping, it still cannot represent every detail of the urban landscape and localised mechanisms of flooding. Assumptions have also been made where urban drainage capacity is uncertain and, in these areas, the outputs of the mapping may be less representative.

The Risk of Flooding from Surface Water mapping has a **confidence score**[7] based on its suitability. In Winchester, the RoFSW map has a confidence score of '3' (town to street), although north of Winchester railway station this has a score of '2' (county to town). These lower confidence areas include Cranworth Road and Harestock.

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7 'What is the Risk of Flooding from Surface Water Map' (accessed March 2021): https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/842485/What-is-the-Risk-of-Flooding-from-Surface-Water-Map.pdf

3.1.3 Historic flooding datasets

The Historic Flood Outline and Recorded Flood Outline datasets are Environment Agency datasets showing the maximum extent of all individual recorded flood outlines from rivers, the sea and groundwater springs and show areas of land that have previously been subject to flooding in England.

3.2 Risk Management Authorities

The Section 19 Investigation was conducted with the full co-operation of the relevant Risk Management Authorities; Southern Water, Winchester City Council, Hampshire County Council and the Environment Agency. These authorities provided their data and local knowledge to inform the assessment. This data included:

- Asset data for public sewers and drainage systems
- Locations of emergency callouts relating to flooding on 27 August
- CCTV footage and photographic evidence of the flooding
- Notes indicating the response from the various Risk Management Authorities
- Other data (including GIS) collected by Risk Management Authorities from the event.

3.3 Community and stakeholder engagement

Stakeholder engagement was sought at an early stage of the Section 19 Investigation, this was undertaken in order to obtain and understand flood risk information that was not readily available e.g. people's experiences of the flooding that occurred, impacts of the flooding and flood history.

3.4 Hydrometric data

Hydrometric data for Winchester was requested from the Environment Agency to better understand the hydrological context of the flooding. Rain gauge data was requested to understand the depth, duration and event rarity for the storm event, whereas groundwater monitoring and river gauge data was requested to understand whether high groundwater or river levels could have contributed to the flooding.

4 Risk Management Authorities

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

4.1 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.

4.2 Lead Local Flood Authority

Lead Local Flood Authorities (LLFA) are responsible for local flood risk management, this includes the risk of flooding from surface water, groundwater and ordinary watercourses (non-main rivers). The LLFA is also responsible for developing, maintaining and applying a strategy for local flood risk management in their area and for maintaining a register of flood risk assets.

LLFAs have powers under Section 19 of the Flood and Water Management Act to undertake a formal investigation (where appropriate and necessary) to identify which authorities have relevant flood risk management functions, and what they have done or intend to do.

Hampshire County Council is the LLFA for Winchester.

4.3 Water and sewerage company

Water companies are Risk Management Authorities and play a major role in managing flood risk. They manage the risk of flooding to water supply and sewerage facilities and flood risks from the failure of their infrastructure, including surface water, combined and foul sewer systems.

Southern Water is responsible for wastewater infrastructure within Winchester.

4.4 District Councils

District and Borough Councils are Risk Management Authorities and key partners in planning local flood risk management. They have a role as a 'category one responder' to flood incidents under the Civil Contingencies Act 2004, including dealing with recovery and resulting homelessness. As the Local Planning Authority, they have a duty to encourage the appropriate development and promote sustainable development. They also have a responsibility for managing drainage assets on district council owned land.

Winchester City Council is the Local Planning Authority for Winchester.

4.5 Highway Authority

The Highway Authority is responsible for managing highway drainage assets and must ensure that road projects do not increase flood risk.

Hampshire County Council is the Highway Authority for Winchester.

4.6 Local residents and businesses

Local residents and businesses are responsible for protecting their property from the risk of flooding. They also have a responsibility for maintaining private drainage connections and in some cases may have **riparian maintenance responsibilities** for watercourses[8].

Residents and businesses should find out about any flood risk in the area and where appropriate, depending on the level of risk, make a written plan of how they will respond to a flood situation. There are measures that can be taken to reduce the amount of damage caused by flooding and properties at risk should be insured. Local residents can **find out if their property is at risk**[9], prepare for flooding, and get help during and after a flood. Both **Hampshire County Council**[10] and **the National Flood Forum**[11] have resources to assist communities with planning and preparing for flooding, further details are available in Section 7.2.2

8 Owning a watercourse (accessed 10 May 2021): https://www.gov.uk/guidance/owning-a-watercourse

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

10 HCC Prepare your community: https://www.hants.gov.uk/community/emergencyplanning/prepareyourcommunity

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

5 Flood investigation

5.1 Community and stakeholder engagement

Due to the rapid onset of the flooding and widespread impacts across Winchester, it was decided to undertake stakeholder engagement to gather additional information relating to the flooding on 27 August.

As a result of the COVID-19 pandemic, stakeholder engagement activities were limited to questionnaires which were provided in an online format, or as a paper copy upon request. The questionnaires used Microsoft Forms to collect information of people's experiences of:

- Flooding in Winchester on 27 August;
- Source of flooding/ mechanism/ duration etc;
- Historic flooding in Winchester;
- The impacts of the flooding (e.g. social, economic, environmental).

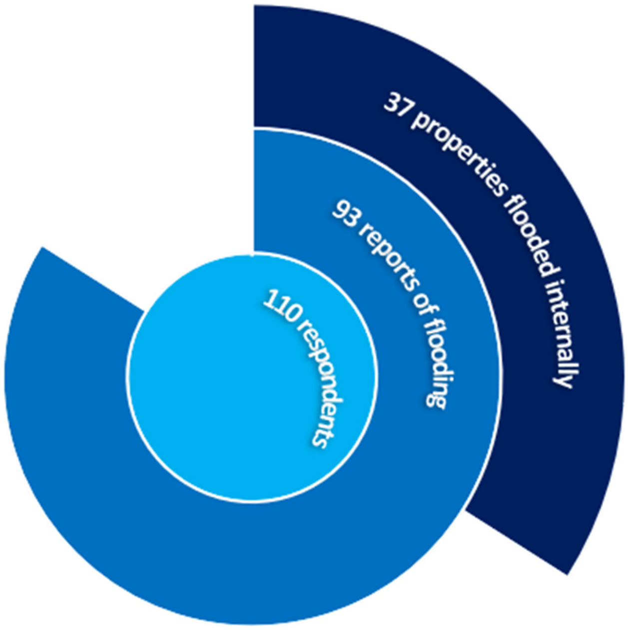
A link to the stakeholder engagement survey was available on Hampshire County Council's website from 18 December 2020, with an initial four-week consultation period set to conclude on 15 January 2021. Awareness of the survey was raised through a combination of a letter drop to residents and businesses known to have been affected, posts on HCC's Twitter account, engagement with local councillors and the Winchester Business Improvement District.

It was decided to extend the consultation period for an additional week to gather further information on the more localised flooding incidents throughout Winchester. This has allowed the LLFA to gather more information on the flooding that occurred for the purposes of the Section 19 investigation.

5.1.1 Responses to the stakeholder engagement survey

A total of 100 responses were received from the stakeholder engagement as of 22 January 2021. 82 of the participants had experienced flooding within the vicinity of their properties on 27 August, this included 34 reports of internal flooding. Only seven participants indicated that they had experienced internal flooding prior to 27 August.

Figure 5-1: Responses to the stakeholder engagement survey



Participants were asked about the source of the flooding on 27 August. As there are often multiple sources of flooding, participants were allowed to select multiple options. 52 responses listed 'overland flow' as a source of flooding with 75 listing 'drains unable to cope/ blocked' as a source of flooding. Only three responses referred to foul sewage as a source of flooding, all of which have been recorded by Southern Water's Sewer Incident Report Form database. Two responses listed groundwater as a source of flooding. There were no responses listing fluvial (watercourse) flooding as a source of flooding on 27 August.

Table 5-1: Number of respondents by road who reported flooding within the vicinity of their properties

Road name	Number of confirmed* internal flooding incidents from the survey	Number of reports of curtilage/ highway flooding in the vicinity of the property
Airlie Road	0	1
Abbey Hill Close	0	1
Andover Road North	1	4
Amport Close	0	1
Appleshaw Close	0	2
Browning Drive	1	3
Chatham Road	0	1
Chawton Close	0	1
Christchurch Road	0	1
Clifton Road	0	2
Cranworth Road	5	14
Buriton Road	2	2
Dean Lane	0	3
Downs Road	0	1
Fairfield Road	1	3
Fromond Road	0	1
Froxfield Close	1	1
Grayshott Close	2	3
Harestock Road	0	1
High Street	6	6
Hillside Road	0	1
Hyde Abbey Road	1	1

Hyde Street	1	1
Imber Road	0	1
Lovedon Lane	0	1
Loyd-Lindsay Square	1	1
Milner Place	0	1
Minden Way	0	1
North Walls	0	1
Priors Dean Road	2	3
Romsey Road	1	2
Royal Winchester Mews	0	1
St. Cross Road	1	1
St. George's Street	1	1
St. James Terrace	1	4
St. Thomas Mews	0	1
Stockbridge Road	1	5
Talavera Road	0	1
Teg Down Meads	1	1
Travellers End	1	2
Upper Brook Street	0	1
Wentworth Grange	1	4
Western Road	1	2
Winnall Valley Road	2	2
Wordsworth Close	1	2
Total	**37**	**93**

*this is the number of confirmed instances of internal flooding only and does not include anecdotal reports of properties other than the respondents which may have flooded during the event

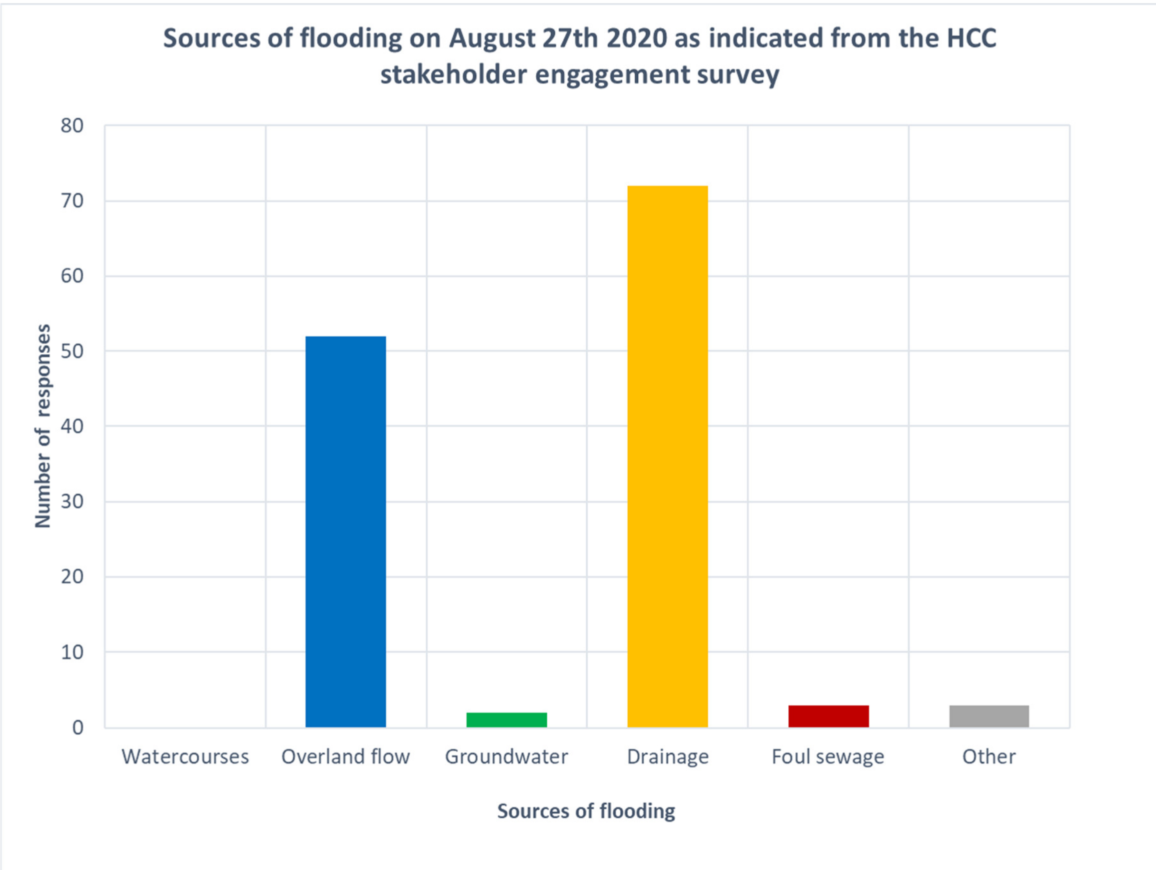
In addition to flood incidents from the stakeholder engagement survey, Winchester City Council and Hampshire County Council had collected information from a number of properties that had been affected by flooding during the event. Collating this information gives an approximation of the number of properties affected by flooding during the event:

Table 5-2: Confirmed internal flood incidents on 27 August 2020

Area	Confirmed internal flooding incidents
High Street	20
Cranworth Road and Fairfield Close	5
Harestock	8
Stockbridge Road and adjoining roads	3
Browning Drive and Wordsworth Close	2
Sleepers Hill and Wentworth Grange	1
Other areas	13
Total	**52**

The collated results indicate that at least 52 properties throughout Winchester experienced internal flooding on 27 August 2020. However, it is likely that internal flooding was more widespread, these incidents are mapped in Figure 6-1.

Figure 5-2: source of flooding as indicated from the stakeholder engagement survey



Out of the 34 reports of internal flooding, 23 listed 'overland flow' as one of the causes of flooding, with the remaining 11 referring to 'drains unable to cope/ blocked' as a source of flooding.

5.1.2 Findings from the stakeholder engagement survey

Information collected was also used to inform the Source-Pathway-Receptor models in Section 6 regarding the pathways, flood durations and flood depths on the day of the event.

The responses highlighted the rapid onset and relatively short duration of flooding:

- The event occurred from 16:45 – 17:20, with the most intense rainfall occurring over 15 minutes within this time. Flooding occurred within 10 minutes of this intense rainfall.
- Flooding lasted from 20 mins to a few hours, with most responses in the range of 30 mins to 1 hour. The flood duration would be expected to vary depending on the condition of drainage systems, assistance from emergency services and with property level considerations.
- Responses consistently identified the roads acting as flow paths for surface water and there were references to surcharging manholes and overflowing drainage systems.
- Almost all the properties indicated to have flooded are within the extent of the 3.33% AEP surface water flood extents as indicated on the RoFSW mapping.
- Many responses made reference to the fact that the drains quickly removed water shortly after the flooding and particularly in the High Street. This indicates that the drainage systems may have been functioning correctly, but that the drainage systems may have experienced a hydraulic overload and surface water was unable to enter the drainage system quickly enough to prevent flooding.

5.2 Emergency response

The rate of onset for the flooding was rapid and as a result there were limited actions that emergency responders could take to manage the flooding when it occurred. Flooding had mostly receded by the time many authorities were aware that it had occurred. Hampshire Fire and Rescue Service attended at least 21 emergency callouts in Winchester on 27 August that were related to flooding. The locations of these callouts were provided to HCC for use in the Section 19 Investigation.

5.3 Subsequent actions by Risk Management Authorities

5.3.1 Environment Agency

The Environment Agency is responsible for managing flooding from rivers and the sea and maintains a strategic overview for all types of flooding in England. The flooding that occurred in Winchester on 27 August was surface water for which the Environment Agency is not responsible for managing.

The Environment Agency has a large network of rain gauges, monitoring stations and boreholes that monitor precipitation, river levels and groundwater levels respectively. This data was made available to HCC for use in the Section 19 Investigation.

5.3.2 Lead Local Flood Authority

Following the events of 27 August, Hampshire County Council identified the flooding as meeting its criteria for 'significant flooding' as set out in its **Local Flood Risk Management Strategy**[12] and **Flood Investigations Guidance**[13]. HCC has commissioned JBA Consulting and Satius Consulting to carry out the Section 19 Investigation, HCC is required to publish the results of this investigation.

