Submitted to
Wirral Borough Council

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Wirral Borough Council:

Section 19 Flood Investigation: 22nd August and 2nd September 2015

May 2016

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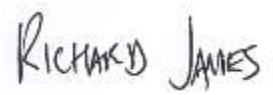

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List of Acronyms

AEP	Annual Exceedance Probability (%)
DCWW	Dŵr Cymru Welsh Water
EA	Environment Agency
FWMA	Flood and Water Management Act 2010
LLFA	Lead Local Flood Authority
mAOD	meters Above Ordnance Datum
MFR	Merseyside Fire and Rescue Service
MP	Merseyside Police
NGR	National Grid Reference
NWAS	North West Ambulance Service
RMA	Risk Management Authority
UU	United Utilities
WBC	Wirral Borough Council

1 Non-Technical Executive Summary

Introduction

As the Lead Local Flood Authority Wirral Borough Council has a responsibility to record and investigate flooding incidents in accordance with Section 19 of the Flood and Water Management Act (2010).

Section 19 of the Flood and Water Management Act states:

1. On becoming aware of a flood in its area, a LLFA must, to the extent that is considers it necessary or appropriate, investigate:

    a. Which Risk Management Authorities have relevant flood risk management functions, and

    b. Whether each of those Risk Management Authorities has exercised, or is proposing to exercise, those functions in response to the flood.

2. Where an authority carries out an investigation under sub-section 1 (above) it must:

    a. Publish the results of its investigation, and,

    b. Notify any relevant RMAs in accordance with Section 19(2) of the Flood and Water Management Act.

This Section 19 Flood Investigation has been prepared for the flooding events of the 22nd of August 2015, the 2nd September 2015 and the intervening period. Further detail about the legislative and policy context is presented within Chapter 2 of this report.

Event Background

On 22nd August 2015 intense rainfall fell across the south-east of the Wirral from Rock Ferry through to Bromborough and Bebington. This event resulted in localised flooding which resulted in road closures and disruption to a number of critical transport routes including the entrance to the Mersey Tunnel.

On the 1nd September 2015 severe rainfall fell for 48 hours across the wider Wirral Peninsular. This consequently led to significant flooding on the morning of the 2nd September, with significant numbers of property damages occurring around (but not limited to) the urban areas of Moreton, Greasby, Pensby, Irby and Thingwall.

A significant amount of data has been collated from the risk management authorities, stakeholders and residents of Wirral to inform this Section 19 Flood Investigation. This data has also been used to determine the number of properties that were flooded during the two events. The key summary statistics are shown in the table below.

Type of Flooding	Date of Flooding			
	22 August	**2 September**	**Unconfirmed Date**	**Totals**
Internal Flooding	7	73	3	**83**
External Flooding	3	57	15	**75**
Unconfirmed	10	138	146	**294**
Totals	**20**	**268**	**164**	**452**

As the table above shows, there were 452 reports of flooding submitted to local authorities and the emergency services between these two dates. Of these 452 reports, 7 can be confirmed as corresponding with internal property flooding on the 22nd August 2015 and 73 on the 2nd September 2015. Given the number of properties flooded and the impact on critical

infrastructure these incidents are considered to be significant flood events that require further investigation under Section 19 of the Flood and Water Management Act.

Further information about the background weather conditions and flood incident details are presented within Chapter 3 of this report.

Causes of the Flooding

Consultation has been undertaken with the relevant local authorities, agencies, project partners and local residents. As part of the consultation process, site visits were also undertaken to gather information directly from residents and to establish the causes of the flooding in the affected areas. Residents were also invited to provide input into the Flood Investigation via an online survey that was co-ordinated by Wirral Borough Council. The data and information collected in this process has been used to inform the understanding of the historic flooding mechanisms for the two significant flood events.

Further detail about the consultation and data collection undertaken for the Flood Investigation is presented within Chapter 4 of this report.

Surface Water Flooding

The rainfall that fell on the 1st and 2nd of September 2015 was severe, amounting to a total depth of 93mm in 48 hours. This depth and intensity of rainfall has an annual probability of occurrence of 1 in 86. The severity and intensity of the rainfall led to significant surface water flooding across the Wirral as water was unable to infiltrate into the ground. This was particularly problematic in the areas around Coronation Park, Rigby Drive and Arrowe Road in Greasby, leading to localised and severe property damages. In many areas the surface water issues combined with sewer flooding.

Sewer Flooding

United Utilities and Welsh Water have a duty to provide and maintain a system of public sewers so that the areas for which they are responsible are effectually drained (Water Industry Act, 1991). Sewerage systems are not, however, designed to accommodate flows from severe weather events. During severe weather the capacity of the sewerage network may be exceeded and result in localised surcharging and/ or flooding. UU classify severe weather as rainfall that has an annual probability of occurrence of 1 in 20 or greater.

Given the intensity and severity of the rainfall on both significant flooding incidents, the capacity of the sewer networks was exceeded in multiple locations across the Wirral Peninsular. This consequently led to localised flooding of highways which, in places, resulted in the flooding of residential properties. This was particularly prevalent in the urban areas of Bebington, Bromborough, Greasby, Irby, Pensby and Thingwall. The severity of the sewer flooding was also impacted by high river levels as drainage systems were unable to effectively discharge.

River Flooding

The significant depth and duration of rainfall resulted in elevated water levels within the Wirral's river systems. In some areas this resulted in localised river flooding at areas including Moreton and the North Cheshire Trading Estate. The river flooding that occurred was heavily compounded by a combination of surface water and sewer flooding.

Combination Flooding

One of the most significant causes of the flooding on the 2nd September resulted from multiple flooding mechanisms occurring and interacting dynamically. Moreton in particular was severely affected by surface water, sewer and river flooding interacting. In brief this interaction can be summarised as follows:

- The intensity of the rainfall was unable to infiltrate into the ground, resulting in surface water flooding.
- The design standard of the local drainage networks was exceeded by the severity of the rainfall.
- Water levels rose within the rivers, preventing the local drainage networks from discharging.
- River flooding later exacerbated the flooding from surface water and sewers.

As the 2nd September flooding demonstrates this combination of flooding mechanisms is technically very difficult to predict and develop effective flood warnings. The management of combined flooding mechanisms also requires input from all of the Risk Management Authorities as it cannot be attributed to a single source.

Local Authority Response

All of the Risk Management Authorities and Emergency Services in the Wirral played a part in the flood incident response to the flooding events. Whilst all agencies and authorities were proactive in their response to the 2nd September flooding incident, the following issues have been identified as impacting upon the effectiveness of the incident response:

- There was limited (if any) warning before the flooding occurred.
- When the flooding did occur it happened very rapidly, leaving little lead time to mount an effective response.
- Information about the scale and severity of the flooding was slow to surface and reach key decision-makers.
- The response of the risk management authorities and emergency services was impacted by the gradual exchange of information and finite availability of resources.
- Misconceptions about roles and responsibilities of the different agencies impacted on the effectiveness of the flood incident response and the resilience of the affected communities.

Lessons Learnt

The review of the flood incident response and impacts of the flooding has been used to identify areas that could be improved in the future. Specifically, the following areas for improvement have been identified:

- Improving communications and contingency planning (i.e. continuing to develop Wirral's Multi-Agency Flood Plan);
- Improving community resilience to repeat events (i.e. through the promotion of local flood action groups); and,
- Improving the understanding of combined flooding mechanisms (i.e. through undertaking further appraisal);

Further assessment of the flood incident response and lessons learnt are detailed within Chapter 6 of this report.

Action Plan

Following this review, a number of actions have been identified to assist with the ongoing flood management across Wirral. Many of the actions should be implemented by Wirral Borough Council along with United Utilities, the Environment Agency, riparian owners, residents and other stakeholders. A number of site-specific and strategic recommendations are made within this report.

The flooding questionnaire undertaken in this Flood Investigation has also shown that many residents consider themselves relatively unprepared or are unaware of the risks of flooding. Many of the actions in the future should therefore continue to promote the growth of community-level resilience to flooding through increasing awareness of flood risk and the provision of resources to help foster local flood action groups.

2 Introduction

2.1 Background

Section 19 (1) of the Flood and Water Management Act (FWMA, 2010[1]) places a duty on Lead Local Flood Authorities (LLFAs), including Wirral Borough Council (WBC), to investigate flood incidents from surface water, groundwater and ordinary watercourses[2], where it considers it 'necessary and appropriate'.

Section 19 of the FWMA states that:

a. On becoming aware of a flood in its area, a LLFA must, to the extent that is considers it necessary or appropriate, investigate:
   i. which risk management authorities (RMAs) have relevant flood risk management functions, and
   ii. whether each of those RMAs has exercised, or is proposing to exercise, those functions in response to the flood.

b. Where an authority carries out an investigation under sub-section (1) it must:
   i. publish the results of its investigation, and
   ii. notify any relevant RMAs in accordance with Section 19(2) of the FWMA.

The FWMA (Section 6 (13)) states RMAs to be:

- The LLFA (WBC) and neighbouring LLFAs;
- The Environment Agency (Environment Agency);
- Internal Drainage Boards (not applicable within WBC);
- Water Company (United Utilities (UU) and Dŵr Cymru Welsh Water (DCWW)) as the sewerage undertaker;
- Highways Authority (WBC).