Hampshire County Council as Emergency Responder opened the Winchester Household Waste Recycling Centre to residents affected by flooding, as access was restricted due to COVID-19. From discussions with the Emergency Planning Unit at HCC, it is clear that the Emergency Planning Unit were not informed of the flooding and as a result they did not respond to the flooding. However, the Emergency Planning Unit has prepared a Multi-Agency Flood Plan for Winchester which identifies rest centres and key infrastructure in Winchester in the event of flooding.

5.3.3 Winchester City Council

Winchester City Council has a role as a 'category one responder' to flood incidents under the Civil Contingencies Act 2004, including dealing with recovery and resulting homelessness. Due to the rapid onset and short duration of flooding across Winchester, there was insufficient time to mobilise an emergency response at the time of the event.

Following the flooding, WCC staff undertook a clean-up of silt in the High Street to make the area safe for pedestrians. Representatives from the council's Environmental Health and City Centre Management departments liaised with flooded properties in the High Street and collected information on which properties had been affected by flooding. This information was provided to HCC for use in the Section 19 Investigation.

12 Hampshire Local Flood Risk Management Strategy (published Oct 2020): https://documents.hants.gov.uk/flood-water-management/local-flood-water-management-strategy.pdf

13 HCC Flood Investigation Guidance: https://documents.hants.gov.uk/flood-water-management/FloodInvestigationsguidance.pdf (accessed February 2021)

5.3.4 Highway Authority

The Highway Authority is responsible for managing highway drainage assets and must ensure that road projects do not increase flood risk. Large areas of the public highway were flooded on 27 August and as outlined in Section 5, the highway provided a conveyance route to surface water flows in Winchester. JBA Consulting held a meeting with both the LLFA and Highway Authority on 03 December to ascertain the causes of flooding and the response of the Highway Authority.

Due to the rapid onset and short duration of the flooding, the Highway Authority was unable to respond to the flooding when it occurred. Following the flooding, the Highway Authority undertook short term maintenance works, including clearance of soakaways in Harestock as a matter of urgency and as part of this work established the presence of a number of additional soakaways in Harestock that were not previously identified and as a result had not been maintained.

The Highway Authority has acknowledged that it had taken longer than usual to undertake routine maintenance in 2020, partly due to greater numbers of parked cars resulting from increased homeworking during COVID-19.

The Highway Authority provided information on the location and conditions of their drainage assets throughout Winchester for use in the Section 19 Investigation.

5.3.5 Southern Water

Southern Water is the water and sewerage undertaker for Winchester and is responsible for managing the risk of flooding to water supply and sewerage facilities and flood risks from the failure of their infrastructure. This includes surface water sewer systems in Winchester. Southern Water have provided their asset mapping within Winchester to aid with the investigation.

5.4 Site visit

JBA Consulting conducted a site visit on 11 January 2021, to visit areas of Winchester affected by the flooding and establish the flood mechanisms of the area. Due to the restrictions imposed by COVID-19, it was not possible to speak to residents or local businesses.

5.4.1 Winchester High Street

An initial walkover of the High Street and surrounding areas was undertaken, the aim of this was to better establish the causes and mechanisms of the flooding that occurred in the High Street and identify any other relevant factors.

The site visit identified the low property thresholds in the High Street as being a particular issue, as these shops could flood even with relatively shallow external flood depths. It was also noted that a number of drains in the Broadway were blocked with silt, these could have exacerbated existing surface water flooding if they were blocked during the event. Although the site visit took place over four months after the event, a number of shops have sandbags in place in an attempt to prevent or mitigate flooding. One shop (Chococo) was noted to have installed flood barriers outside the main entrance.

Figure 5-3: Flood barrier installed on property in the High Street

The visit to the High Street also included St George's Street where a number of properties also flooded, it was identified that this was likely the result of a surface water flooding on the junction of Friarsgate. Jewry Street was also visited as a number of properties were known to have flooded. The flood mechanism was not identified, however the kerb lines were noted to be relatively low and the property thresholds were at pavement levels. Consequently, these properties could have flooded with relatively shallow external flood depths.

The visit to the High Street also identified deficiencies in the Risk of Flooding from Surface Water mapping, which show minimal surface water flows from the B3420 and Romsey Road, contrary to CCTV footage. It was identified that the kerb lines and camber of the B3420 bridge over the railway are sufficient to provide a conduit to shallow, high velocity flows from higher areas whereas the RoFSW mapping show surface water flowing into the railway cutting.

5.4.2 Cranworth Road

The Cranworth Road area and adjoining roads were also visited, it was noted that a number of large channel drains were present on the pavement in Stockbridge Road, as with the High Street a number of drains were also noted to be blocked with silt at the time of the site visit. A number of properties along Stockbridge Road had rainwater downpipes that discharged directly onto the pavement rather than directly entering into a drainage system. Whilst the steep urbanised catchment is likely to be the main mechanism, it is possible that these factors could have contributed to flows and the increased the rate of onset of the flooding.

It was noted that some property thresholds in the lowest point of Cranworth Road were not significantly higher than street level and that the camber of the road was higher than kerb heights in places. This is significant as flood depths could be expected to be greatest in this area and these factors may have exacerbated flooding. However, Cranworth Road sits in a low spot as a result of the natural topography and surface water runoff from surrounding roads could be expected to pool in this location.

5.4.3 Harestock

A site walkover was conducted for a number of areas in Harestock including Priors Dean Road, Buriton Road, Grayshott Close and Bradley Road. These areas were visited to identify the causes and mechanisms of flooding, this was important as there was no available CCTV footage on the day of the event and photographic evidence was more limited. The walkover identified a number of blocked highway drains that may have contributed to or exacerbated flooding. The site walkover also identified that a number of properties along Buriton Road were using sandbags as a barrier to prevent flooding.

Figure 5-4: Use of sandbags in Harestock

Kerb lines and pavements were not noted to be low, however many of the properties along Priors Dean Road and Buriton Road are at a lower elevation than the road, once surface water could overtop the kerb lines, it would follow the topography towards these properties.

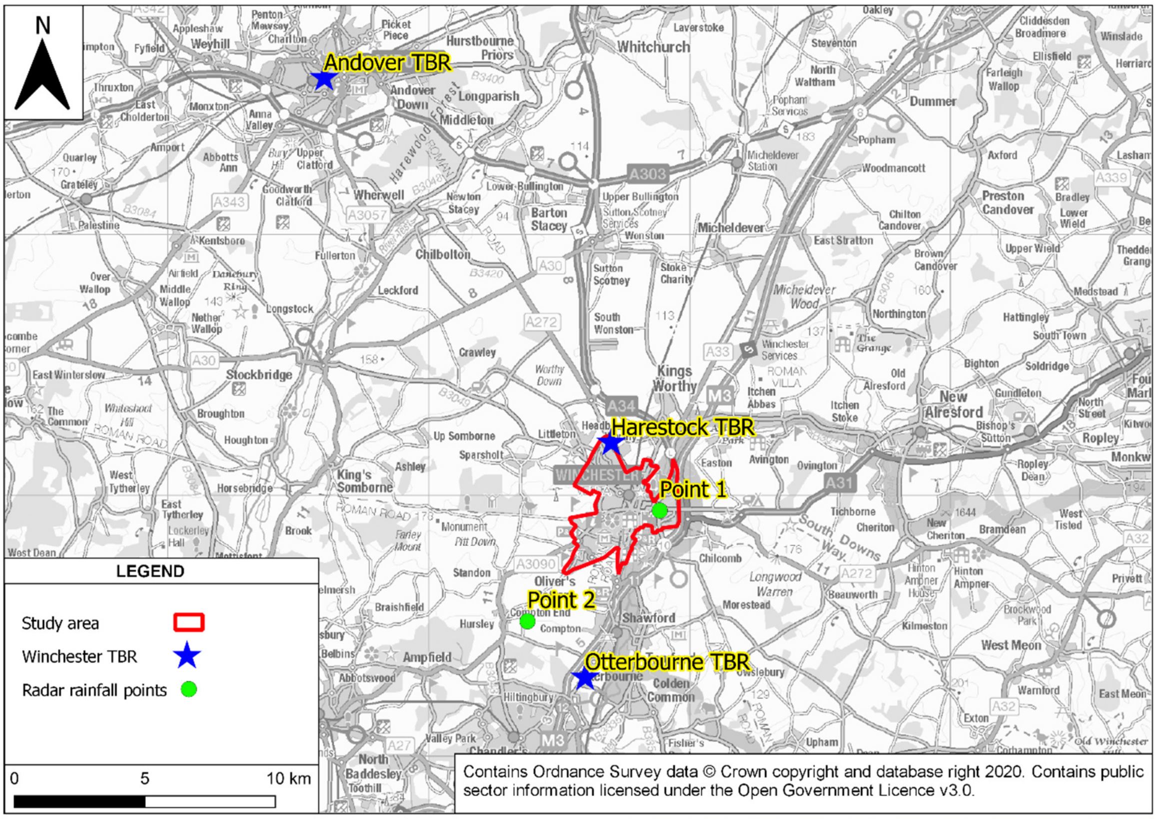
A number of other properties in the area including Winslade Road were noted to be using sandbags. These were not identified prior to the site visit, however they correlate with areas within the 3.33% AEP extent on the RoFSW mapping.

5.5 Hydrometric data analysis

5.5.1 Estimation of storm return period

Rain gauge data was requested from the Environment Agency to determine the return period of the storm event on 27 August. The closest tipping bucket rain gauges to the study area are Harestock, Otterbourne and Andover, with the Harestock gauge being the closest by a considerable distance.

Figure 5-5: Locations of rain gauges and data extracted from rainfall radar

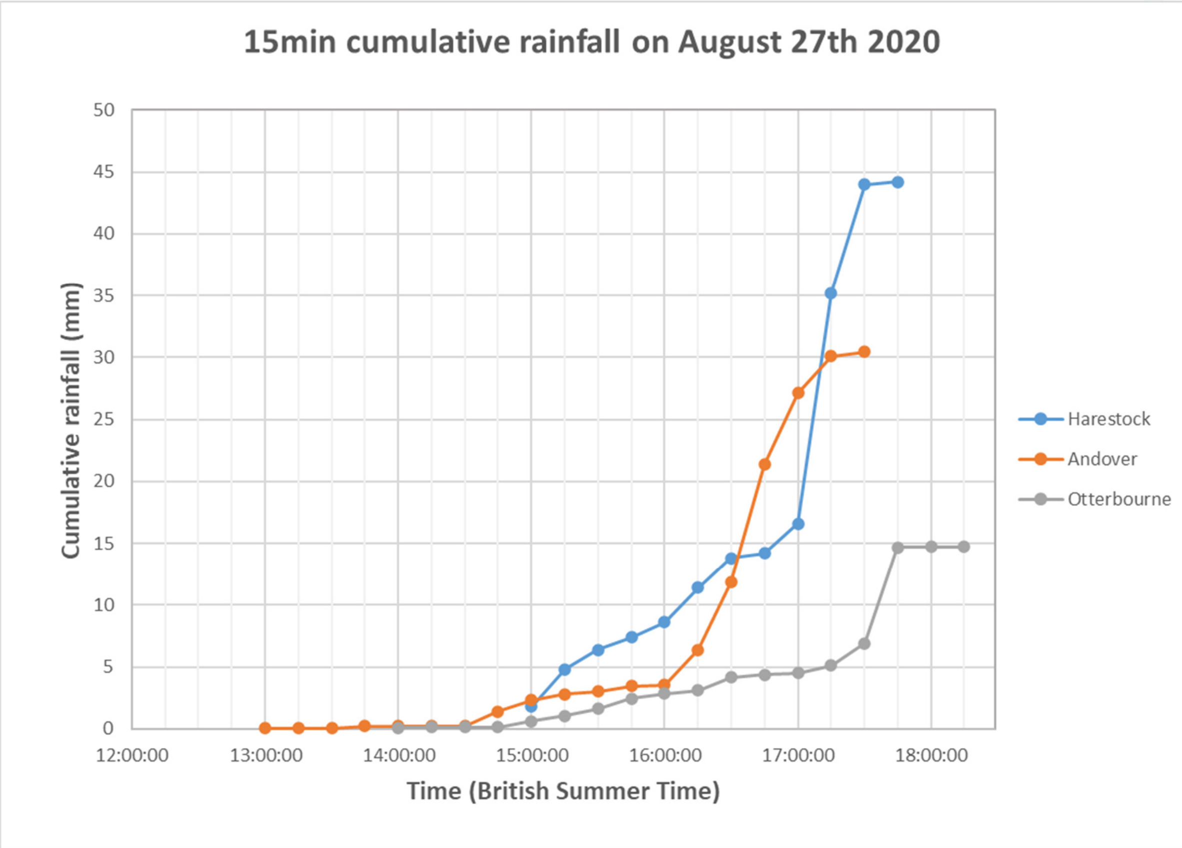


Rain gauge data was aggregated to 15-minute intervals and the cumulative rainfall plotted over this time period. The data is recorded in Greenwich Mean Time (GMT), as the event took place during British Summer Time (BST), this was shifted forward by 1 hour to compensate.

All three rain gauges recorded a distinct peak later in the afternoon where a significant amount more rainfall was recorded than earlier in the afternoon. This occurred at approximately 16:15 in Andover, 16:45 in Harestock and 17:15 in Otterbourne and would indicate than rainfall moved in a roughly north-south direction. This analysis indicated that there were significant differences in rainfall between the three locations with the Harestock gauge recording a significant amount more rainfall than either the Andover or Otterbourne gauges, including earlier in the afternoon, prior to the peak of the event.

The main peak of the event occurred at 16:45 in Harestock, by which time the gauge had recorded 14.20mm of rainfall over the preceding 1hr 45 mins, this was a similar amount of rainfall recorded by the Otterbourne gauge, which recorded 14.74mm of rainfall over the entire event. A total of 44mm of rainfall was recorded over the entire event by the Harestock Gauge, with 27.4mm recorded between 17:00 – 17:30.

Figure 5-6: Comparison of rain gauge data on 27 August 2020



Due to the distance between gauges and the differences in event totals, it was decided to obtain radar rainfall from the Environment Agency to determine the uncertainty in the rainfall that was recorded in August and how it compared to the rain gauge data. Data including 15 min rainfall totals, rainfall intensities and a catchment average for the event were extracted from the rainfall radar data.

The FEH web service was used to purchase point descriptors for Winchester, allowing rainfall rarity (the return period) to be calculated for each gauge and radar point.

Table 5-3: FEH point descriptors used in rainfall rarity analysis

Descriptor	Value
National Grid Reference	SU 47836 29570
BFIHOST	0.925
Standard Average Annual Rainfall	800 mm

The gauge and rainfall radar data indicated that the main peak of the event was preceded by less intense rainfall over a few hours, as a result it was decided to calculate the return period for both the entire event and the peak of the event.

Table 5-4: rainfall rarity results for entire storm duration

Rain Gauge	Start time	End time	Duration (hours and minutes)	Total rainfall depth (mm)	Return period (1 in x years)
Harestock	14:50	17:40	2:50	44.20	1 in 41
Andover	13:00	17:30	4:30	30.47	1 in 4
Otterbourne	14:00	18:15	4:15	14.74	N/A*
Point 1**	14:45	17:15	2:30	17.31	1 in 1
Point 2**	14:30	17:30	3:00	15.87	1 in 1

**Rainfall depth and duration outside range for rainfall-rarity calculation at specific gauge*

***Rainfall radar data sampled at points indicated on figure*

Table 5-5: Rainfall rarity results for the peak of the storm

Rain Gauge	Start time	End time	Duration (hours and minutes)	Total rainfall depth (mm)	Return period (1 in x years)
Harestock	16:45	17:30	0:45	29.80	1 in 29
Andover	16:15	17:15	1:00	35.60	1 in 42
Otterbourne	17:15	17:45	0:30	9.58	1 in 1
Point 1**	16:45	17:15	0:30	13.58	1 in 3
Point 2**	16:45	17:45	0:30	11.59	1 in 2

**Rainfall depth and duration outside range for rainfall-rarity calculation at specific gauge*

***Rainfall radar data sampled at points indicated on figure*

Analysis of the event rarity for both the rain gauges and the rainfall radar showed a high degree of spatial variability ranging from less than 1 in 1 to 1 in 42 years. The return period for the Harestock gauge was consistently high across both the entire event and the peak.

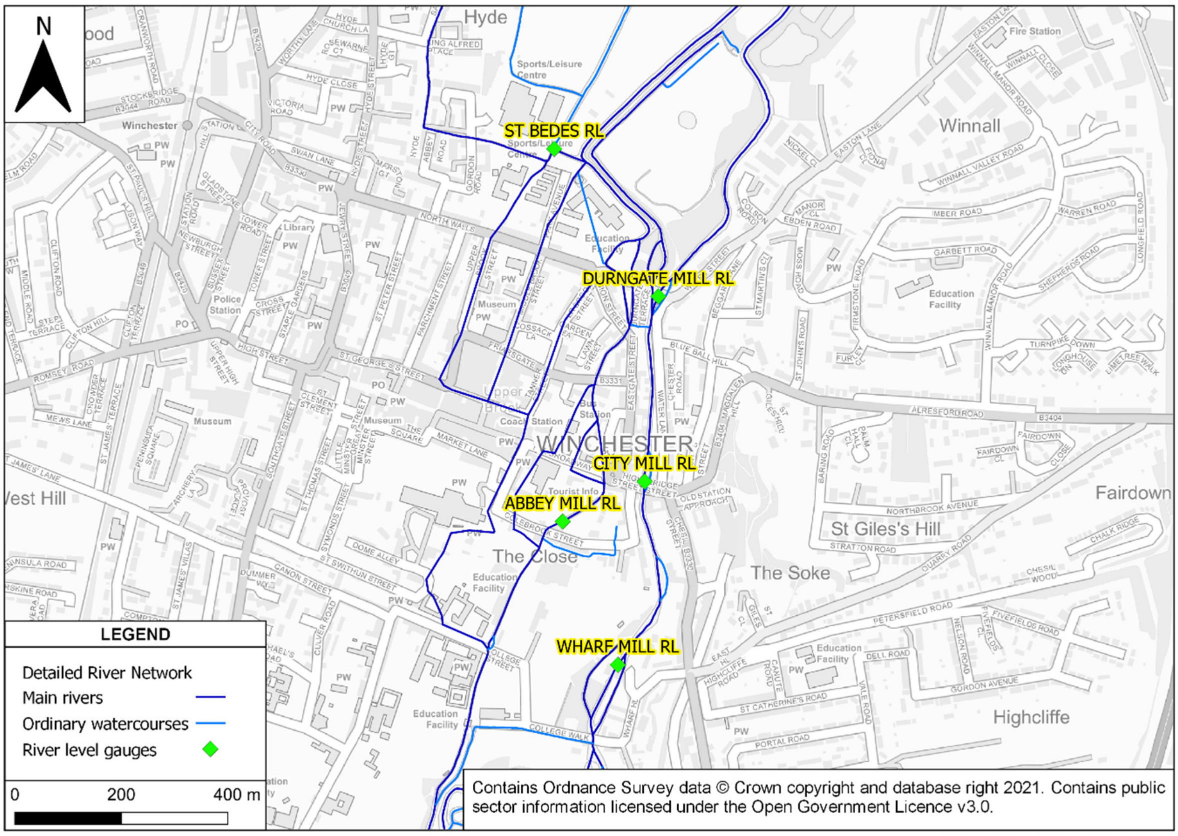
The rainfall radar data showed significantly lower totals in comparison to the rain gauge data and as a result, FEH indicated that the return periods were quite low, typically 1 in 1 years. However, rainfall radar data is typically less accurate with recording high intensity convective rainfall events such as the storm event that affected Winchester. The Environment Agency also highlighted that Dean Hill towards the west of Winchester is affected by tree shadowing which may affect the quality of the rainfall radar data. As a result, the Harestock rain gauge should be considered as the most reliable source of data for calculating the return period.

The storm event that affected Winchester on 27 August was therefore likely to be between a **1 in 29 and a 1 in 42 year event**.

5.5.2 River levels during flood event

River gauge data was requested and analysed to determine whether high river levels in the River Itchen could have resulted in surcharged outfalls and affected the ability of surface water drainage systems in the High Street to discharge runoff.

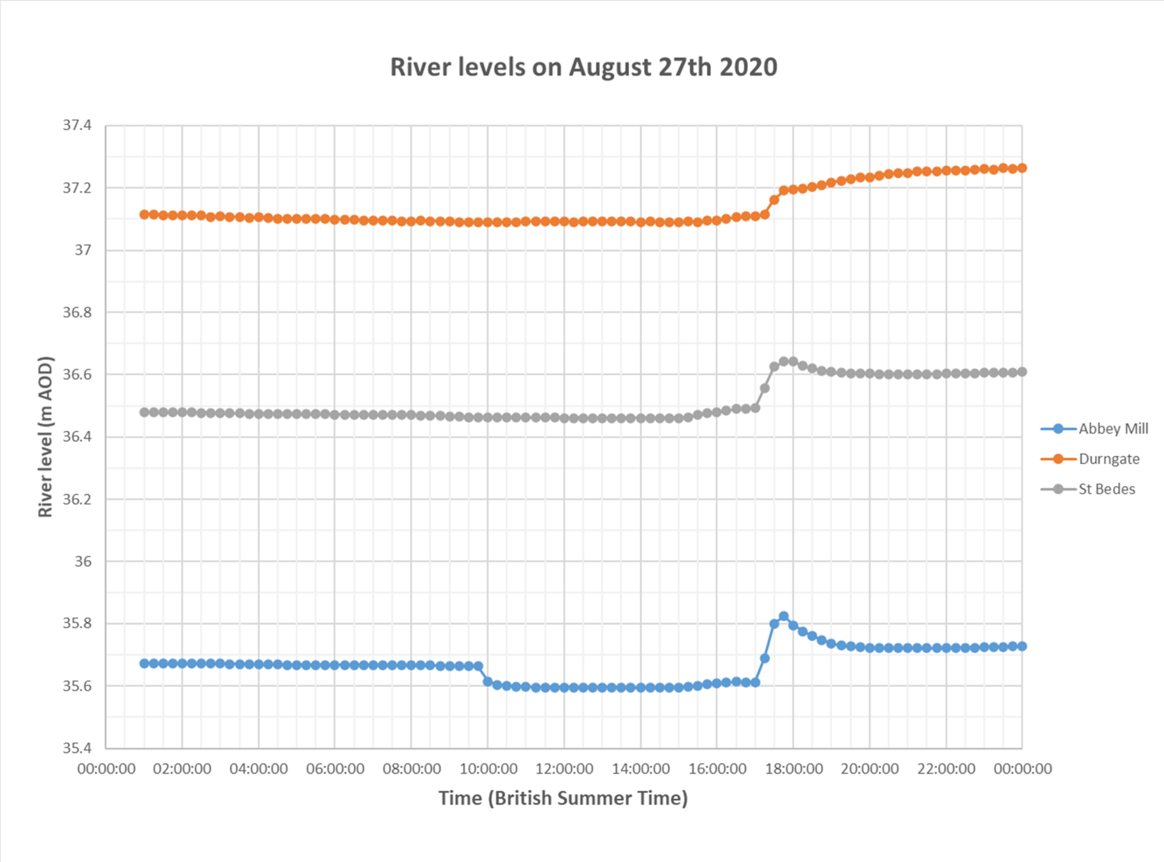
Figure 5-7: Location of river gauges assessed for the investigation



Analysis of river gauge data from the River Itchen before, during and after the 27 August event indicate that river levels were at a normal level for August prior to the event. However, a consistent peak was indicated on the day of the event for all five of the river gauges for which data was requested.

Further analysis of the event data shows that the increase in river level started at approximately 17:00, for the majority of gauges this continued to rise rapidly until reaching a peak at 17:45. River levels then slowly decreased before returning to pre-event levels on 29 August. It should be noted that the increase in river level was relatively minimal, with the increase limited to approximately 200mm above normal levels during the peak.

Figure 5-8: River gauge data on 27 August



Responses to the stakeholder engagement surveys in Section 5.1.2 identified that the most intense rainfall and surface water flooding occurred from 16:45 – 17:20, this is before the peak in river levels identified from the gauge data. The surface water drainage system in High Street was noted to have started to clear flood waters within 20 mins of the peak of the flood event, if surface water drainage systems had been surcharged by high river levels in the Itchen it is unlikely that these systems would have been able to discharge the flood water in the High Street so quickly.

It is more likely that this system did not have the capacity to cope with the large volumes of surface water runoff generated from the event and it is unlikely that the flooding would have been a result of high river levels.

5.5.3 Groundwater monitoring data

Groundwater monitoring data was reviewed to establish whether high groundwater levels during the event could have contributed to the flooding on 27 August. High groundwater levels have the potential to impede infiltration into the soil, they can also reduce the capacity of surface water drainage systems, particularly when drainage systems are poorly maintained.

The Environment Agency has three groundwater monitoring boreholes within the vicinity of Winchester; these are Harestock, Guildhall and New Barton Farm (Figure 5-9). Data from these stations was requested and analysed to determine the relative height of the water table at the time of the event. The Harestock station recorded 'missing data' and was unable to be used in this analysis.

Figure 5-9: Locations of groundwater monitoring locations near Winchester

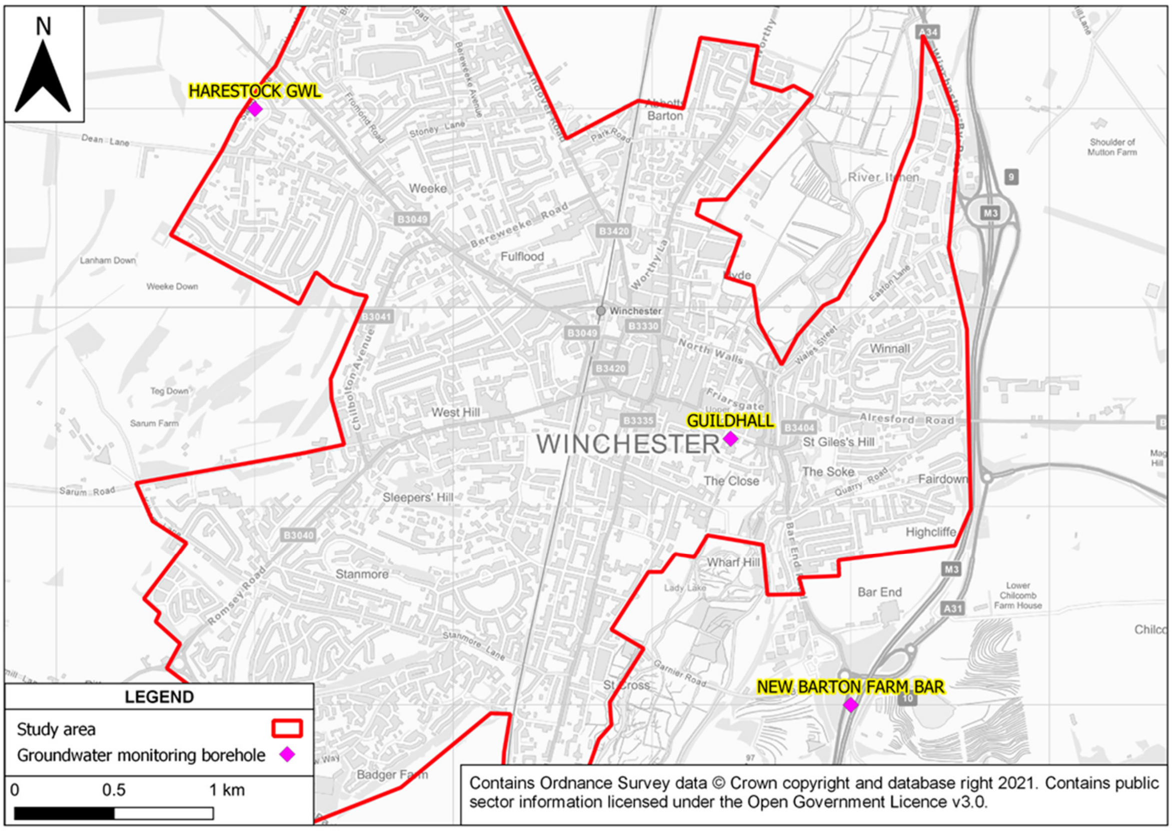
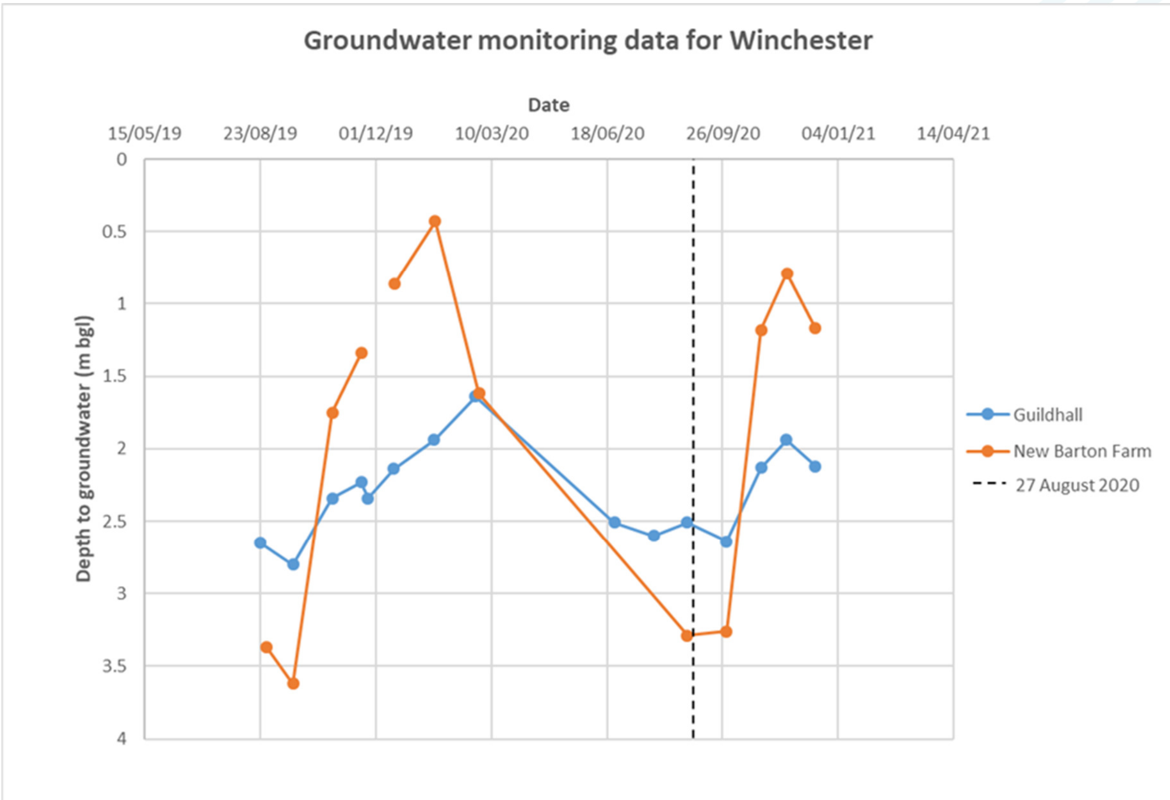


Figure 5-10: Groundwater monitoring data for Winchester



The data indicates that groundwater levels were approximately 2.5 – 3.5m below ground level during August 2020, this is relatively consistent with data from August 2019. This data follows the general pattern of groundwater levels being at their lowest levels during the summer months and higher during Autumn – Spring. Based on the timing of the flood event, it is unlikely that high groundwater levels would have had an impact on the 27 August flooding.