2.2 Criteria for Investigating Flooding Incidents

In agreement with all Merseyside Local Authorities, WBC, who acts as LLFA for the Wirral area, investigates flooding under Section 19 where it meets criteria which define the flooding as 'significant'. A flooding investigation is deemed significant if it:

- Caused internal flooding to 8 or more residential properties / business premises within a kilometre square area;
- Flooded one or more items of critical infrastructure e.g., a pumping station, an emergency services station, electricity substation, hospital, etc.;
- Caused a transport link to be totally impassable for a significant period:
  - Category 1 highways (motorways) and rail links – 1 hour or more;
  - Category 2 and 3a highways – 2 hours or more;
  - Category 3b, 4a, 4b highways – 4 hours or more.

Where an investigation has been undertaken following a significant flood event, WBC will prepare a report. The report detailing the investigations and resulting actions will be produced in an appropriate format and published on the Council's website.

Following the above set of criteria, it was deemed necessary to complete a Flood Investigation due to the significant numbers of flood incidents reported across the Wirral on 2nd September 2015, including flooding to property and highways. This report will also investigate flooding from the period 22nd August 2015 to 2nd September 2015 inclusive, since there were reports of sewer and surface water flooding affecting property and priority highways on 22nd August 2015 and isolated reports of flooding were received by WBC between these dates.

[1] Flood and Water Management Act 2010: http://www.legislation.gov.uk/ukpga/2010/29/contents

[2] An ordinary watercourse includes every river, stream, ditch, drain, cut, dyke, sluice, sewer (other than public sewer) and passage through which water flows which does not form part of a Main River.

2.3 Risk Management Authority Duties and Responsibilities

The legal framework for managing flooding lies with a number of different agencies; the key responsibilities for each are outlined below. Reference should be made to the relevant legislation for further information.

2.3.1 Wirral Borough Council (LLFA)

WBC, as the LLFA, has a strategic overview role and a responsibility to investigate flood incidents from surface water, groundwater and ordinary watercourses where it is considered necessary and appropriate. As part of this role, WBC hold Operational Flood Group Meetings with the RMAs to discuss and report on flood management.

WBC has a consenting and enforcement responsibility for ordinary watercourse regulation for those ordinary watercourses within the administrative area.

The FWMA outlines that the LLFA has powers to designate structures and features that affect flooding in order to safeguard assets that are relied upon for flood risk management of surface water, groundwater and ordinary watercourses. Once a feature is designated, the owner must seek consent from the authority to alter, remove or replace it (FWMA Schedule 1, Section 1).

WBC as the Highway Authority also has the duty to maintain adopted highways within their administrative area under Section 41 of the Highways Act 1980[3]. Highway maintenance includes that of the road drainage networks (drains and gullies).

Under the Civil Contingencies Act (2004)[4], WBC are a Category 1 Responder and therefore have the duty to put in place emergency plans and assess local risks to inform the emergency planning. WBC are also required to make information available to the public about civil protection matters and maintain arrangements to warn and advise the public in the event of an emergency.

2.3.2 Environment Agency

The Environment Agency has a strategic overview role and responsibility to investigate flooding from Main Rivers and the sea. The Agency also has permissive powers to carry out emergency or maintenance work on Main Rivers[5] under Section 165 of the Water Resources Act (1991)[6].

The FWMA outlines that the Environment Agency has powers to designate structures and features that affect flooding in order to safeguard assets that are relied upon for flood risk management for fluvial (Main River) and tidal sources. Once a feature is designated, the owner must seek consent from the authority to alter, remove or replace it (FWMA Schedule 1, Section 1). The Environment Agency has permissive powers to issue flood warnings communities at risk of flooding. It should be noted that is a permissive power and is not a statutory duty.

2.3.3 United Utilities & Dŵr Cymru Welsh Water

Under the FWMA, United Utilities and Welsh Water are responsible for managing the risks of flooding from their respective surface water, foul and/or combined sewer systems where the sewer flooding is wholly or partly caused by an increase in the volume of rainwater (including snow and other precipitations) entering or otherwise affecting the system.

United Utilities (UU) and Welsh Water (DCWW) have a duty to provide and maintain a system of public sewers so that the areas for which they are responsible are effectually drained (Water Industry Act, 1991)[7]. Sewerage systems are not, however, designed to accommodate flows from severe weather events. During severe weather the capacity of the sewerage network may be exceeded and result in localised surcharging and/ or flooding. UU classify severe weather as rainfall that exceeds a 1 in 20 year return period. Larger, more intense storms would therefore be expected to result in surcharging of the sewer network.

UU and DCWW are required to deliver a significant reduction in sewer flooding incidents by 2020. Their performance commitment includes flooding caused by hydraulic inadequacy of sewers, and other causes of flooding such as blockages, collapses and equipment failures. This commitment does not differentiate between the causes as they have the same impact on the customer.

[3] Highways Act 1980: http://www.legislation.gov.uk/ukpga/1980/66/contents

[4] Civil Contingencies Act 2004: http://www.legislation.gov.uk/ukpga/2004/36/pdfs/ukpga_20040036_en.pdf

[5] Main Rivers are watercourses shown on the statutory main river maps held by the Environment Agency, the Department of Environment, Food and Rural Affairs (in England) and the Welsh Assembly Government (in Wales). They can include any structure or appliance for controlling or regulating the flow of water into, in or out of the channel.

[6] Water Resources Act (1991): http://www.legislation.gov.uk/ukpga/1991/57/contents

[7] Water Industry Act (1991): http://www.legislation.gov.uk/ukpga/1991/56

UU investigates all flooding incidents that are reported to them and undertakes a verification exercise to understand the issues and flooding mechanisms. This may include a site visit and CCTV survey to determine if there were any blockages in the network. Any blockages encountered during the investigations are cleared to ensure that the sewer has maximum capacity.

2.4 Other Stakeholder Duties and Responsibilities

2.4.1 Riparian Owners

Riparian owners are those that own land or property adjacent to a watercourse. Riparian owners have a responsibility to maintain the bed and banks of the watercourse; this includes maintenance of any owned structures, such as trash screens or culverts.

Section 25 of the Land Drainage Act (1991)[8] outlines that where the flow of a watercourse is obstructed; the riparian owner is responsible to resolve the condition. Section 28 of the Land Drainage Act (1991) outlines the responsibility of the riparian owner to undertake maintenance of their watercourse if it is impeding the flow of water.

Riparian owners must let water flow through their land without obstruction and must accept flood flows through their land. Riparian owners have no duty in common law to improve the drainage capacity of a watercourse. Further information can be found in the Environment Agency's document 'Living on the Edge' (2012)[9].

2.4.2 Local Residents

Residents who are aware that they are at risk of flooding should take action to ensure that they and their properties are protected. Residents should report flooding incidents or potential problems (such as blockages) to the LLFA or appropriate organisation if known.

2.5 Consultation

Investigation of the flooding on the Wirral on 22nd August 2015 to 2nd September 2015 inclusive has been undertaken in consultation with the key stakeholders and RMAs.

The Environment Agency commenced the consultation feedback shortly after the flooding and over the following weekend, with teams out supporting the community, gathering data and inspecting Environment Agency assets.

WBC held a Multi-Agency De-brief for the significant flooding event on 2nd September 2015 at Wallasey Town Hall on Tuesday 15th September 2015. The meeting was attended by the RMAs, the Emergency Responders and other parties involved in the flooding, including WBC, EA, UU, Merseyside Police, SP Energy Networks and Magenta Living.

A community drop in session was also held at Moreton Community Centre on Wednesday 16th September 2015, with representatives from WBC, EA and UU present to speak to residents about cleaning up the damage, emergency planning and how to prepare for any future floods.

Following the appointment, AECOM undertook an independent consultation process, which commenced with collecting data from the RMA's, Emergency Responders and other stakeholders involved in the flooding. Consultation with the following parties has been undertaken:

- Wirral Borough Council;
- Environment Agency;
- United Utilities;
- Dŵr Cymru Welsh Water;
- Merseyside Police;
- Merseyside Fire and Rescue;
- North West Ambulance Service;
- Met Office;
- SP Energy Networks;

[8] Land Drainage Act (1991): http://www.legislation.gov.uk/ukpga/1991/59/contents

[9] Environment Agency (2012) Living on the edge – A guide to your rights and responsibilities of riverside ownership. http://www.environment-agency.gov.uk/homeandleisure/floods/31626.aspx

- Magenta Living.

Through the consultation process, the above parties have provided information on historic flooding and clarification of the operational response during the events.

As part of the consultation process, site visits were also undertaken to gather information directly from residents and to establish flooding mechanisms for the worst affected areas. Residents were also invited to provide input into the Flood Investigation via an online survey which was co-ordinated by WBC.

2.6 Site Description

The Wirral is located in North West England and is a peninsular bounded to the west by the River Dee, forming a boundary with Wales, to the east by the River Mersey and to the north by the Irish Sea. The peninsular is roughly rectangular and is approximately 24km long and 11km wide. The southern third of the peninsular is in the county of Cheshire and the top third, the Metropolitan Borough of Wirral, is in the county of Merseyside.

The Wirral is a mixture of large urbanised areas, and more rural towns and villages. The more heavily urbanised areas are concentrated to the north east, around the built up district of Birkenhead. The west and south of the peninsula consists of smaller towns and villages and is more rural.

3 Flood Incident Details

3.1 Overview

On 22nd August 2015 intense rainfall was also experienced in the south-east of the Wirral from Rock Ferry through to Bebington and Bromborough. There were reports of sewer and surface water flooding affecting property and priority highways, with flooding affecting critical transport routes including the Mersey Tunnel approach road and Spital Dam in Bromborough.