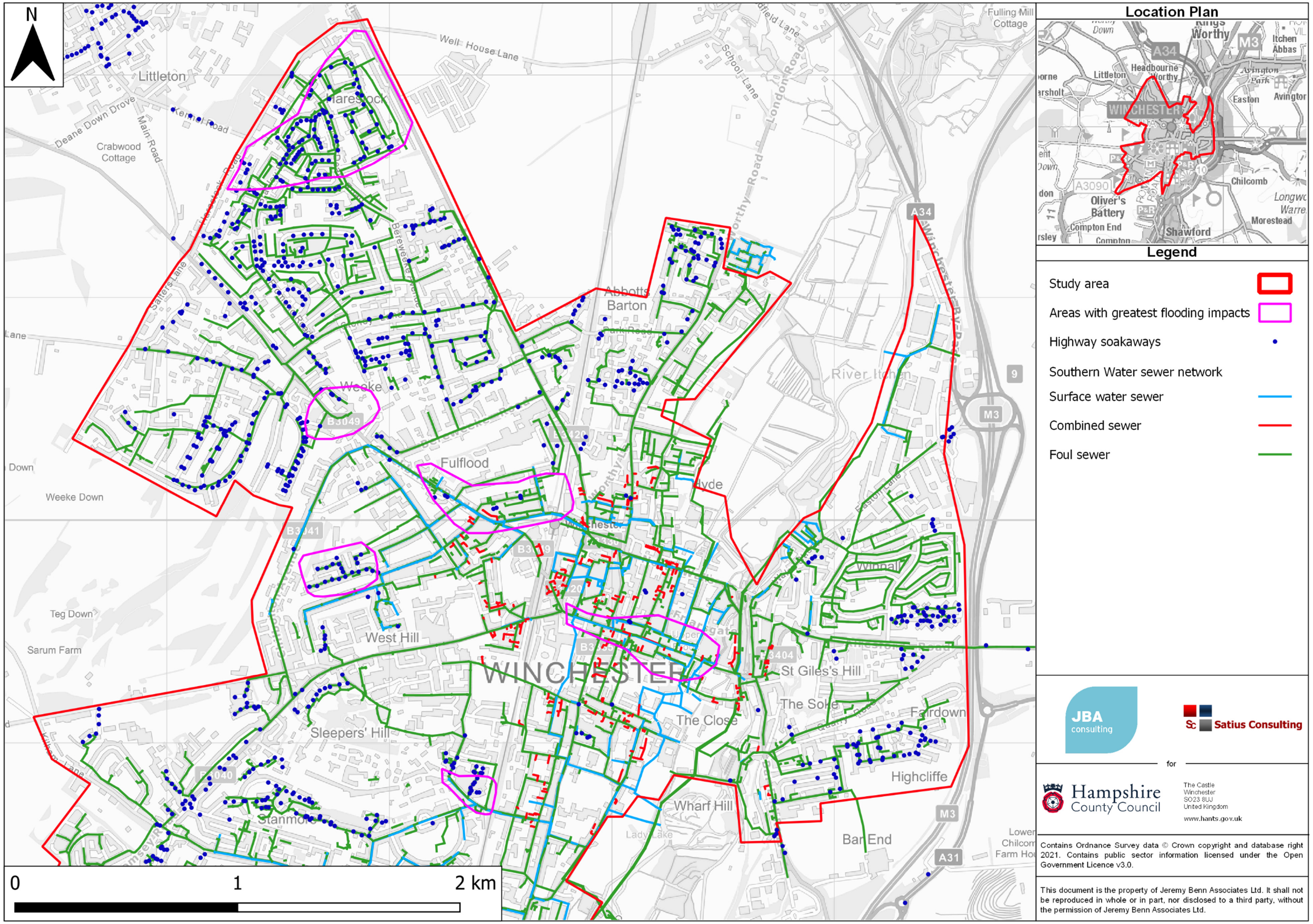
5.6 Review of asset condition and design

As this was surface water flooding, the design and capacity of existing surface water drainage assets in the main locations were reviewed to determine whether these could have been expected to manage the volume of surface water runoff from the event. Figure 5-11 indicates the extent and type of drainage assets in Winchester along with the locations of highway soakaways. The sewer system (including surface water, foul and combined sewers are owned and maintained by Southern Water, while the highway soakaways are owned and maintained by Hampshire County Council in its role as Highway Authority.

This mapping indicates that there are separate foul and surface water sewer drainage systems over the majority of Winchester, with only small sections of combined sewer systems. The asset mapping indicates that where there are surface water sewer systems, the extent of the highways soakaways is quite limited indicating that the surface water sewers provide drainage for the public highway through existing gullies and connections into these sewers.

There are areas of Winchester where there are a large number of highway soakaways, in these areas there do not appear to be dedicated surface water sewer systems. These areas include Harestock, Sleepers Hill and Browning Drive.

Figure 5-11: The extent and type of sewer systems in Winchester and locations of highway soakaways



5.6.1 Surface water sewer network

Southern Water's sewer records were reviewed to understand whether a lack of capacity in the surface water sewer system could have contributed to the flooding. The High Street and Cranworth Road are both served by existing surface water sewer systems. In the High Street, the sewers range from a 225 – 375mm diameter pipe which discharge to the River Itchen. In Cranworth Road the surface water system is a 300mm pipe which discharges to a 525mm pipe in Stockbridge Road.

Improvement works were undertaken in Winchester High Street in 2009, these include improvements to the existing drainage system which was replaced 'like-for-like', these drawings were reviewed in the investigation. The previous sewer network had been throttled from a 450mm to a 400mm pipe in the High Street outside ASK. HCC added an additional surface water sewer network in 2009 running parallel to this, ranging from a 375mm – 450mm diameter pipe. The scope of these improvement works stopped at Debenhams and it is envisioned that the next phase of improvements (Silver Hill) would include further improvements along the High Street towards the Broadway.

The **Design and Construction Guidance**[14] for foul and surface water sewers has been reviewed to determine typical sewer design standards. This indicates that modern surface water sewer systems are designed to convey flows from 1 in 30 year events without flooding, and it is likely that the rainfall event on 27 August was more extreme than this. It should be noted that these are present day design standards and older surface water sewer systems are unlikely to have been designed to meet these design standards. As a result, they would be less able to cope with significant flows in comparison to more recently designed sewers.

5.6.2 Highway drainage system

Review of asset mapping from the Highway Authority indicates that the public highway in a number of areas of Winchester is drained to soakaways, these areas include Harestock, Browning Drive and Sleepers Hill. These assets are typically noted to have a capacity of between 4-8m^3 in the affected area of Priors Dean Road and a '0.2 maintenance frequency', indicating that routine maintenance is undertaken once every five years. Routine maintenance for highway gullies in Winchester is typically undertaken on a '0.3 schedule' occurring once every three years, although in some areas of Winchester this is undertaken more frequently, including Harestock where gullies are indicated to be maintained once a year and Cranworth Road where this is undertaken twice a year.

The design standard of highway drainage systems varies depending on individual councils, however CIRIA C635 '**Designing for exceedance – good practice**'[15] states that highway drainage systems are commonly designed to only manage flows up to a 1 in 1 or 1 in 2-year event. This is an important consideration as it has been established that the public highway provided a pathway for the majority of surface water flows. With consideration to typical design standards of these systems, the estimated storm event would have significantly exceeded the capacity of the highway drainage system.

In Winchester, the highway drainage system typically discharges to either the public sewer network, as is the case in the High Street and Cranworth Road, or to soakaways such as those in Harestock. Although public sewer systems are typically designed for a higher standard than highway drainage systems, the ability of the public highway to discharge runoff is limited by the capacity of the highway drainage system that drains it.

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14 Design and Construction Guidance (Appendix C): https://www.water.org.uk/wp-content/uploads/2020/03/SSG-App-C-Des-Con-Guide-v-2-100320-C.pdf

15 CIRIA C635 (2006) 'Designing for exceedance – good practice' (Table 3.1)

6 Source-Pathway-Receptor model

6.1 Priority areas for source-pathway-receptor analysis

JBA compiled information from a wide range of sources including Hampshire Fire and Rescue Service callouts from the event, Risk Management Authority data and responses to the stakeholder engagement survey to determine the locations of properties that were flooded on 27 August 2020. This indicated that flooding was widespread across Winchester on 27 August with a number of more localised instances of flooding.

Heatmap analysis (Figure 6-1) was undertaken to determine areas which were more severely impacted by the flooding where detailed Source-Pathway-Receptor mapping would be required to understand the flood mechanisms. This was based on the number of properties (residential and commercial) that experienced internal flooding on 27 August.

This analysis identified three main areas which were most severely impacted by the flooding:

- High Street and adjoining roads – at least 20 commercial properties are known to have experienced some degree of internal flooding on the High Street and adjoining roads.
- Cranworth Road – up to 11 residential properties are known to have experienced some degree of internal flooding along Cranworth Road and Fairfield Road.
- Harestock – at least 15 residential properties are known to have experienced some degree of internal flooding in Harestock. This includes Priors Dean Road, Buriton Road and Grayshott Close.

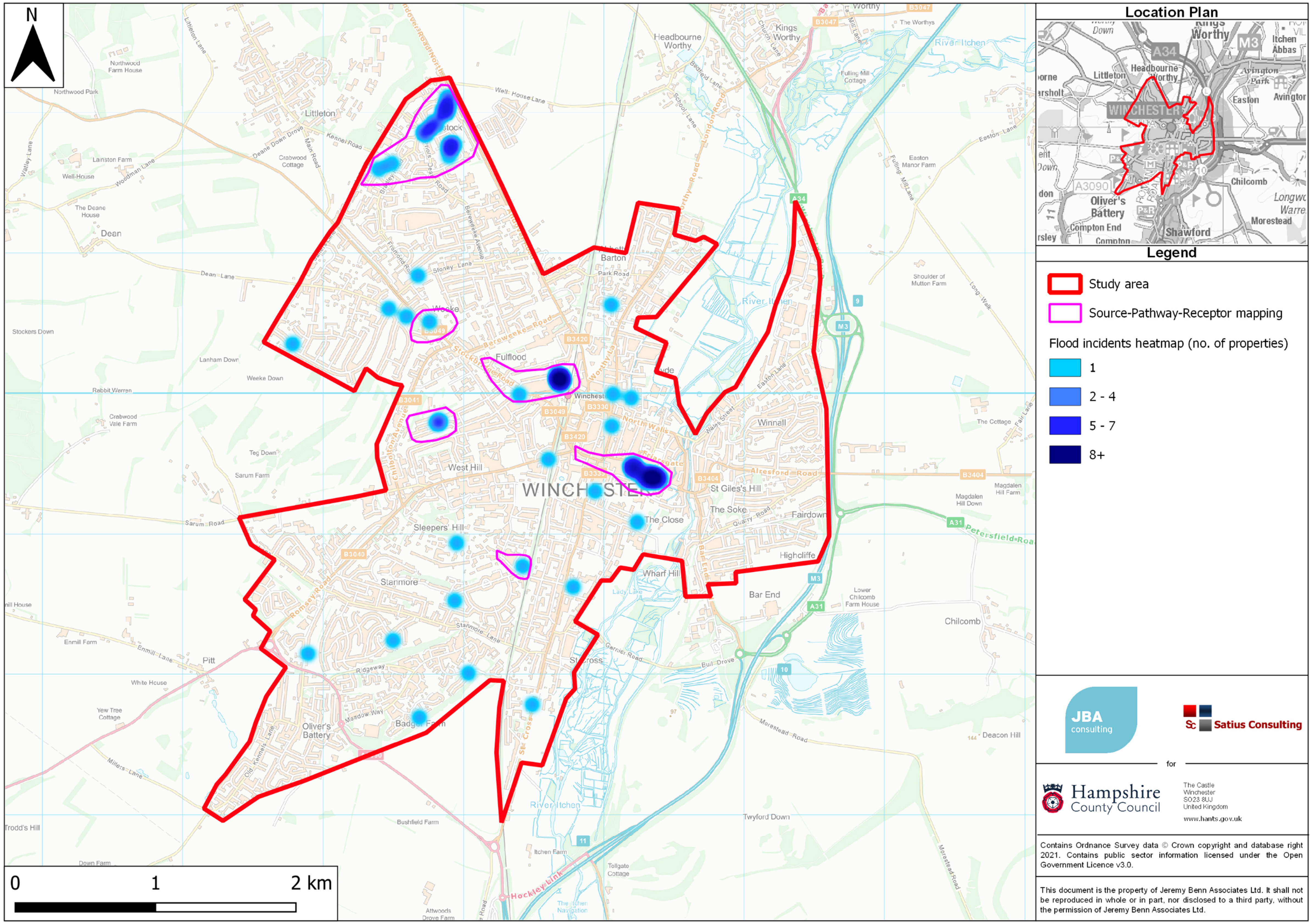
Three additional areas of interest were also identified as requiring further analysis, these were:

- Sleeper Hill and Wentworth Grange;
- Browning Drive and Wordsworth Close; and
- Stockbridge Road/ Weeke Pond.

There were a number of other, more localised flood incidents on 27 August in Winchester, although source-pathway-receptor models have not been produced for these areas. In the majority of these incidents there was insufficient information to accurately determine the flood mechanisms and produce detailed mapping, however a summary of some of these areas can be found in Section 6.8.

The source-pathway-receptor models aims to identify the sources of flooding in each of these areas, map the flow routes and pathways which conveyed flood water, and identify the receptors affected by flooding, including estimated flood depths and the impacts of flooding to those receptors. The purpose of this assessment was to build a conceptual model of the flooding that occurred in order to identify appropriate recommendations. Photographs and CCTV footage from the event has been used alongside these models for reference.

Figure 6-1: Flood incidents heatmap indicating all reports of flooding across Winchester on 27 August 2020



6.2 Winchester High Street

6.2.1 Source

Responses to the stakeholder engagement surveys (outlined in Section 5.1.2) identified that intense rainfall occurred from 16:45 – 17:20 and was closely followed by surface water flooding to the High Street.

The High Street slopes towards the east, and the Broadway is topographically lower than the western end of the High Street, with the western end situated at approximately 56m AOD and the Broadway 580m to the east at 36m AOD.

CCTV footage from the event shows manhole covers lifting in the High Street (location 3 Figure 6-3), it is likely that this is the result of a hydraulic overload, and this may have acted as a secondary source of flooding once drainage systems became surcharged. This may have exacerbated surface water flooding in the area, however the primary source of the flooding is considered to be surface water runoff as a result of the steep topography.

6.2.2 Pathway

CCTV footage from the town centre (location 4, Figure 6-3) indicates that surface water runoff flowed down Romsey Road towards the High Street. Surface water continued to flow down the High Street (location 3, Figure 6-3) before pooling in the Broadway (location 2, Figure 6-3). The Broadway continues east where it is slightly elevated, which causes surface water to pool in this location.

The High Street is completely impermeable and there are no green spaces which could slow surface water flows. As it is required to be accessible for pedestrians the High Street is relatively flat, this results in few obstacles to impede flows or cause surface water to pool in the High Street prior to the Broadway. These factors may have exacerbated the velocity and volume of surface water flooding in the High Street.

A number of manhole covers lifted in the High Street, likely as a result of hydraulic overload, this exceedance would have led to additional flows which were unable to be stored in the sewer network to be conveyed along the High Street towards the Broadway.

In addition to the primary conveyance route down the High Street, a number of secondary flow paths are indicated to have contributed to the flooding. This includes Colebrook Street adjacent to the Guildhall to the south of the Broadway. It is also likely that a smaller volume of surface water from the eastern side of the Broadway may have contributed to the surface water flooding in the High Street.

Properties along St Georg e's Street, adjacent to Upper Brook Street were also flooded on 27 August. This flooding is unlikely to be related to the main surface water flow path along the High Street. However, the Risk of Flooding from Surface Water mapping indicates that significant pooling occurs on the junction between St George's Street and Friarsgate. The kerb lines and camber of the highway at this location is relatively low, which could have led to the flooding of these properties.

The Risk of Flooding from Surface Water mapping predicts little to no surface water flows entering the town centre from the B3420 and Romsey Road, this contradicts CCTV footage from the event. Analysis of the RoFSW mapping indicates significant flows on Romsey Road on the western side of the railway cutting and indicates that these flows are pooling in the railway cutting. This is inaccurate as the high velocity, shallow flows are unlikely to overtop the kerb lines at the highway extent and as a result surface water runoff will flow towards the High Street.