Just a week and half later heavy rainfall fell overnight on both the 1st and 2nd of September. Consequently many parts of the Wirral experienced flooding on the morning of the 2nd September 2015. Flooding to property and highways has been recorded from multiple sources, with widespread surface water sewer flooding across the borough. Though surface water flooding characterised the event, it also combined with ordinary watercourse and Main River flooding in Moreton and Prenton.

This section of the report details the meteorological conditions, rainfall and weather warnings during the 2nd September flood event. This review has used data supplied by the Environment Agency and the Met Office and, at the time of issue, no detailed information has been received about the conditions on the 22nd August. It has therefore not been possible to quantitatively analyse the criticality or intensity of this rainfall for this event.

3.2 Meteorological Conditions

The Met Office has provided a summary of the metrological conditions on the 2nd September 2015, which states:

> *"North-West England and North Wales saw near or below average rainfall during August, and there were no large rainfall accumulations in the area towards the end of the month which may have left ground and river conditions 'primed' for flooding. The large-scale weather pattern on the 1st and 2nd of September (below) saw a slow-moving low pressure system in the North Sea, maintaining a showery north-westerly airflow across much of the UK. This situation typically sees showers organised into bands, either in troughs perpendicular to the airflow or in convergence lines along the flow, and it is this latter, slower-moving, phenomenon which can tend to produce localised, large rainfall accumulations, especially when showers are more energetic due to daytime heating in summer, or overnight close to windward coasts due to warm seas."*

Figure 3-1 shows the North Atlantic Analysis Chart for 0600 GMT on 2nd September 2015.

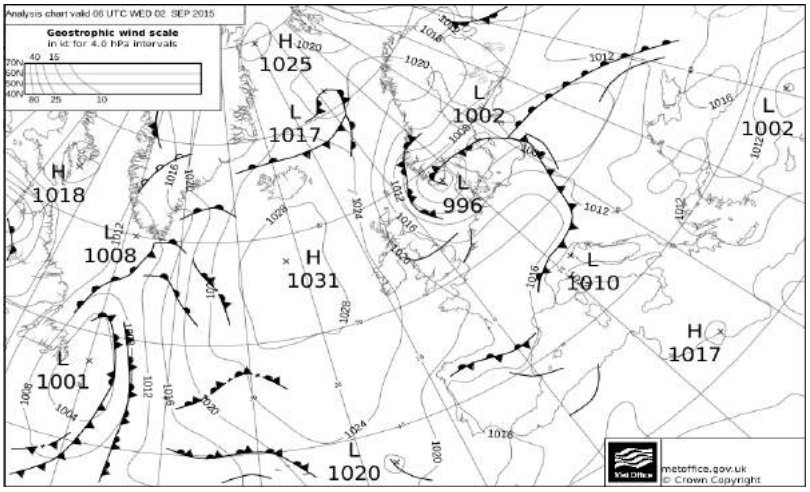


Figure 3-1 North Atlantic Analysis Chart for 0600 GMT on 2nd September

Graphic courtesy of the Met Office

3.3 Hydrometric Data

Table 3-1 provides a summary of the relevant Environment Agency hydrometric gauges within the study area.

Table 3-1 Hydrometric Gauging Stations

Name	Description	Location
Moreton TEL	Rain Gauge (15 minute intervals)	Moreton
Greasby Road	River Level Only (15 minute intervals)	Arrowe Brook
Acton Lane	Stage-Discharge (15 minute intervals)	Arrowe Brook
Davis Road	River Level Only (15 minute intervals)	River Birket
Great Culvert	River Level Only (15 minute intervals)	River Birket
Fornalls Bridge	River Level Only (15 minute intervals)	River Birket
Ford Lane	River Level Only (15 minute intervals)	River Fender

The locations of the hydrometric gauges are shown in Figure 3-2.

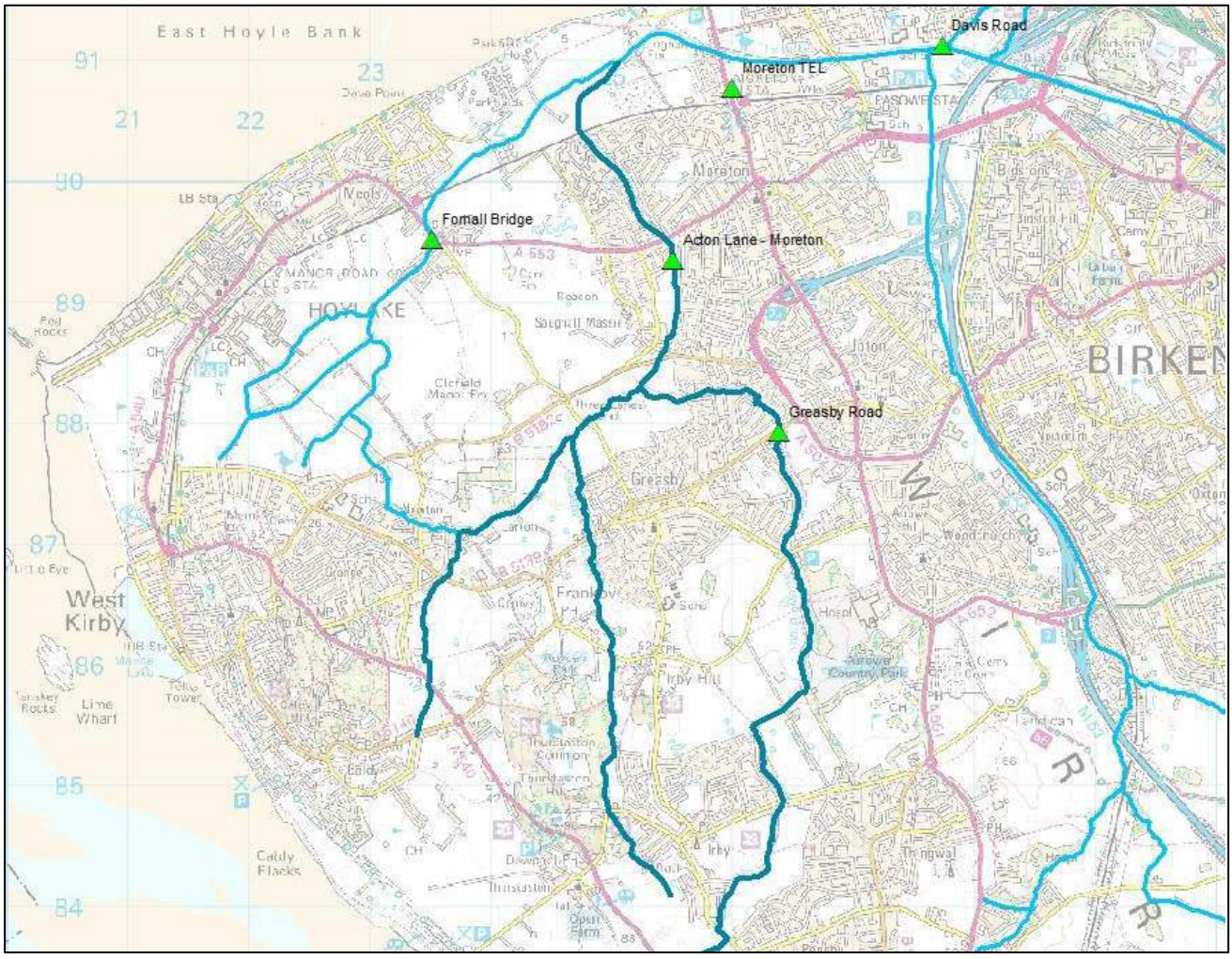


Figure 3-2 Hydrometric Sites

Graphic courtesy of the Environment Agency

3.4 Observed Rainfall

As Table 3-1 indicates, there is limited rain gauge coverage on the Wirral peninsular, with the Environment Agency operating a single rain gauge at Moreton. As rainfall is often variable over any given catchment, the post-event analysis undertaken by the Environment Agency has also used rainfall radar to supplement the analysis of the observed rainfall. Rainfall radar is widely available as both observed and forecast datasets. Whilst rainfall radar should not be considered as a direct substitute for ground based observations, it is necessary to adopt a combined approach where the rain gauge coverage may only be partially representative of the area rain fall over the study catchment.

Although the majority of the flooding occurred on the morning of the 2nd September 2015, the rainfall radar and ground based observations show that the rainfall arrived in 2 significant pulses over the study area. Based upon the combined hydrometric data, the Environment Agency estimates that:

- The first pulse of rainfall occurred after 00:00 on the 1st September, with an estimated total of 43mm in 3 hours (giving an average of 14.3mm/hr).
- The second pulse of rainfall occurred after 00:30 on the 2nd September, with an estimated total of 50.2mm in 6 hours (giving an average of 8.4mm/hr).

The use of the Moreton rain gauge alone suggests that only 38mm fell over a 12 hour period from 00:30 to 12:30 on the 2nd September (giving an average of 3.1mm/hr). This demonstrates that the rain gauge was not representative of the conditions over the wider study area and this was likely attributable to the spatial variability of the rainfall over the Wirral catchments. The rainfall radar sequence for the morning of the 2nd September highlights the spatial variability of the rainfall over the Wirral peninsular (Figure 3-3).

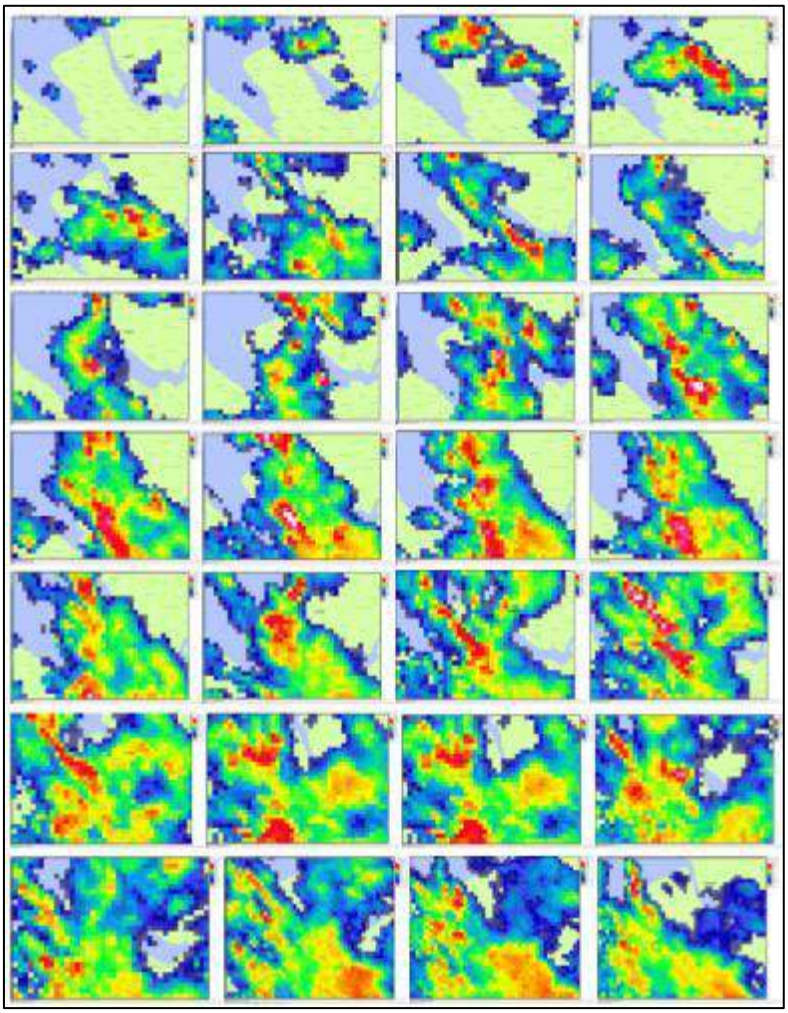


Figure 3-3 Rainfall Sequence on Wednesday 2nd September 2015 from 00:030 to 06:30 GMT (15 minute intervals)

Graphic courtesy of the Environment Agency

3.5 Rainfall Rarity

The Environment Agency has used the estimated rainfall totals presented in Section 3.4 to estimate event rarity for the flood event using the Depth-Duration-Frequency (DDF) rainfall model. DDF curves describe rainfall depth as a function of duration for given return periods at specified locations within the UK and can be reproduced using the Flood Estimation Handbook (FEH) CD-ROM. The Environment Agency state:

> *"The majority of rainfall initially fell in an isolated area to the West of the Arrowe Brook catchment and the highest rainfall intensity commenced from 31 August to 01 September from 22:00 to 01:00 (duration 3 hours) with a cumulative rainfall total of 43mm (estimated event rarity of 51 years). This would be considered localised with high intensity showery conditions. Note this preceded the main rainfall that fell on the catchment and prior to reported flooding.*
>
> *SJ 30512 80530. Main rainfall falling throughout the period of 02 September was a longer duration of 5.5 hours (50.2mm) giving a rarity of rainfall event in the order of 57 years. Time line was from 00:50 to 06:20 (02/9/2015).*
>
> ***An estimate using the 2 consecutive rainfall events over the 48 hour period using the radar data gives a cumulative total of 93 mm, and gives an estimated rarity of 84 years."***

The DDF model for the Arrowe Brook catchment has been reproduced in Figure 3-4 and Figure 3-5. The DDF model demonstrates that a 93mm 48 hour rainfall profile over the Arrowe Brook catchment has an equivalent return period of 84 years.

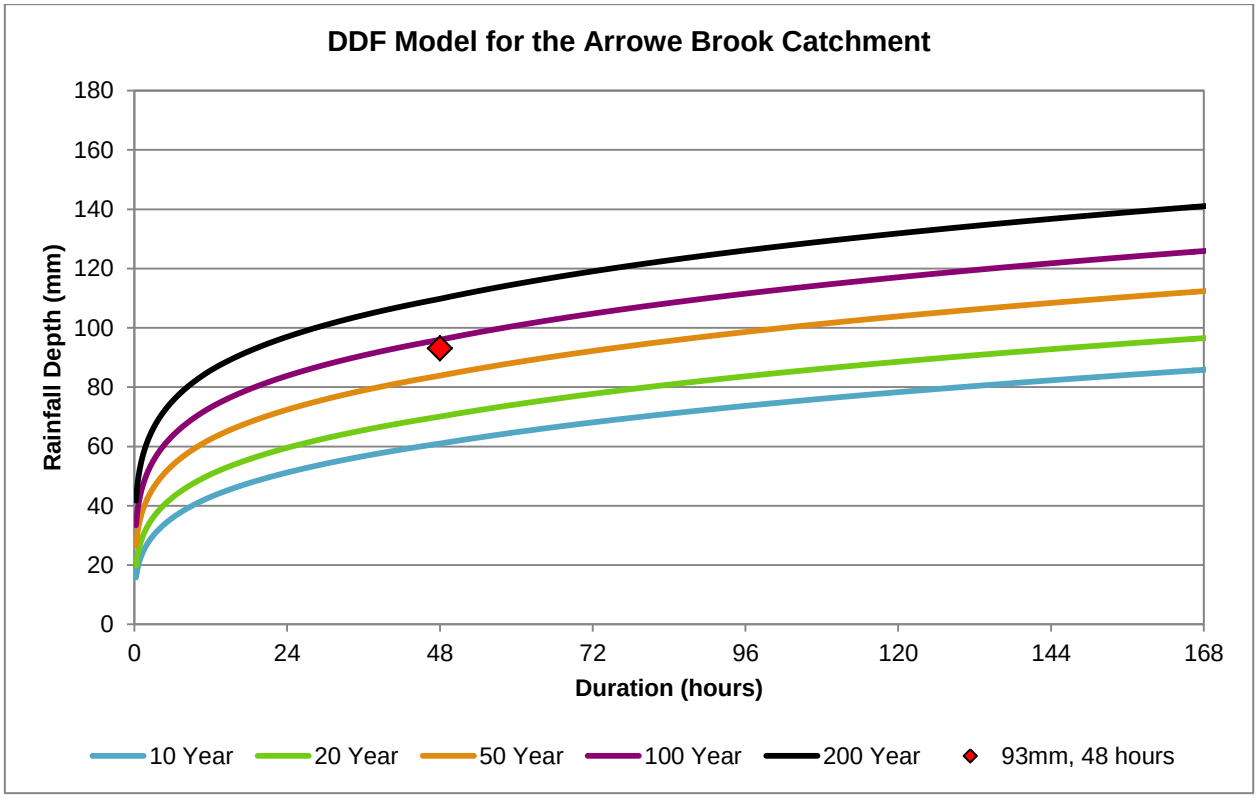


Figure 3-4 Depth Duration Frequency Curves for the Arrowe Brook Catchment (325100 390000)

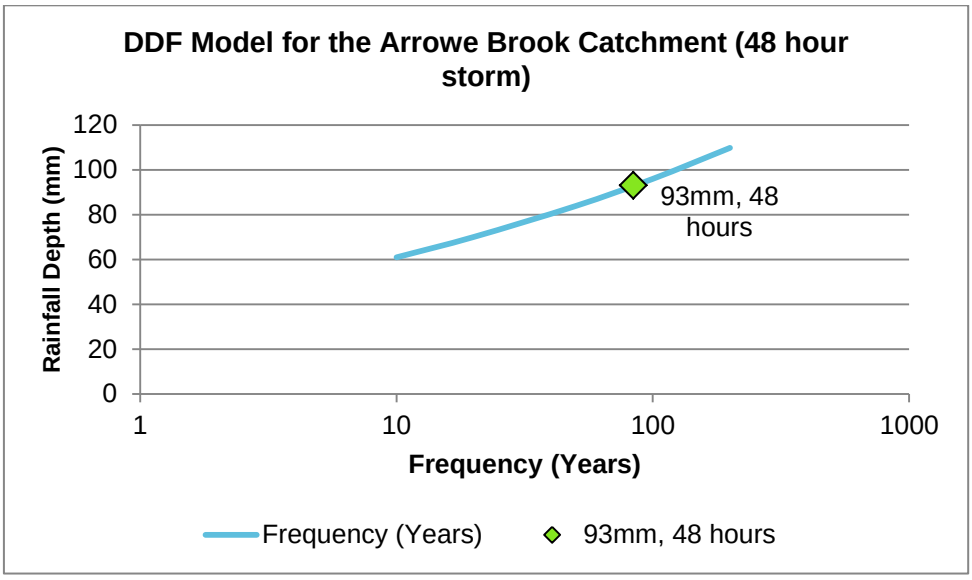


Figure 3-5 Depth Duration Frequency Curve for a 48 Hour Storm over the Arrowe Brook Catchment

3.6 Weather Warnings

On the 1st September 2015 the Met Office forecasts produced for the UK highlighted the potential for banded shower to produce localised large rainfall accumulations in the North-West, noting that 15mm in 1-2hrs was possible where this occurred. The Met Office's report on this event states:

"There was much variation in detail between forecast models, but a common theme was to highlight a risk of organised shower activity 'from northern England southwards' with a particular focus on North and North East Wales. Within this broad area highlighted, a risk assessment was made on the basis of some areas seeing perhaps 20-25mm in 2-3hrs late in the night and into the daytime on the 2nd. Overnight updates to this forecast extended the higher risk area eastwards to cover areas adjacent to Liverpool Bay, and to incorporate the risk of 30mm in 3 hrs or less.