6.2.3 Receptor

Surface water pooled at the Broadway, as the Broadway rises slightly to the east which prevents surface water from continuing to flow, this led to flooding of commercial properties along eastern side of the Broadway. Surface water flooding also occurred in Colebrook Street, adjacent to the flooded areas of the Broadway and at the junction of St. Georges Street.

The High Street is heavily pedestrianised and as a result, property thresholds for commercial properties are close to, or at ground level. This resulted in flooding to a number of shops along the Broadway and the High Street, even where water was flowing rather than pooling; although the majority of properties that flooded were along the Broadway where surface water was pooling. The northern side of the High Street is at a slightly lower elevation, as a result the majority of properties flooded in the High Street were on the northern side.

The rate of onset for the flooding was noted to be rapid, with businesses having little time to react in order to prevent flooding to their businesses. Flood depths in the Broadway were noted to be approximately 500mm externally. Some shops along the Broadway noted that flooding along the Broadway lasted for approximately 20 minutes after which the surface water drainage system in the Broadway was able to start clearing flood waters.

The low thresholds of the commercial properties along the High Street may have exacerbated the number of properties flooded and flood damage in comparison to residential dwellings in Winchester. This resulted in damage to flooring and equipment for businesses in the High Street in addition to loss of trade resulting from the flooding, although many businesses managed to reopen the following day.

Figure 6-2: Source-Pathway-Receptor mapping for Winchester High Street

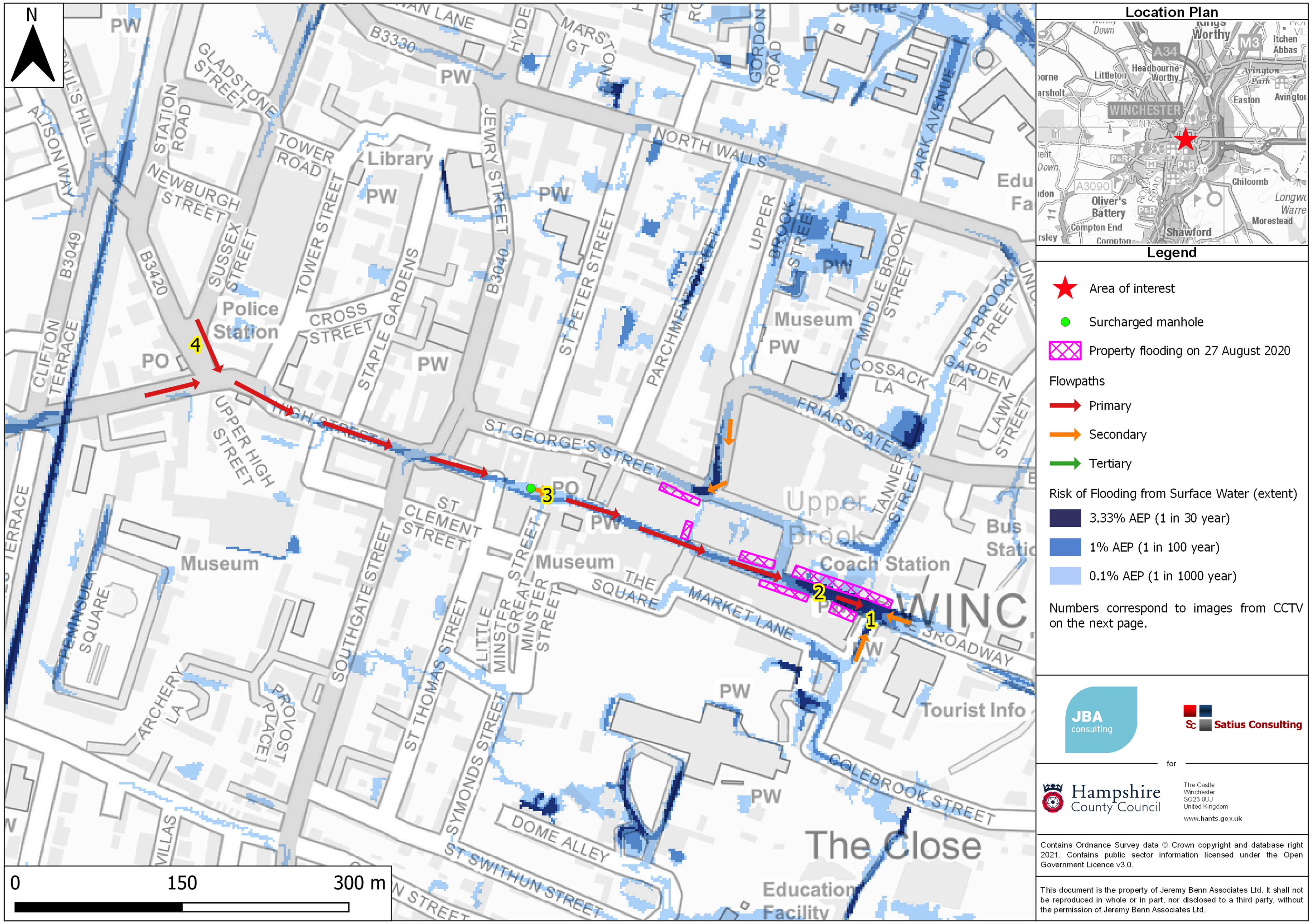


Figure 6-3: Photographs of the flooding in Winchester High Street on 27 August2020

1. Surface water flooding along Colebrook Street (looking south)

2. Surface water flooding along the Broadway (looking west)

3. Surface water flowing along the High Street (looking east)

4. Surface water flowing along Romsey Road towards the High Street (looking south east)

6.3 Cranworth Road

6.3.1 Source

Footage captured by residents along Stockbridge Road indicates that the source of the flooding was surface water runoff following intense rainfall. Responses to the stakeholder engagement surveys (outlined in Section 5.1.2) identified that intense rainfall occurred from 16:45 – 17:20, this was closely followed by surface water flooding.

The steep topography results in a relatively large and steep catchment area for surface water flows in this part of Winchester, with flows converging and accumulating in Cranworth Road.

The Risk of Flooding from Surface Water mapping predicts significant pooling in Cranworth Road. Cranworth Road is situated in a low spot, with the northern end of the road at approximately 57m AOD, the southern end at 54m AOD and the centre of the road at 50m AOD. This results in surface water pooling in the centre of the road. Stockbridge Road (B3049) forms a junction at the southern end of Cranworth Road this road rises significantly towards the north west and is approximately 80m AOD less than 1km to the north west of Cranworth Road.

The findings from the stakeholder engagement survey identified surface water drainage as a potential issue in the Cranworth Road area, with blocked leaves identified to have been an issue. Whilst issues with surface water drainage, such as blockages caused by leaves may have exacerbated flood risk in the area, the main source of the flooding is considered to be surface water runoff as a result of the steep topography.

6.3.2 Pathway

Stockbridge Road acts as the main conduit for surface water flows into Cranworth Road. Video footage from the event shows significant volumes of surface water cascading east along Stockbridge Road (locations 3 and 4, Figure 6-5), these flow north into Cranworth Road before the tunnel under the railway line. These flows appear to be relatively shallow although due to the topography are moving rapidly.

Responses to the stakeholder engagement survey indicate that surface water runoff also flowed along adjoining roads including Fairfield Road and Hatherley Road before pooling in the low spot in Cranworth Road. Surface water flows were also noted to have originated to the south east, flowing along Milverton Road and Western Road before converging with the main flow path flowing east along Stockbridge Road, these secondary and tertiary flow paths are indicated in Figure 6-4.

6.3.3 Receptor

Flooding to 11 residential properties was reported on Cranworth Road during the 27 August 2020 event.

Surface water pooled in the low spot in Cranworth Road, close to the junction of Fairfield Road (locations 1 and 2, Figure 6-5). Maximum flood depths in Cranworth Road were noted to be between 300 - 600mm, this was sufficient to cause damage to parked cars.

Responses to the stakeholder engagement survey indicate that the flooding lasted for approximately one hour from 17:00 – 18:00, with flooding occurring within 15 minutes of heavy rainfall.

Properties at the lowest point of Cranworth Road, towards the junction of Fairfield Road experienced internal flooding. Internal flood depths were noted to be relatively shallow and less than 100mm. Flooding caused damage to carpets and furniture to a number of properties in Cranworth Road.

Water is also known to have entered the tunnel under the railway line causing flooding to a depth of approximately 120mm, this was noted to be a recurrent issue. As a result of the flooding, many homeowners keep sandbags outside their properties as seen on the site visit on 11 January 2021.

An additional property along Western Road suffered internal flooding as a result of surface water runoff flowing along Western Road. When this water exceeded kerb height it flowed towards the property and caused internal flooding to the entire ground floor.

The Risk of Flooding from Surface Water mapping shows flood extents along Cranworth Road to be extremely large during the 3.3 AEP event, with only a small amount of water flowing through the tunnel on Stockbridge Road during the 0.1% AEP event. Responses from the stakeholder engagement survey indicate that flooding in this location is recurrent. It is unlikely the tunnel has been accurately represented on the RoFSW mapping. Although these areas of Cranworth Road are likely to be at 'high' risk of flooding from surface water, as indicated from the 27 August flooding, the extents are unlikely to be as large as the mapping would indicate.

Figure 6-4: Source-Pathway-Receptor mapping for Cranworth Road on 27 August 2020

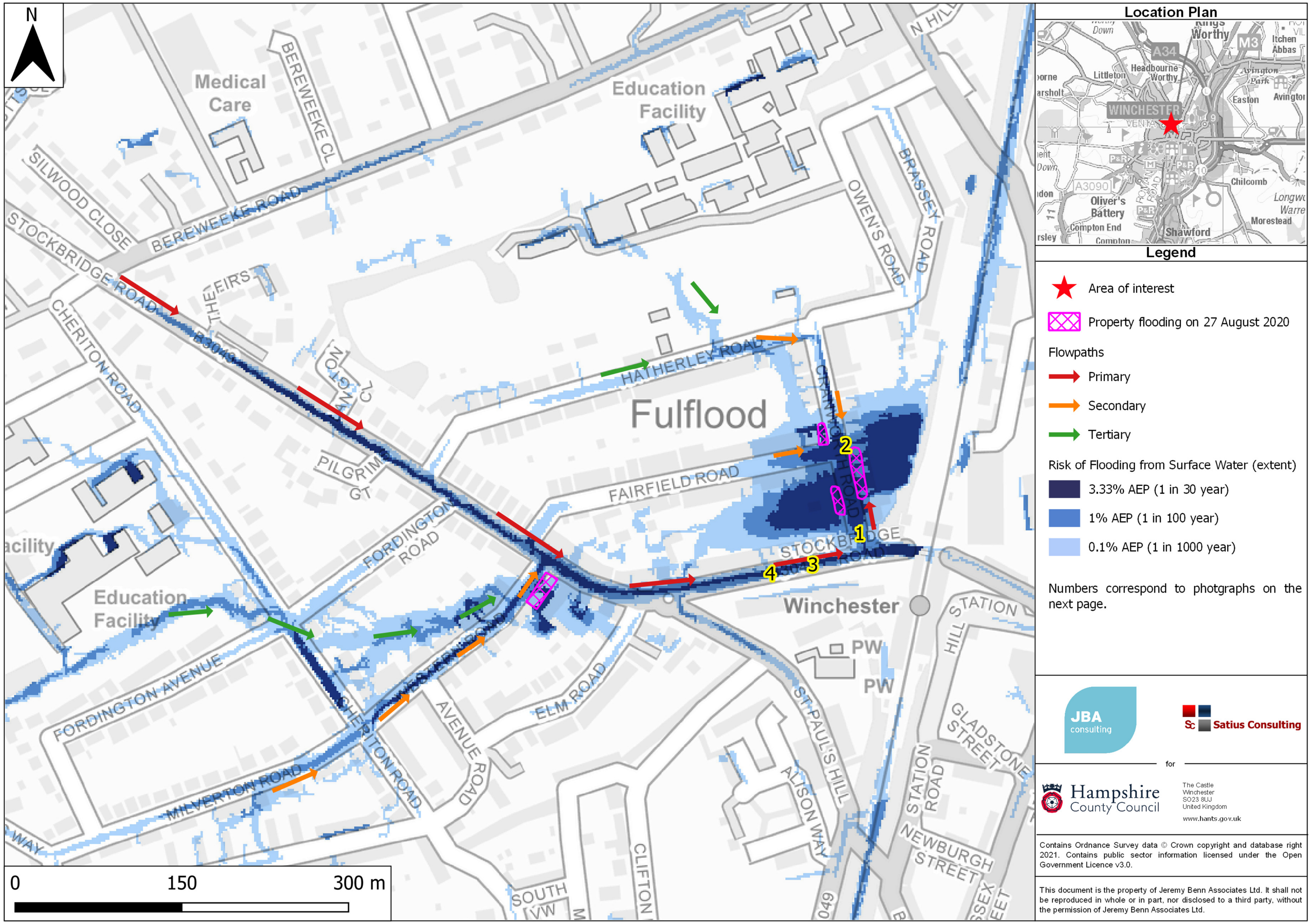


Figure 6-5: Photographs of the flooding in Cranworth Road on 27 August 2020

	
Surface water flooding in Cranworth Road (looking north)	Surface water flooding in Cranworth Road (looking south)
	
Surface water flowing along Stockbridge Road (looking east)	Surface water flowing along Stockbridge Road (looking west)

6.4 Harestock

6.4.1 Source

Responses to the stakeholder engagement survey indicate that the source of the flooding was surface water runoff following intense rainfall. These responses (outlined in Section 5.1.2) identified that intense rainfall occurred from 16:45 – 17:20, this was closely followed by surface water flooding.

The topography of Harestock is steep and ranges from approximately 60m AOD in the east and 90m AOD in the west and the area slopes towards the north east. Responses to the stakeholder engagement survey indicate that the source of flooding was surface water runoff from roads.

Surface water drainage was identified as a potential issue in Harestock, and there were known drainage issues in Priors Dean and Buriton Road prior to 27 August, resulting in flooding of the highway. However, these drainage issues did not lead to internal property on previous occasions. Drainage issues may have exacerbated flood risk in Harestock, however the main source of the flooding is considered to be surface water runoff as a result of the steep topography.

6.4.2 Pathway

Surface water flows are likely to have originated in topographically higher areas, the site visit by JBA identified properties with sandbags along Winslade Road, where surface water is predicted to pool on the RoFSW mapping. From Winslade Road surface water followed the roads which provided a pathway to convey flows. Water flowed north down Bradley Road and Burley Road before pooling in the junction of Priors Dean Road and Bradley Road.

Surface water was noted to have continued to flow from the junction of Priors Dean Road in a north east direction through an alleyway where it entered the rear gardens of properties along Grayshott Close and Chawton Close, causing flooding to a number of these properties. The water then flowed downslope towards the junction of Buriton Road.

Responses to the stakeholder engagement survey indicate that surface water flows originated from both sides of Buriton Road, Rockbourne Road and across Grayshott Close from Priors Dean Road.

A secondary flow path is indicated to be present along Priors Dean Road, this would have flowed along Buriton Road, flowing north along Foxfield Close before flooding Appleshaw Close. Responses to the stakeholder engagement survey indicate that flows from Appleshaw Close followed the lowest point round the rear gardens of properties on the north side of the cul-de-sac before continuing north, downslope to Buriton Road.

The RoFSW mapping indicates that surface water flows continue downslope from Buriton Road causing flooding to properties in Andover Road North. Responses to the stakeholder engagement survey indicate that water pooled along the front of these properties from Andover Road North which sits at a higher elevation than the properties rather than entering through the rear of the properties.

From this information, it can be inferred that the Risk of Flooding from Surface Water mapping is a good indicator of the flooding mechanisms in this area, as experienced on 27 August and flooding was mainly a result of the steep topography of the area. These flow paths are indicated in Figure 6-6.

6.4.3 Receptor

Residential properties in Buriton Road, Grayshott Close, Andover Road North and Appleshaw Close are known to have flooded internally during the event. The properties that flooded are often at a lower elevation than the adjoining highway and as a result provided a flow path for surface water runoff.

Internal flood depths were noted to be relatively shallow and commonly less than 100mm, although depths in the range of 200 – 400mm were reported for a small number of properties. Responses to the stakeholder engagement survey indicate that the flooding lasted for approximately one hour from 17:00 – 18:00. A number of residents took quick action to divert water and prevent it from entering their homes, this may have reduced the number of properties flooded in the Harestock area.

Flooding caused damage to a number of properties, with a small number of properties having extensive internal flood damage, with residents having to replace carpets, furniture and possessions on the ground floor of their properties. In other cases, flood damage was less severe although this still required substantial cleaning efforts and replacement of carpets.

As a result of the flooding, many homeowners keep sandbags outside their properties as seen on the site visit on 11 January 2021.

Figure 6-6: Source-Pathway-Receptor mapping in Harestock on 27 August

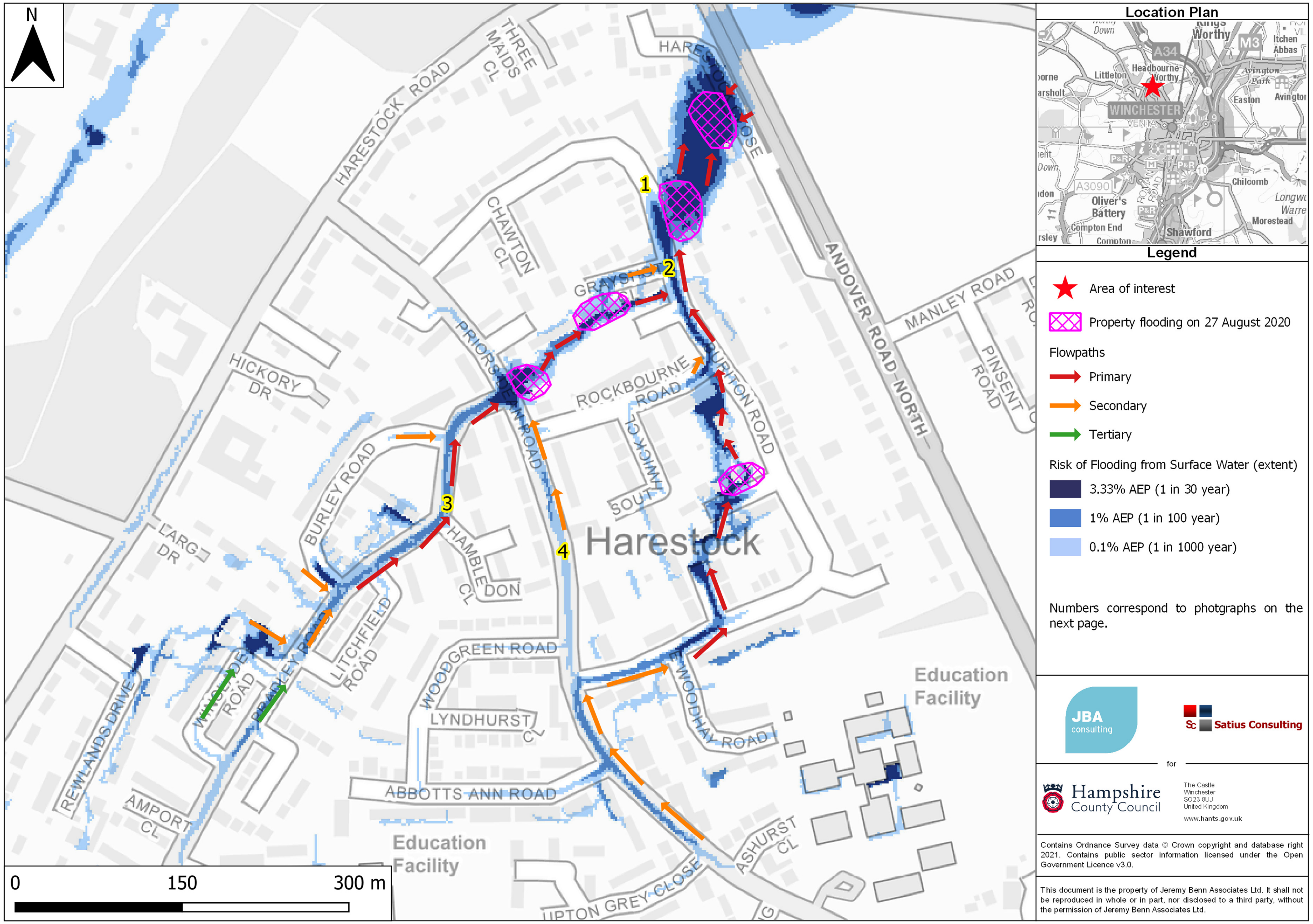


Figure 6-7: Photographs of the Harestock area and flooding on August 27th 2020

	
1. Surface water flooding at the junction of Buriton Road and Grayshott Close (looking south)	2. Surface water flooding to properties at Andover Road North (looking west)
	
3. Looking north along Bradley Road showing the topography	4. Looking north along Priors Dean Road showing the topography

6.5 Wentworth Grange

6.5.1 Source

Responses to the stakeholder engagement survey indicate that the source of the flooding was surface water runoff from Sleepers Hill and Sparkford Road following intense rainfall. These responses (outlined in Section 5.1.2) identified that intense rainfall occurred from 16:45 – 17:20, this was closely followed by surface water flooding.

6.5.2 Pathway

Surface water runoff flowed from Sleepers Hill and Sparkford Road which are at a higher elevation (approximately 49m AOD) in comparison to Wentworth Grange (approximately 41m AOD). This runoff converged at the junction with Airlie Road before flowing down slope towards the railway bridge. Large volumes of surface water runoff also flowed into Wentworth Grange (location 2 and 4 in Figure 6-8 and Figure 6-9) due to the camber of the road, this runoff pooled in the cul-de-sac (location 1 in Figure 6-8 and Figure 6-9) where it rose, to depths of approximately 200mm in Wentworth Grange.

This pooling lasted for a period of 2 – 3 hours before draining away. The surface water runoff also washed silt and gravel into Wentworth Grange which was noted to have caused an access issue. This indicates that surface water flows had a high velocity to transport this silt and gravel and responses noted that pavements on Sleepers Hill appeared to have been eroded or stripped of gravel following the event.

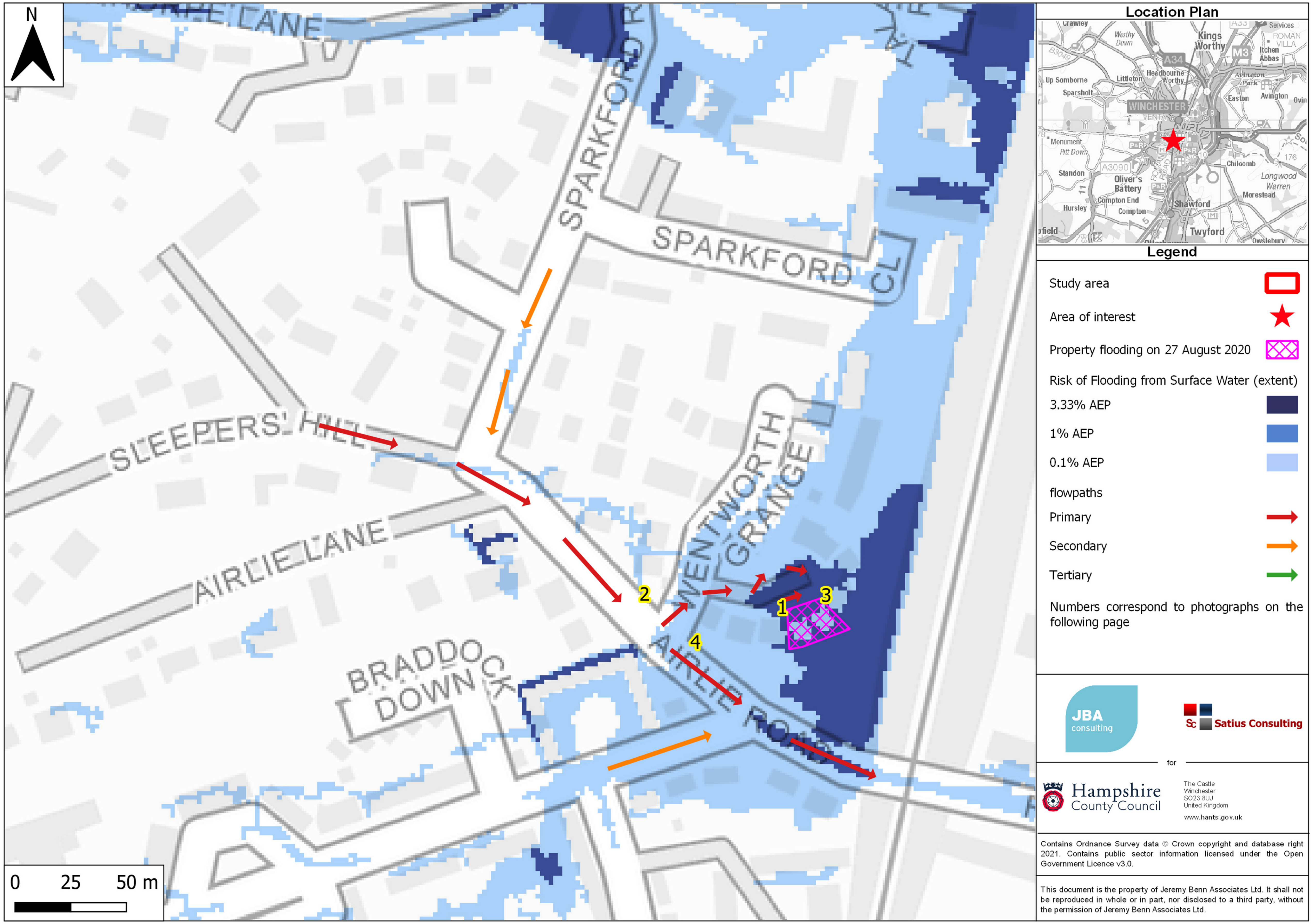
Responses noted that at first the drainage appeared to cope with the volumes of water before the water levels started rising in the road. It was noted that road drains along Wentworth Grange appeared to be blocked following the event. Responses have indicated that Wentworth Grange has flooded on a number of previous occasions.

6.5.3 Receptor

At least one property in Wentworth Grange experienced flooding, although this was mostly limited to the highway, driveways and the gardens of the dwellings with surface water surrounding a number of properties to a depth of approximately 80mm (location 3 in Figure 6-8 and Figure 6-9). The responses also note that several properties were close to flooding internally with water within the curtilage and close to reaching the property thresholds.

Responses to the stakeholder engagement survey indicated that there may be inadequate or insufficient drainage along Sleepers Hill that may have contributed to this although it should be noted that these areas are at a significantly higher elevation than Wentworth Grange. It was also noted that the drains appeared to cope with the water at first, before being overwhelmed.

Figure 6-8: Source-Pathway-Receptor mapping for Wentworth Grange and Sleepers Hill on 27 August



PHOTOS REDACTED

6.6 Browning Drive and Wordsworth Close

6.6.1 Source

Responses to the stakeholder engagement survey indicate that the source of the flooding was surface water runoff following intense rainfall. These responses (outlined in Section 5.1.2) identified that intense rainfall occurred from 16:45 – 17:20, this was closely followed by surface water flooding which occurred from 17:10 – 17:15 and lasted for approximately 20 to 30 minutes.

The topography of the area is steep and ranges from approximately 97m AOD at the top of Shelley Road to 88m AOD at the junction with Browning Drive. Browning Drive Slopes from both the north and south side, with the lowest point in the road at the position of numbers 6 and 8. Responses to the stakeholder engagement survey indicate that the source of flooding was surface water runoff from roads.

6.6.2 Pathway

The stakeholder engagement surveys indicate that surface water runoff originated from the surrounding roads, including Shelley Close (location 1 in Figure 6-10) and Byron Avenue (location 2 in Figure 6-10), this runoff flowed to the lowest point in the area at the centre of Browning Drive where survey responses indicated that the highway drains were unable to cope with the volume of water. Water continued to pool in the centre of Browning Drive before overtopping the kerb, causing internal flooding to at least one property on Browning Drive (location 3 in Figure 6-10). Surface water cascaded down the side of these properties into the rear gardens of properties in Wordsworth Close (location 4 in Figure 6-10), before flowing out onto Wordsworth Close.

These responses also noted that subsequent investigations of the condition of the highway drainage system in Browning Drive determined that these were not blocked. They also note that this is a recurrent issue and highway flooding has occurred several times a year since at least 2010 and has occurred following the incident. Browning Drive and Wordsworth Close, including the affected properties are within surface water flow paths as predicted on the Risk of Flooding from Surface Water mapping.

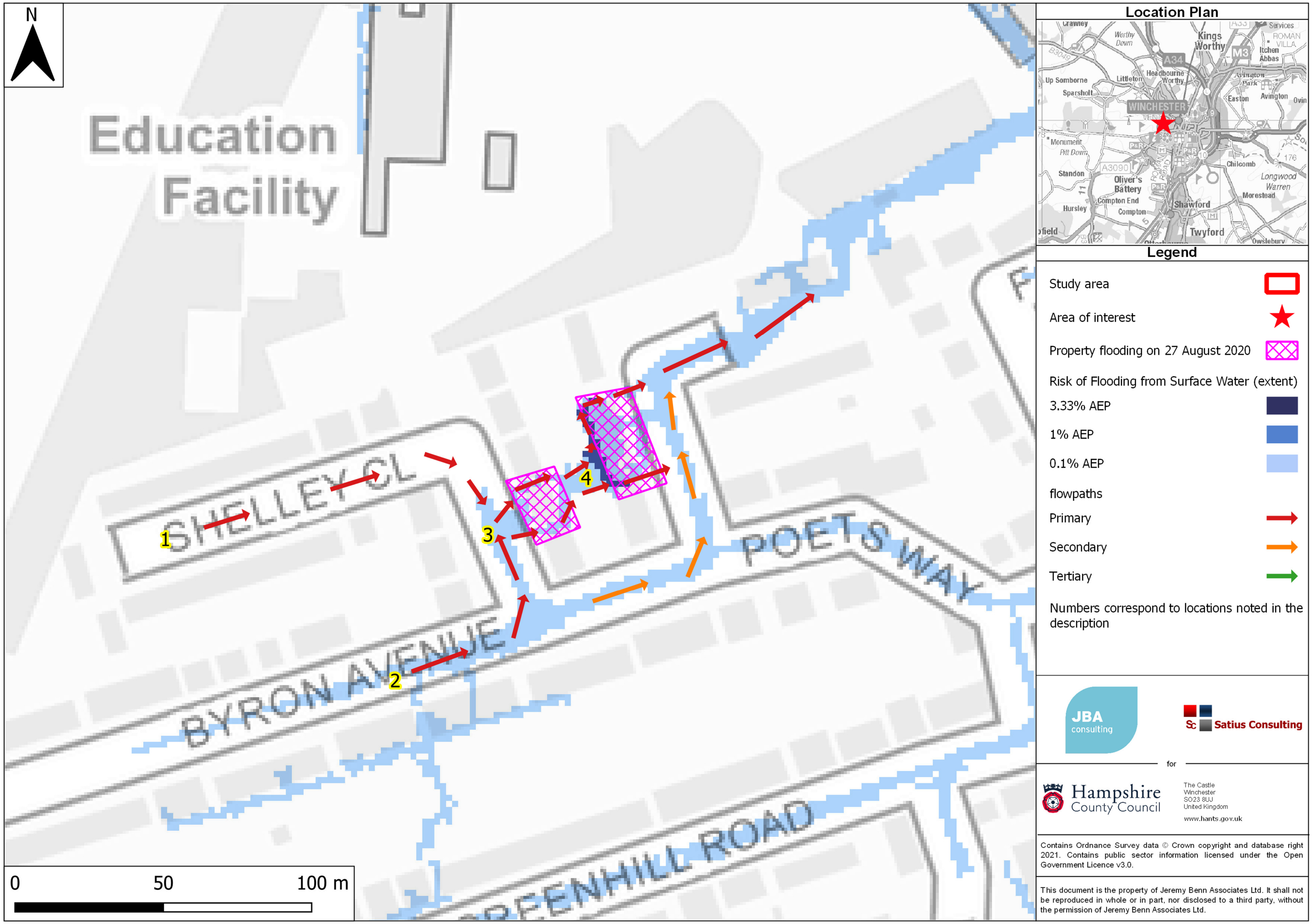
6.6.3 Receptor

Internal property flooding impacted at least two properties along Browning Drive and Wordsworth Close in the west of Winchester. The driveways of properties along Browning Drive slope down from the road, as a result surface water runoff flows towards these properties once it overtops the pavement. This caused flooding to a garage and ingress into the adjoining property through an internal wall. Water also pooled at the front of these properties and was noted to be close to entering through the front door.