The joint risk assessment process undertaken by the Met Office Chief Meteorologist and the Flood Forecasting Centre suggested that there was a low risk of minor flooding impacts from this scenario, predominantly from surface water flooding. This risk is not sufficiently high for a Met Office National Severe Weather Warning Service (NSWWS) rain warning, and is equivalent to a GREEN ('very low') flood risk on the FFC's Flood Guidance Statement (FGS). The FGS issued on the 1st specifically mentioned 'Heavy showers across parts of the north-west of England and North Wales on Tuesday 1st September 2015 and Wednesday 2nd September may cause localised [river and surface water] impacts'. So no warnings were issued.

Further risk assessment was made on several occasions during the night based on observed accumulations, and the decision remained that a warning was not required. The observed impacts did not become apparent until well into the morning of the 2nd.

In the event, observed rain gauge rates and accumulations over 1-4hrs were less than had been catered for in forecasts and in assessing the need for warnings. On the morning of the 2nd September, observed hourly rates from gauges did not exceed 10mm/hr, with a highest hourly total of 9mm (to 8.15 GMT) on the morning of the 2nd. Consequently the level of impact, assessed 'moderate' in NSWWS terms, was some way in excess of what would be expected, or even possible, from these rainfall amounts.

Our conclusion remains that either a) there were localised much higher rainfall intensities and accumulations which occurred across the Wirral on the morning of the 2nd which were not captured by either the rain gauges or by rainfall radar, or b) there were antecedent or other environmental conditions which made the area unusually susceptible to fairly modest summer rainfall. "

4 Data Collection

4.1 Consultation

During the consultation process, various forms of flooding records and data were provided by the consultees listed in Section 2.5. Table 4-1 summarises the data provided to AECOM for use in this Section 19 Flooding Investigation.

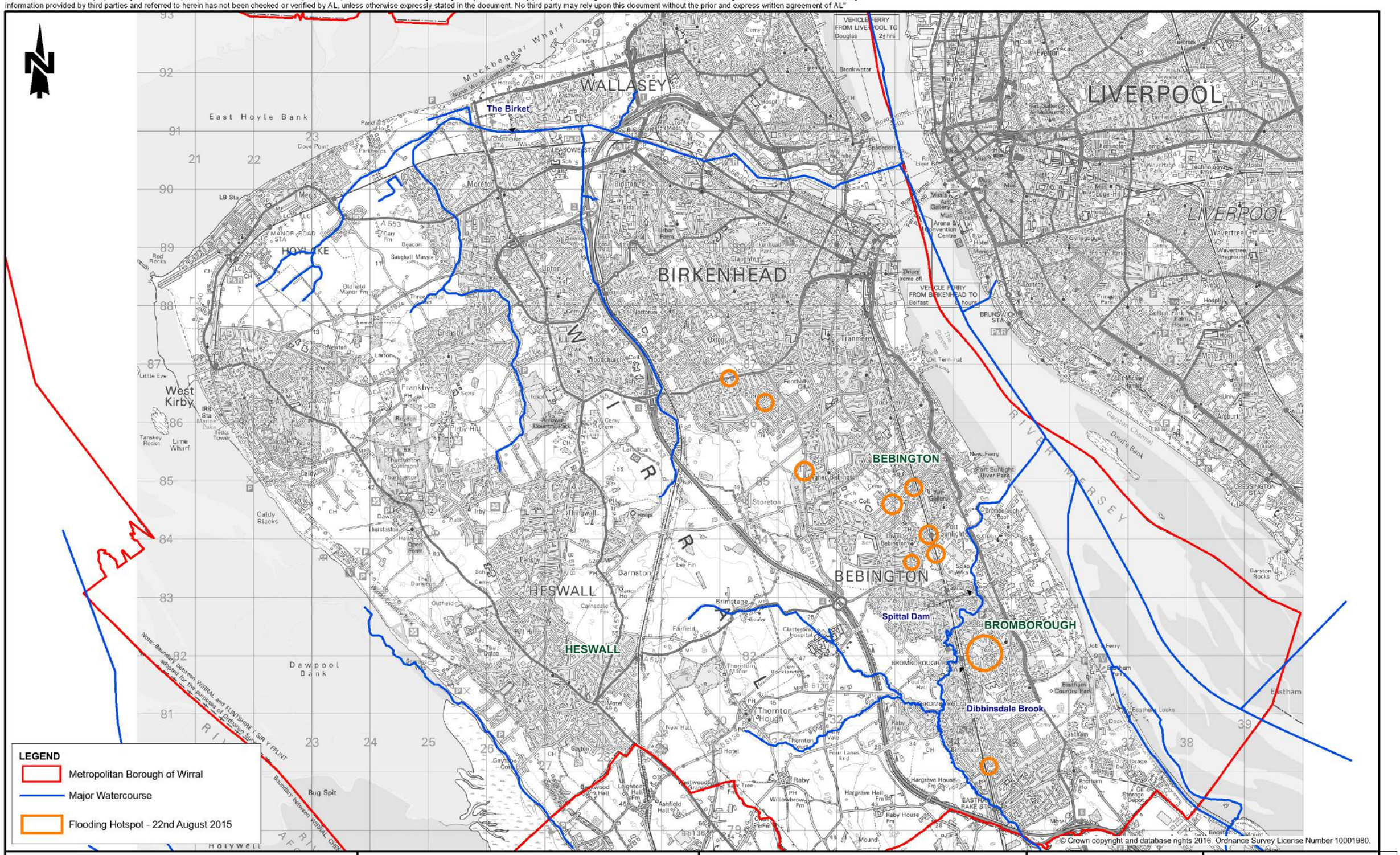
Table 4-1 Data Register

Consultee	Information
DCWW	• DCWW search for flooding records or information on the flooding in Heswall
Environment Agency	• Investigation Summary Report • Post Flooding Event Survey Information • Estimated Flood Extents for Moreton and Prenton Brook • Modelled and historic flood outlines • Hydrometric gauge data • Community drop in feedback summary table • Arrowe Brook modelling report
Local Residents	• Photographs, anecdotal evidence
Magenta Living	• Record of flooded properties for 2nd September 2015 • Photographs of flooding • Timeline of events for 2nd September 2015 and the following week
Met Office	• Report on the weather situation surrounding the 2nd September 2015 flooding.
Merseyside Fire & Rescue	• Call Out Log from 2nd September 2015 and flood event de-brief form
Merseyside Police	• Incident Report for 22nd August and 2nd September 2015
North West Ambulance Service	• Summary of Alerts / Call Outs
SP Energy Networks	• Timeline of flooding on 2nd September 2015 and photographs
United Utilities	• Verified Flooding Data for 22nd August and 2nd September 2015
Wirral Borough Council	• Emails to regarding flooding sent to WBC's Highway Asset Inbox • Call out log for 2nd September 2015 • CRM Report for 2nd September 2015 • Wirral Incidents (UU) (Unverified) • Flooding timeline • Multi-Agency Flood De-brief Meeting Notes

4.2 Data Review

The data collected as part of the consultation process was used to identify which parts of the Wirral had experienced flooding between the 22nd August 2015 and the 2nd September 2015. Spatial data was plotted in Mapinfo, a Geographic Information System (GIS), and the reported incidents of flooding were reviewed to identify geographical flooding 'hotspots' where multiple reports of flooding were identified in close proximity of each other.

The flooding hotspots that have been identified for the 22nd August 2015 event are shown in Figure 4-1 and the hotspots for the 2nd September 2015 event are shown in Figure 4-2. This data has also been provided to WBC for use in their flooding register.