In Wordsworth Close, surface water runoff flowing from Browning Drive pooled at the rear of properties and was noted to have reached almost 700mm depth before entering through a patio door and causing internal flooding.

This flooding has led to one resident having to temporarily move out and has caused damage to carpets and flooring. In at least two cases, action by residents to bail water out of driveways and clear private soakaways prevented additional internal property flooding. Residents have also bought sandbags in an attempt to mitigate future flooding.

Figure 6-10: Source-Pathway-Receptor mapping at Browning Drive and Wordsworth Close on 27 August



6.7 Weeke Pond – Stockbridge Road

6.7.1 Source

The source of the flooding to the property in the vicinity of Weeke Pond, was the pond overflowing during the event. This was due to the high volumes of surface water runoff generated during the event on 27 August.

Weeke Pond has existed for roughly four hundred years and was previously poorly maintained. It is understood that WCC undertook a full restoration in 1995 and the Weeke Pond Improvement Scheme has won multiple awards[16]. This scheme included the installation of petrol interceptors and mapping from HCC indicates that there is connectivity between the pond and the highway drainage system and it is understood that the pond is fed entirely from surface water runoff from the highway.

6.7.2 Pathway

Stockbridge Road has a significant gradient and this would have led to the generation of large volumes of surface water runoff during the event on 27 August. Furthermore, the Risk of Flooding from Surface Water mapping indicate that additional flows could have originated from Westley Close in the South. As there is connectivity between the highway drainage and the pond, it is likely that water levels in the pond would have risen rapidly with these flows exceeding the outflow capacity of the pond and led to overtopping. Stockbridge Road up to Butts Close south of the pond are also at a higher elevation than the pond, this would have resulted in additional surface water flows pooling in the pond. (location 3 in Figure 6-12)

Once flows overtopped the pond, this led to flooding of Stockbridge Road (Figure 6-11 and location 1 in Figure 6-12) which would have flowed downslope towards Cranworth Road. The highway drainage in this location would also have become surcharged, preventing any additional flows from being drained. The pond is at a higher elevation than houses on the north side of the road, flows from the pond followed the topography through the garden of the property before causing internal flooding (location 2 in Figure 6-12).

6.7.3 Receptor

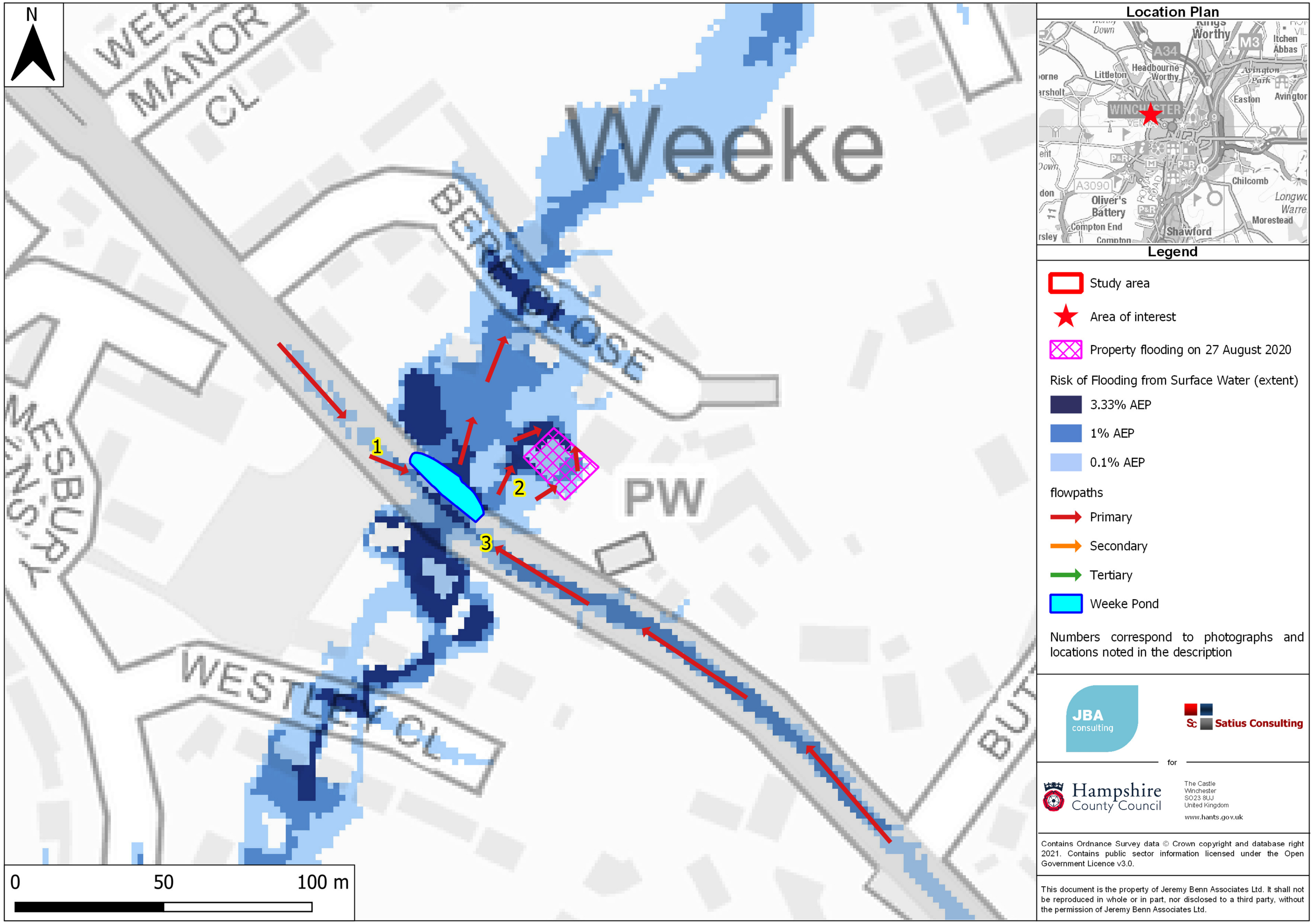
One property is understood to have been internally flooded due to flows from Weeke Pond and it is noted that this property is lower than the elevation of the pond. Responses to the stakeholder engagement survey indicate that external flood depths were approximately 200 – 300mm. Internal flood depths were noted to be approximately 50mm with damage occurring to the entire ground floor.

16 St Barnabas West Neighbourhood Design Scheme (2007)

Figure 6-11: Flooding to Stockbridge Road from Weeke Pond (left) on 27 August

A number of other properties are also known to have flooded along Stockbridge Road or adjoining roads, including properties along Western Road and Dean Lane. These properties are all within surface water flood extents as predicted by the Risk of Flooding from Surface Water mapping.

Figure 6-12: Source-Pathway-Receptor mapping for Weeke Pond, Stockbridge Road



6.8 Other areas of Winchester

As shown in Figure 6-1, there were other more localised instances of surface water flooding on 27 August that led to internal property flooding or flooded significant lengths of the public highway, in addition to the areas outlined in the previous sections. A list of affected locations has been provided below, however detailed source-pathway-receptor mapping was not developed for these areas as there was insufficient information to develop a detailed understanding of the flood mechanisms.

Based on the data collected during the flood investigation, a summary of the flooding is provided in the following sections. Please note that this does not include every instance of property flooding identified on 27 August. In many of these cases there is limited information available.

Localised instances of internal property flooding occurred in a number of other locations across Winchester, these include but are not limited to the following locations:

- St Cross Road;
- Loyd-Lindsay Square;
- Jewry Street;
- Olivers Battery Road North; and
- City Road.

6.8.1 St Cross Road

The stakeholder engagement survey received one report of internal property flooding at St. Cross Road, due to runoff from surrounding areas and the exceedance of drainage assets in St. Cross Road. An additional report of highway flooding at the junction of St. Cross Road and Mead Road was raised as an issue during the event, the report stated that the junction at this location floods regularly.

6.8.2 Loyd-Lindsay Square

A property in Loyd-Lindsay Square is known to have flooded internally due to surface water runoff. It was noted that drains were not able to cope with surface water runoff during the event. There are no further details on the flooding at this property and the RoFSW mapping does not show this area to be at risk of flooding from surface water.

6.8.3 Jewry Street

At least one commercial property along Jewry Street flooded internally during the event. It is understood that the property thresholds are at pavement level for accessibility. Residents have raised concerns that this may have been exacerbated by raising the road levels as a result of resurfacing works.

6.8.4 Olivers Battery Road North

Olivers Battery Road North flooded during the event, with several properties experiencing curtilage flooding. It is unknown whether any of these properties were flooded internally, however Hampshire Fire and Rescue Service are known to have provided emergency assistance at this location. No further details are available at this location.

6.8.5 City Road

The junction between City Road, Andover Road and Stockbridge Road outside The Albion was known to have flooded during the event. However there is no internal property flooding known to have occurred as a result of this. Although the RoFSW mapping only shows this area to be within the 0.1% AEP extent, it is likely this is a result of minimal flow passing through the Stockbridge Road tunnel, which may not be representative of flood risk.

Figure 6-13: CCTV footage showing flooding on City Road on 27 August

7 Conclusions and Recommendations

7.1 Conclusions

JBA has collated data from a wide range of sources which indicates that at least 52 properties (Table 5-1) suffered some degree of internal flooding on 27 August, with significantly more likely to have been affected (based on stakeholder engagement – section 3.3). In some cases, as with Hampshire Fire and Rescue Service callouts, details of the incidents are unknown and the investigation has been unable to corroborate whether some of these properties were flooded internally. The flooding that occurred on 27 August 2020 impacted a number of residential and commercial properties throughout Winchester, although primarily in the High Street, Cranworth Road and Harestock.

The source of this flooding was surface water runoff immediately following an intense rainfall event. Lead Local Flood Authorities (HCC) are responsible for managing surface water flood risk, although they have no remit to conduct an emergency response. HCC exercised their powers to undertake a Section 19 investigation as the event on 27 August fulfilled its criteria of 'significant flooding'.

This runoff was rapidly conveyed as high velocity sheet flow on the public highway, which was exacerbated due to the steep topography and high degree of urbanisation in the city. Surface water pooled in low spots such as the Broadway and Cranworth Road, where the depth of water was sufficient to cause internal property flooding.

Evidence collected during the stakeholder engagement exercise indicated that surface water flooding receded relatively quickly. This indicates that surface water flooding was the result of an exceedance of the design capacity of surface water drainage systems and was unlikely to be the result of blockages.

Due to the rapid onset of the flooding, there was only time to mobilise for a limited emergency response, with 21 properties across the city receiving emergency assistance from Hampshire Fire and Rescue Service. However, Hampshire County Council as both the LLFA and Highway Authority, and Winchester City Council took a number of actions following the event, including emergency maintenance for on highway drainage systems, clearance and commissioning the Section 19 investigation.

Analysis of rainfall rarity on 27 August determined that the storm event was between a 1 in 29 and a 1 in 42-year event. This is a more extreme event than highway drainage systems are typically designed for[17], and slightly more extreme than surface water sewer systems are typically designed for[18], as a result these drainage systems could not reasonably be expected to manage surface water flows associated with this event. Furthermore, the rapid drain-down following the flooding suggests that these drainage systems were functioning and that these systems suffered a hydraulic overload due to the volume of water rather than from a blockage.

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17 CIRIA C635 (2006) 'Designing for exceedance – good practice' (Table 3.1)

18 Sewers for Adoption 8 9draft): https://www.water.org.uk/wp-content/uploads/2018/10/SfA-8-Master-2.pdf

7.2 Potential mitigation options

A range of potential options that may help to mitigating the causes or impacts of the flooding have been considered here. In identifying these options, the causes and mechanisms of the flooding have been taken into account. These options have not been appraised as part of the Section 19 investigation and further work would be required. In identifying these options, we have not considered relative costs and timescales, buildability, health, safety and environment, stakeholder perceptions and public acceptability or land ownership.

7.2.1 Improved asset maintenance regimes

The main cause of the flooding has been identified as intense rainfall leading to overland flow, which likely exceeded the design capacity of highway drainage systems. However, gully clearance and regular maintenance checks are important in ensuring quick and effective drainage of surface water. Gullies may become blocked from falling debris or materials being washed into them, including soil, waste and leaves, reducing their drainage capacity.

It is important to note that the difficulty in preventing gully blockages often requires a reactive approach to be taken to tackle these problems. Blockages may be worsened due to bad weather, time of year, poor usage and damage. The site visit on 11 January (Section 5.4) noted a number of gullies in the High Street and Harestock that appeared to be blocked with silt, more frequent cleansing in specific areas such as the High Street could improve their performance and reduce residual flood risk.

A recommendation for increased gully maintenance and clearance in priority areas could help mitigate surface water flood risk to properties, by reducing the amount of water pooling on roads. Areas of interest for improved maintenance include:

- The High Street and adjoining roads;
- Cranworth Road/ Stockbridge Road; and
- Harestock.

7.2.1 Improved asset mapping

Meetings with the Highway Authority identified a number of instances where the Highway Authority was not aware of the presence of assets. This could lead to potential issues with lack of maintenance exacerbating or causing flooding issues if left unaddressed. Where new or previously unknown drainage assets are identified, it is recommended that these assets mapped and included in the relevant maintenance schedules. It has been confirmed that this action is already being undertaken.

7.2.1 Property Flood Resilience measures

Property Flood Resilience (PFR) can provide effective products and measures, at an individual property level, to reduce the impact of future floods, by either aiming to limit water entry (resistance) or by adapting the internal fabric of the property to limit damage (resilience).

Although resistance measures are not able to entirely prevent flood water ingress, they aim to limit damage and ensure properties are adapted to cope with the impacts of floods and recover quickly from these disruptive events. They are generally significantly lower in cost than resilient adaptation works to the property fabric itself, whereby flood water entering a property would lead to minor or no damage. While constraints of both approaches include funding, homeowner willingness and individual property structural risks, the lower cost and less invasive resistance measures will often meet business case cost/benefit approval for Government funding support for community schemes in areas where flood risk is high.

During the site visit (Section 5.4), it was noted that a small number of properties in Winchester were already utilising reactive measures such as flood barriers, although the majority were reliant on sandbags which are not considered to be effective at preventing the ingress of flood water.

The use of PFR in Winchester is suggested due to its potential to improve the resilience to a number of residential and commercial properties where surface water flood risk is high and where there may be limited space to incorporate large volumes of surface water storage. This is particularly evident in the High Street and Cranworth Road (Section 6) where there is no space to incorporate large scale storage features such as basins along the main conveyance routes for surface water flows and where the steep slopes make it difficult to design these types of features.

7.2.2 Community preparation and resilience

Residents should find out about any flood risk in the area and make a written plan of how they will respond to a flood situation. There are measures that can be taken to reduce the amount of damage caused by flooding and properties at risk should be insured.

Local residents can **find out if their property is at risk**[19], prepare for flooding, and get help during and after a flood. The Environment Agency has prepared a template to produce **Personal Flood Plans**[20] on their website, these can assist residents with preparing for flood events in advance.

Communities can work together to improve their resilience and plan for flood events. Both **Hampshire County Council**[21] and **the National Flood Forum**[22] has resources to assist communities with planning and preparing for flooding, this could include setting up a Flood Action Group.

7.2.3 Disconnecting roof water drainage

Disconnecting existing downpipes and redirecting surface water runoff into rain gardens, above ground water butts or underground rainwater harvesting tanks, could relieve pressure on existing surface water drainage systems and provide sustainability benefits as a result of water re-use. This option could be used alongside street scale SuDS retrofit options in the High Street, which is currently completely impermeable.

Rainwater can be reused for non-potable purposes such as gardening, toilet flushing and car washing with water butts. Water butt sizes can range from a small 100l tank up to 22,000l. They can be provided in a variety of shapes and incorporated into a variety of settings. Rainwater harvesting tanks are typically larger and stored underground with a pumped supply for water re-use. As their capacity is dependent on the re-use of water, both systems should be designed with an overflow to discharge excess water through infiltration or discharge to a downstream drainage component.

7.2.4 SuDS retrofit

There may be opportunities to retrofit Sustainable Drainage Systems (SuDS). The use of SuDS techniques could reduce surface water flood risk to properties by freeing up capacity in existing surface water drainage systems, allowing these drainage systems to manage surface water flows more easily. Due to the high degree of urbanisation in Winchester, opportunities to retrofit SuDS to reduce surface water flood risk may be limited to source control techniques such as rain gardens, tree pits and permeable paving (Appendix B).

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19 Long term flood risk for England: https://flood-warning-information.service.gov.uk/long-term-flood-risk

20 Personal flood plans: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/444659/LIT_4112.pdf

21 HCC Prepare your community: https://www.hants.gov.uk/community/emergencyplanning/prepareyourcommunity

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

Analysis of the flood event and source-pathway-receptor analysis (Section 6.2) indicated that surface water runoff flowed down the High Street as sheet flow and that surface water drainage systems suffered a hydraulic overload in the High Street. The use of SuDS features in the High Street could free up capacity in these drainage systems, which can be considered completely impermeable at present, enabling these drainage systems to more easily cope with the volumes of surface water runoff generated during extreme events. In addition, incorporating SuDS features into the High Street could also lead to amenity and biodiversity value.

Source-pathway-receptor mapping in (Section 6.4) indicates that Bradley Road provided a primary conveyance route for surface water flows (Figure 6-6), that led to internal property flooding in Harestock. There is a large playground along Bradley Road in Harestock that could potentially be utilised as a storage area for surface water runoff from Bradley Road (Appendix A). Source-pathway-receptor mapping indicated that this flow path directly led to flooding in Priors Dean Road on 27 August, with flows continuing downslope and causing flooding to properties in Grayshott Close and Buriton Road. Use of playgrounds as multi-use SuDS features is considered an acceptable approach[23], although permission would be required from the landowner, signage indicating the intended multi-functional use would also be required.

7.2.5 Review of existing surface water mapping

The source-pathway-receptor mapping identified a number of areas where the Risk of Flooding from Surface Water mapping inaccurately represented surface water flood risk. These included cases within Winchester where surface water appeared to be flowing off bridges into the railway cuttings leading to smaller flood extents downslope. There were also cases where road tunnels under the railway were not correctly modelled, leading to additional flows pooling in Cranworth Road more than would be expected. These issues with the surface water mapping are outlined in Appendix C.

A review and 'health check' on existing surface water mapping would indicate where these inaccuracies are, with a view to consider enhancing the current Risk of Flooding from Surface Water mapping in Winchester, allowing HCC and WCC to improve their understanding of surface water flood risk.

Examples of enhancements to the existing Risk of Flooding from Surface Water mapping could include the following:

- Climate Change uplifts;
- Incorporating recent LIDAR DTM into the model;
- Hydrology update to FEH 2013;
- Update to roughness grid (based on current MasterMap and new development areas);
- Updated loss values in urban areas (based on current MasterMap and new development areas);
- Replacements of DTM edits with culverts (based on LLFA asset information).

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23 CIRIA C753 SuDS Manual (chapter 22, p. 479)

7.2.6 Surface water flood forecasting

Surface water flooding occurred rapidly on 27 August, and there was insufficient time for emergency responders to mobilise for an emergency at the time of the event. A flood forecasting system for surface water flooding could be set up to deliver advance warning of potential surface water flooding in Winchester. This would require access to live rainfall radar data for the area, in addition to a flood forecasting system to determine the likelihood of surface water flooding occurring. This could enable emergency responders to provide a more rapid response to surface water flooding, installation of PFR measures, and for asset managers to undertake pre-emptive maintenance works.

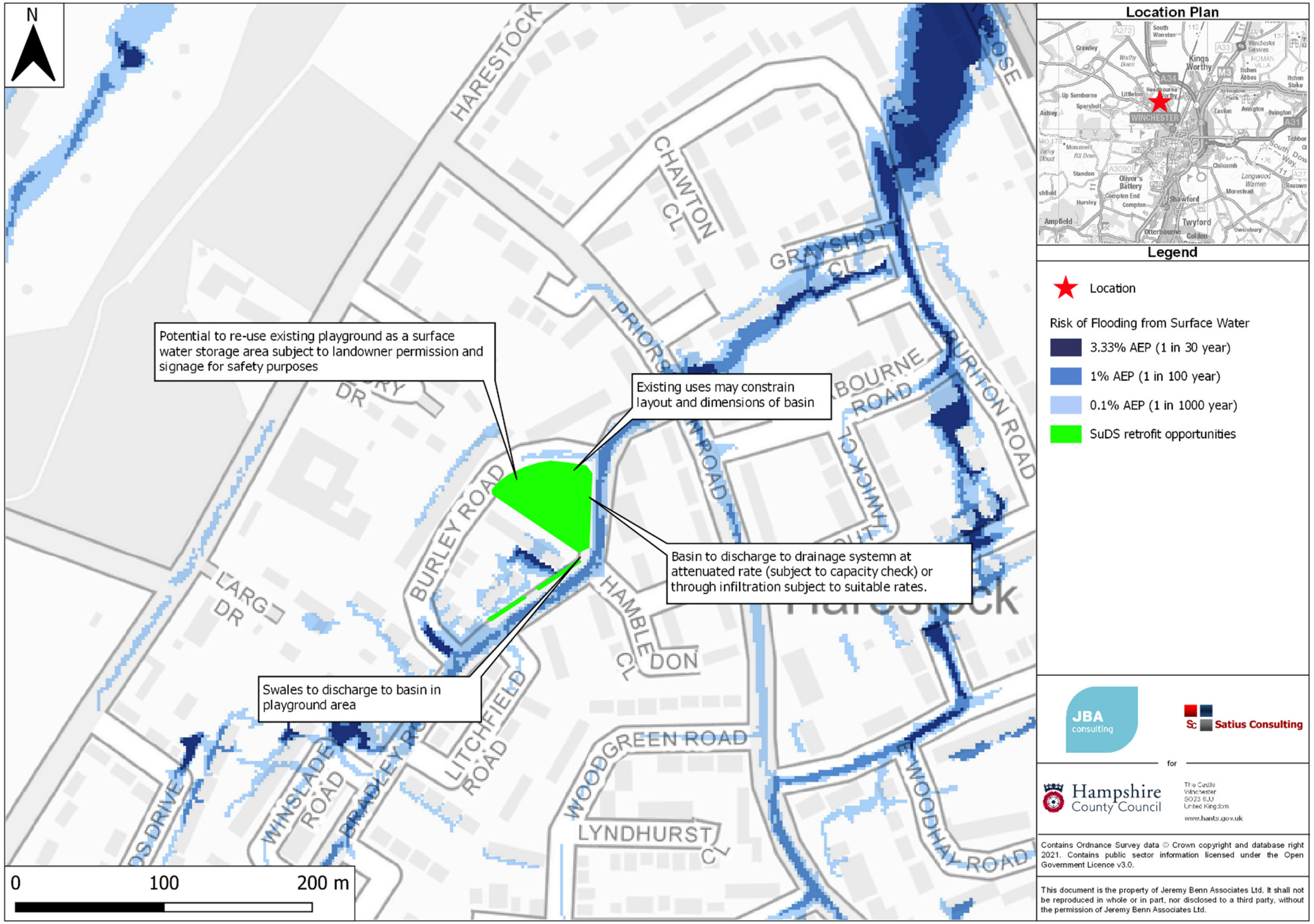
7.2.7 Other potential mitigation options

In addition to the mitigation options identified above, other potential options that could mitigate the causes and impacts of flooding have been identified:

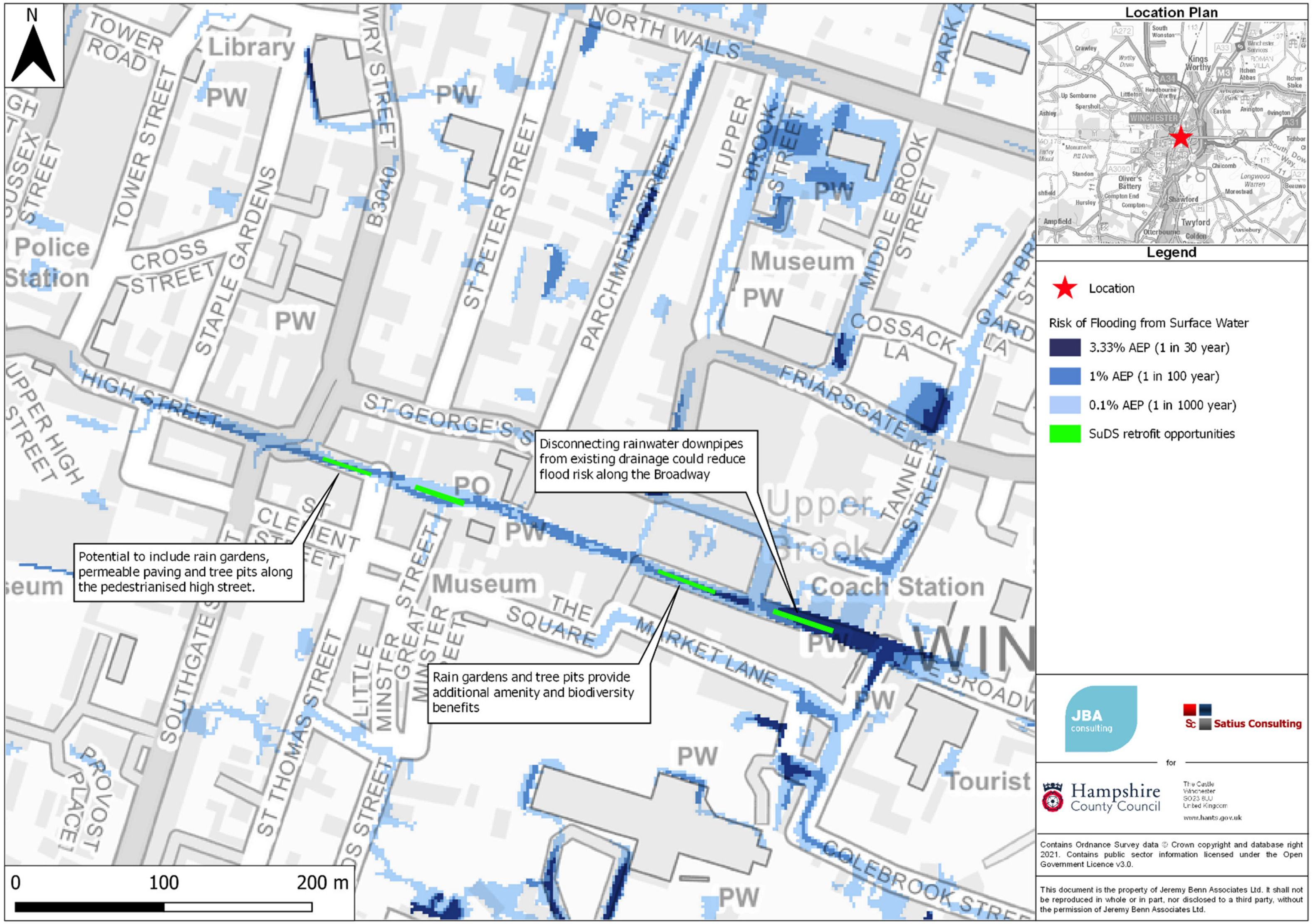
- Increasing the capacity of the highway drainage system at targeted locations;
- Localised kerb raising to improve conveyance of surface water flows on the highway;
- Extend the High Street drainage improvement works to the Broadway.

Appendices

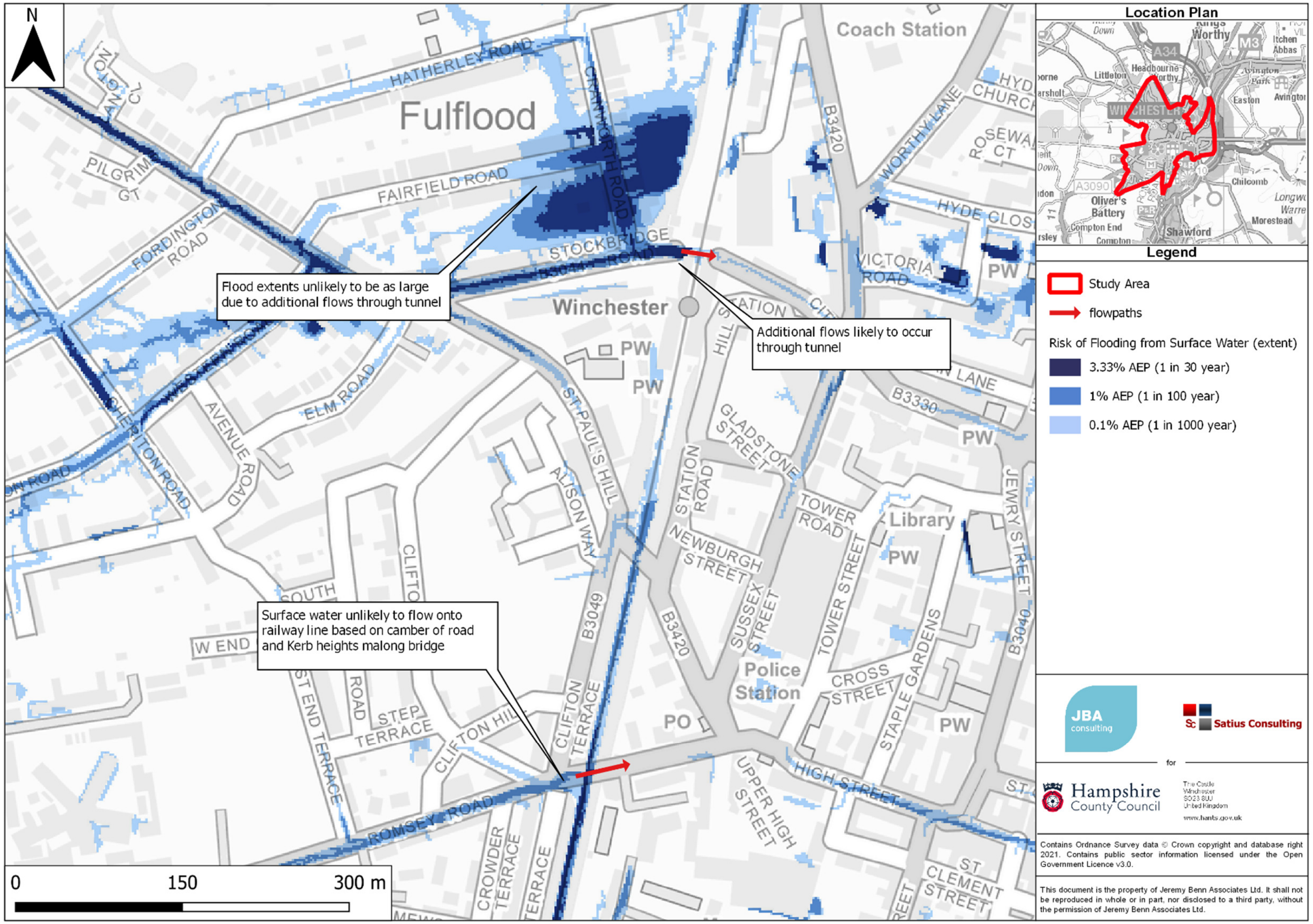
A SuDS retrofit options in Harestock



B SuDS retrofit options in Winchester High Street



C Inaccuracies in existing surface water mapping



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