Client: WIRRAL

Project: SECTION 19 FLOOD INVESTIGATION 22ND AUGUST AND 2ND SEPTEMBER 2015

Title: FLOODING HOTSPOT OVERVIEW MAP FOR 22ND AUGUST 2015

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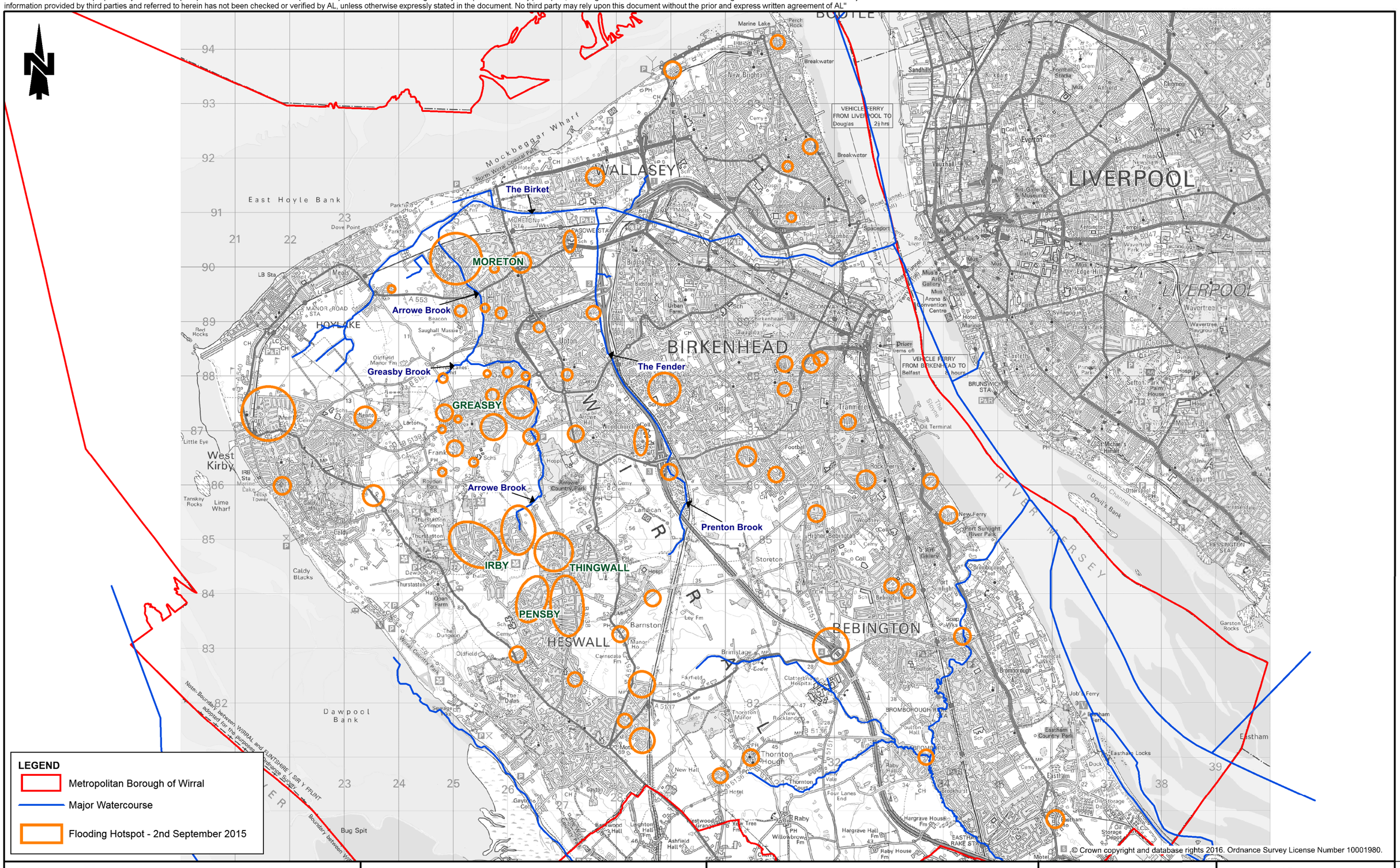

Client: WIRRAL

Project: SECTION 19 FLOOD INVESTIGATION 22ND AUGUST AND 2ND SEPTEMBER 2015

Title: FLOODING HOTSPOT OVERVIEW MAP FOR 2ND SEPTEMBER 2015

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4.3 Key Statistics

The flood incident data can be summarised in terms of date and type (internal property flooding or external flooding). A breakdown of these key statistics is presented in Table 4-2. It should be noted that due to the variety of sources considered and quality of data it has not been possible in all instances to verify the date or type of flooding record.

Table 4-2 Key Flood Report Statistics

Type of Flooding	Date of Flooding			
	22 August	**2 September**	**Unconfirmed Date**	**Totals**
Internal Flooding	7	73	3	**83**
External Flooding	3	57	15	**75**
Unconfirmed	10	138	146	**294**
Totals	**20**	**268**	**164**	**452**

Critically, the 2nd September 2015 flooding incident meets the significance criteria (i.e. 8 reports of internal property flooding) for a Section 19 Flood Investigation with 73 confirmed records of internal flooding collated for the event. Whilst only 7 internal flooding records were collated for 22nd of August, this event has also been considered due the impact on transport links including the Mersey Tunnel approach road and public highway in the Bromborough and Bebington area.

4.4 Site Visits

The distribution of the flooding 'hotspots' and other relevant information gathered from the consultees was reviewed to determine the potential flooding mechanisms and identify areas that may benefit from a site walkover in accordance with the project brief. The site visits were undertaken between 1st March 2016 and 3rd March 2016. The scope, extent and timing of the site work was agreed with Neil Thomas (WBC Project Manager) prior to undertaking work on site.

The objective of the site work was to:

- Identify and appraise historic flooding mechanisms;
- Engage with local residents and stakeholders to capture local knowledge of the 2015 flood events; and,
- Provide bespoke advice to historically affected residents with an emphasis on flood risk resilience measures.

The following flooding hotspots were targeted for site visits as part of the agreed scope:

- Greasby, including areas around:
  - Arrowe Road, Brookdale Close, Circular Drive, Coronation Park, Joan Avenue, Norwood Road, Rigby Drive, Rowan Court and Rylands Hey
- Moreton, including areas around:
  - Carnoustie Close, Felton Close, Millhouse Lane, Tern Way, Town Meadow Lane and Wastdale Drive
- Irby, Pensby and Thingwall, including areas around:
  - Glenwood Drive, Mayew Road, Somerset Road, Ridgewood Drive, Thingwall Drive, Rosemead Avenue and King's Drive
- The North Cheshire Trading Estate

Residents were notified in advance of the site visits via a letter drop that was co-ordinated by WBC. The stakeholder engagement aspect involved both pre-arranged and unscheduled visits to residents within these targeted areas. Local knowledge was captured via a formal questionnaire which was developed and agreed in conjunction with WBC (a blank questionnaire template is included within Appendix A). This questionnaire was also made available online and residents were provided a link to this in the letter drop undertaken by WBC.

5 Site Specific Flooding Mechanisms

The following chapter summarises the flooding investigated for areas identified as being affected between the 22nd of August 2015 and the 2nd September 2015. For each site, an overview is provided, flooding mechanisms discussed, RMA responses outlined and recommendations to reduce flood risk suggested. The majority of this chapter focuses on the 2nd of September flooding incident given the significant impact to people, property and large volume of data that was captured for this event.

5.1 Bebington and Bromborough

5.1.1 Site Overview

Bromborough is a large village within the Metropolitan Borough of Wirral, in Merseyside, England. It is situated on the Wirral Peninsula, to the south of Bebington and to the north of Eastham. The Dibbinsdale Brook is an Environment Agency main river that flows south to north through this area. Bebington and Bromborough experienced localised flooding primarily during the 22nd August flood events and again during the 2nd September flooding. This flooding had a significant impact on main roads and road closures were completed by WBC Highways and Merseyside Police during the 22nd August flooding incident.

Key sites of interest are shown in Figure 5-1.

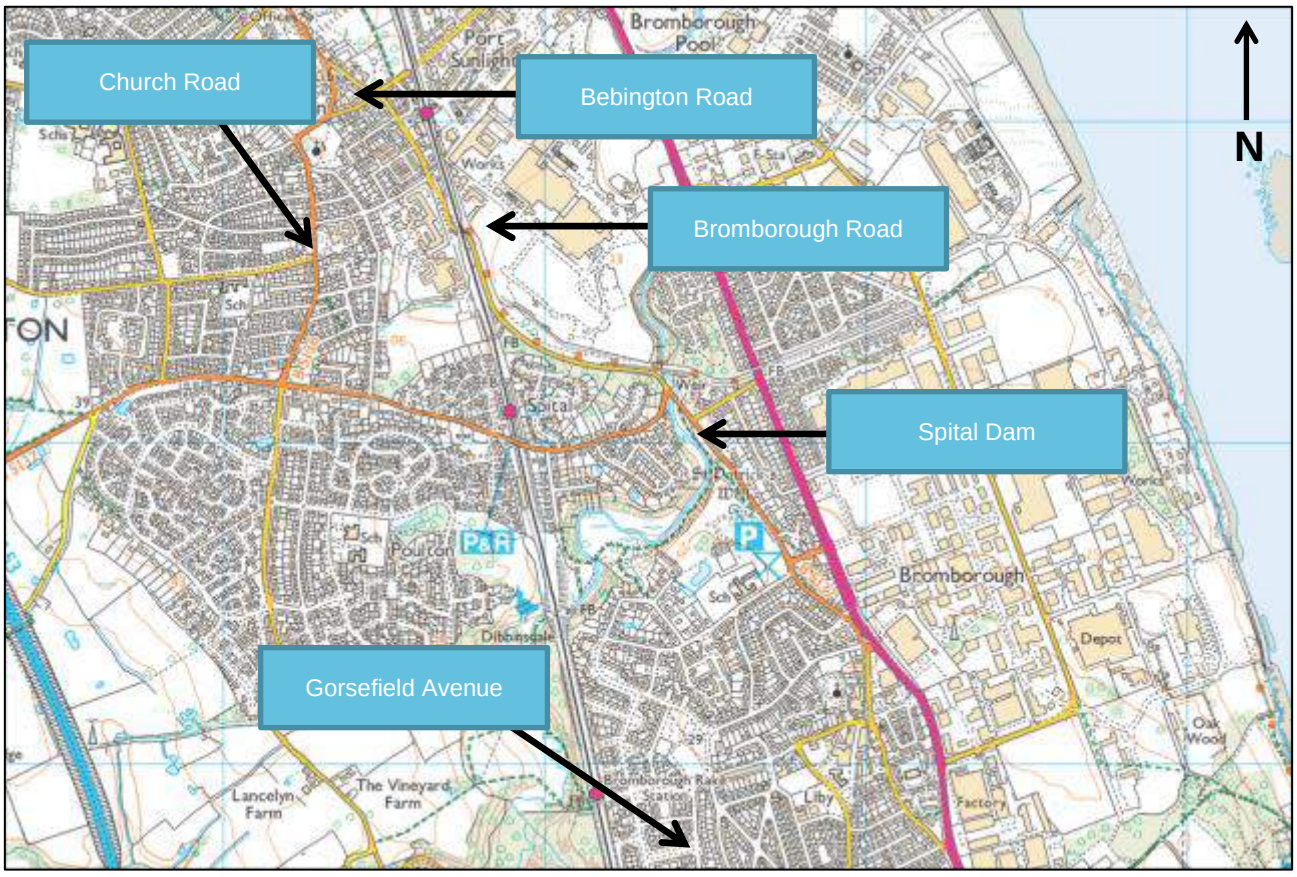


Figure 5-1 Bebington and Bromborough

5.1.2 Flooding Impacts

The key flooding impacts in this area are as follows:

- Spital Dam was subject to flooding up to a depth of 1.2m. This caused significant disruption to vehicular traffic. This occurred during both the 22nd August and 2nd September flood events, with a motorist being rescued from his car by Merseyside Fire and Rescue during the 2nd September incident. Photographs of the flooding can be seen in Photograph 5-1 and Photograph 5-2.
- Bromborough Road was flooded near Unilever and the Port Sunlight Station as was Bebington Road.
- A number of residents at Port Causeway reported external property flooding from the public highway during the 22nd August flooding.
- Gorsefield Avenue was flooded on the evening of the 22nd August, resulting in internal property flooding.
- Further public highway flooding was reported on The Rake, Woodchurch Road, Prenton Lane and Mount Road.

Photograph 5-1 Bromborough Road Flooding (2/9/15)

Photograph 5-2 Bromborough Road Closures (2/9/15)

Images from the Liverpool Echo http://www.liverpoolecho.co.uk/news/liverpool-news/re-read-wirral-flooding-chaos-9974697

5.1.3 Flooding Mechanisms

United Utilities has undertaken post-event investigations into the areas affected by the 22nd August 2015 flooding which were reported to them. These investigations conclude:

- The 1 in 20 year design standard of the surface water sewers at Port Causeway, Mount Road and The Rake were exceeded due to the severity of the 22nd August rainfall.
- There were a number of single reports of flooding which resulted from soft blockages causing localised flooding.

In addition to the UU investigations it is anticipated that:

- The flooding at Spital Dam resulted from both surface water ponding in the low point on the road and fluvial floodwater from the Dibbinsdale Brook. High water levels within the Dibbinsdale Brook would have also prevented the local drainage network from effectively discharging into the watercourse.

5.1.4 RMA Response to Flooding

Based upon the available information AECOM understands that other relevant RMA actions in this area include:

- WBC Highways undertook a number of road closures for flooded roads in this area, including Spital Dam, Bebington Road and Bromborough Road.
- UU has undertaken post-event investigations to verify the cause of the issues.

5.1.5 Recommendations

The evidence reviewed as part of this Section 19 Flood Investigation indicates that the flooding at this location was relatively localised and that post-event investigations have already been undertaken. Additional works could include:

- Updating the WBC Traffic Management Plan with a road closure plan for Spital Dam and the other areas of Bromborough Road that have experienced repeated highways flooding historically.
- Although UU received no reports of flooding from residents, UU are aware of the flooding and various flooding mechanisms and are currently working with the EA and Wirral BC on a partnership funded scheme to potentially mitigate flood risk in the future.

5.2 Greasby

5.2.1 Overview

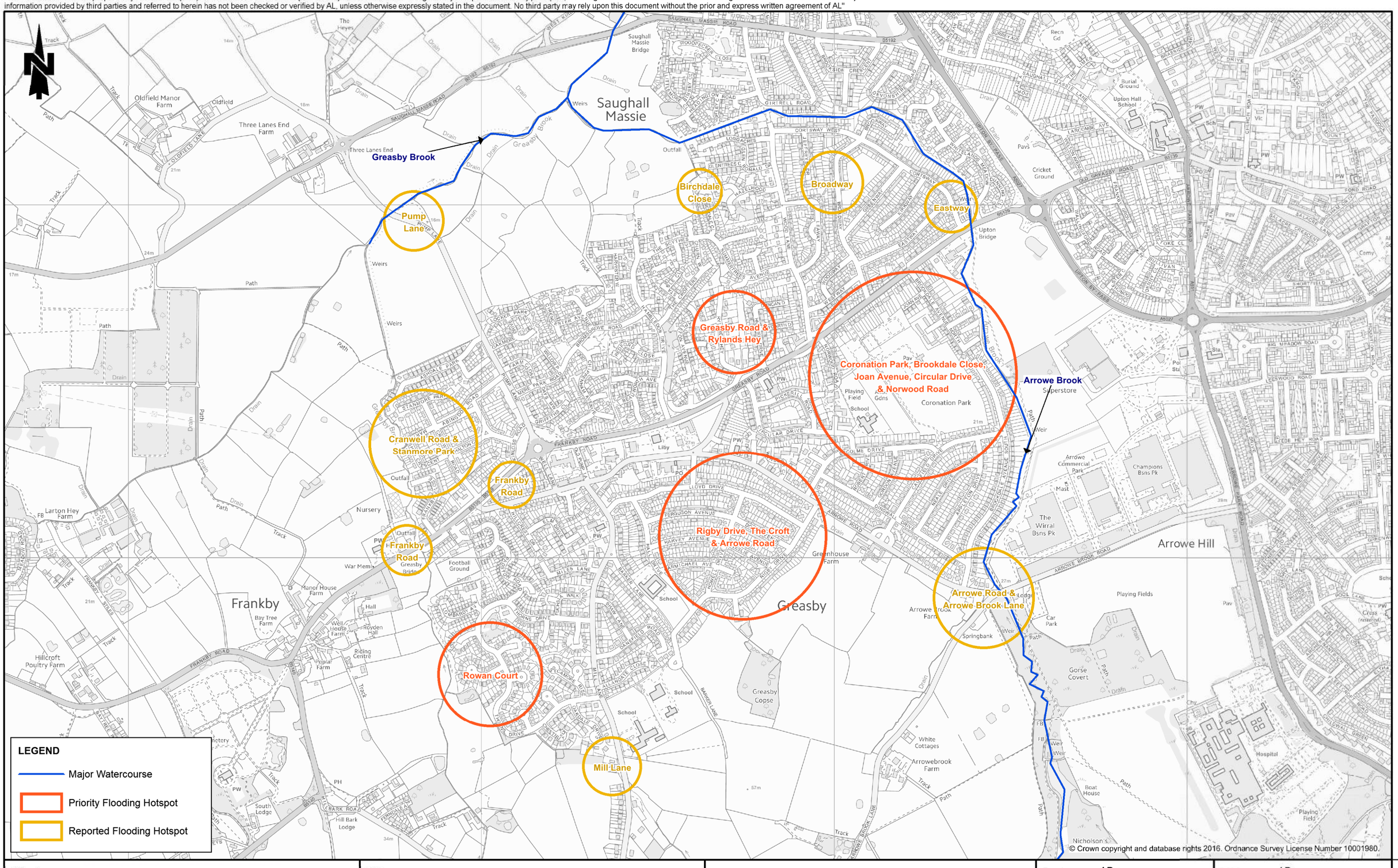
Greasby is a large village located near the centre of the Wirral Peninsula with a population of approximately 10,000 inhabitants. Both the Arrowe Brook and Greasby Brook (Environment Agency main rivers) flow south to north through the village. Several other unnamed ordinary watercourses are also present and have several connections with the surface water sewer network.

The stakeholder consultation and data review presented in Section 4 identified multiple reports of property and highway flooding during the 2nd September 2015 event. The majority of these issues relate to surface water, sewers and ordinary watercourses. The main rivers were not reported as being the source of any flooding issues within this location.

The data review has been used to delineate flooding hotspots, as shown in Figure 5-2. Following the observations made on site and consultation with local residents it apparent that the flooding mechanisms in several of the identified hotspots are linked. Accordingly, the flooding hotspots can be broadly categorised into three flood 'cells':

- East Greasby, including:
  - Coronation Park
  - Brookdale Close
  - Joan Avenue
  - Circular Drive
  - Norwood Road
- Central Greasby, including:
  - Rigby Drive
  - The Croft
  - Arrowe Road
  - Rylands Hey
- West Greasby, including:
  - Rowan Close

The subsequent points in this section discuss the evidence of flooding, site observations, flooding mechanisms, RMA response and suggested actions accordingly.



Client: WIRRAL

Project: SECTION 19 FLOOD INVESTIGATION 22ND AUGUST AND 2ND SEPTEMBER 2015

Title: GREASBY FLOODING HOTSPOTS

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5.2.2 East Greasby

5.2.2.1 Coronation Park

The survey team commenced the site visits in the Coronation Park car park. Extensive pooling of surface water was observed and no formal drainage was apparent at this location (Photograph 5-3). There was no evidence that the surface water ponding in the car park directly impacted on the adjacent residential properties, although this could have potentially impacted them historically.

Photograph 5-3 Standing Water in the Coronation Park Car Park (1/3/16)

The grassed areas of the park were waterlogged (Photograph 5-4), with multiple instances of standing water observed. The park itself covers an area of approximately 8 hectares. A notice in the park's information board suggests that the park was previously a clay excavation pit which was later capped with excavation material from the Mersey tunnel (Photograph 5-5).

Significant clay deposits and low permeability soils may prevent the infiltration of surface water into the ground and result in the generation of overland flow which residents indicated has happened historically (including on both the 22nd August and the 2nd September 2015). A drainage ditch is present on the park's western boundary (adjacent to the allotments) and was observed to be conveying a small volume of water at the time of the visits. This feature may afford a low level of protection to the playing fields and the adjacent residential properties.

Photograph 5-4 Waterlogged Soils in Coronation Park (1/3/16)

Photograph 5-5 A Brief History of Coronation Park (1/3/16)

5.2.2.2 Brookdale Close

Dialogue with stakeholders and local residents at Brookdale Close indicated that water from Coronation Park is routed overland in a northerly direction following heavy rainfall. This subsequently pools against the fences at the back of Brookdale Close and then seeps beneath the garden fencing to the rear or the properties (Photograph 5-6). The properties are also at the bottom of a topographic gradient at this location.

The residents at Brookdale Close confirmed that the majority of the flooding was external, with the exception of 2 individual homes that experienced internal flooding. The residents also confirmed that the properties which experienced historic flooding have now had new doors fitted by Magenta Living.

Photograph 5-6 Surface Water behind Brookdale Close (1/3/16)

Photograph 5-7 Brookdale Close (1/3/16)

5.2.2.3 Joan Avenue

The survey team undertook a walkover at Joan Avenue at the request of residents who had experienced severe flooding during the 2nd September 2015 event. This visit also entailed the provision of bespoke flood risk resilience advice to the residents. The residents at Joan Avenue indicated that the flood flow route originated from the Coronation Park and was influenced by the topography of the adjacent bowling green. The overland flow was subsequently routed through and around a number of properties on Joan Avenue (Photograph 5-8) and onto Greasby Road.

Photograph 5-8 Flooding at the back of Joan Avenue (2/9/15)

Photograph Courtesy of a Local Resident

5.2.2.4 Circular Drive

The survey team was able to speak with one resident at Circular Drive who indicated that the historic flooding was a result of surface water exceeding the capacity of the UU surface water sewer network. The resident also stated that some of the gullies may have been blocked at this location. The resident stated that the flooding was constrained to the roadway and

has not resulted in any internal property damage. UU has confirmed that they do not hold any records of this location being at hydraulic capacity and it has not been reported to them by local residents.

5.2.2.5 Norwood Road

The survey team attempted to make contact with a number of residents on Norwood Road to investigate the reported incidents of flooding. Whilst the majority of the residents were not available at the time of the drop-ins, the team made contact with a resident who indicated that the flooding was a result of surcharging sewers on the main road and that UU had been in attendance following the event undertaking maintenance and post-event clearance works.

5.2.2.6 Flooding Mechanisms

Following a review of the historic flooding information, meteorological conditions, stakeholder consultation and site observations it is concluded that the flooding within this area was a result of:

- Limited infiltration capacity within the grassed areas of Coronation Park resulting in the generation of a large volume of surface water. If there are significant clay deposits beneath the park this may create an impermeable lining which would exacerbate this issue.
- Wet antecedent conditions arising from the rainfall on the 1st of September may have further reduced the infiltration capacity of the grassed areas of the park prior to the second pulse of rainfall on the 2nd September.
- The topography of the grassed area of Coronation Park slopes towards the north. Water unable to infiltrate into the ground would be routed overland in this direction towards Brookdale Close and Joan Avenue.
- The hydraulic capacity of the UU drainage network beneath Norwood Road and Circular Drive being exceeded due to the significant intensity of rainfall (with an estimated return period of 84 years for the 48 hour storm). UU's sewerage systems are not designed to accommodate flows from severe weather events (i.e. those greater than a 1 in 20 year rainfall event) (as detailed in Section 2.3.3).

The flooding mechanisms for the West Greasby are summarised in Figure 5-3.

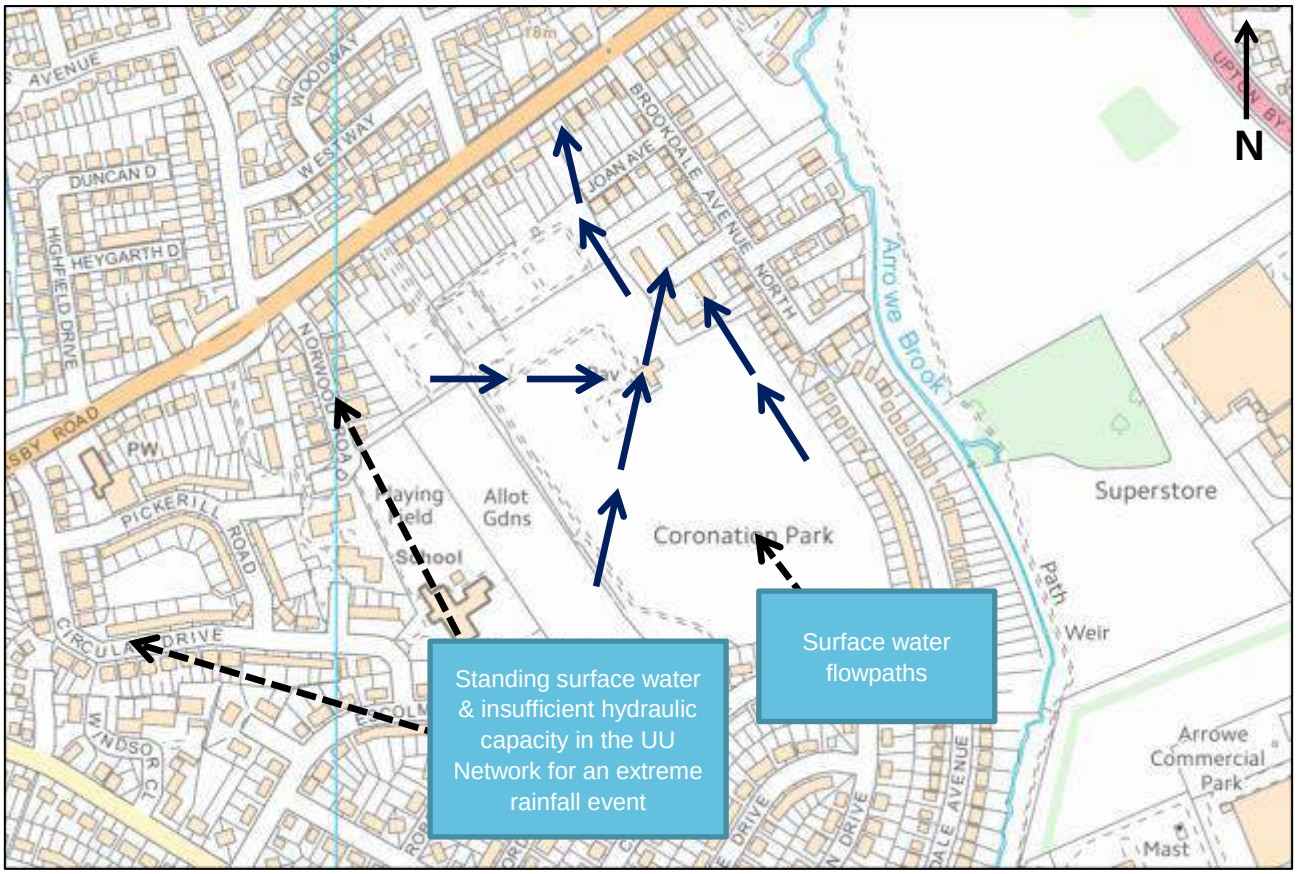

Figure 5-3 East Greasby Flooding Mechanisms

5.2.2.7 RMA Response to Flooding

AECOM understands that the following actions have been undertaken by RMA's following the flooding:

- WBC has commissioned this Section 19 Report to investigate the flooding issues.
- UU has undertaken post-flood investigations, clearance and maintenance work on Norwood Road.
- Magenta Living has fitted flood resilience measures on the properties at the properties on Brookdale Close.

5.2.2.8 Recommendations

The evidence reviewed as part of this Section 19 Flood Investigation indicates that the flooding experienced at this location is primarily attributable to the volume of surface water runoff generated by the large contributing area at Coronation Park. Flood risk from this source may also increase in the future due to the effects of climatic change on rainfall intensity.

Improving the drainage and ability of Coronation Park to attenuate surface water runoff may therefore reduce flood risk to residents on Brookdale Close, Joan Avenue and Greasby Road. These resilience improvements could be potentially undertaken in tandem with other works to improve the amenity of the park in line with the objectives of WBC's Wirral Parks and Open Spaces Strategy[10], specifically Objective 4.2:

Table 5-1 Excerpt from the Wirral Parks and Open Spaces Strategy

OBJECTIVE 4.2: Wirral's parks and open spaces address climate change issues and deliver environmental sustainability.

The parks and open spaces strategy needs to take account of Borough wide strategies and policies including the Climate Change Strategy, Environmental Management System (EMS), Shoreline Management Plan, Coastal Strategy and Floods and Water Management Act.

Long term climate forecasts (Climate UK), indicate a likelihood of higher average temperatures and more seasonal extremes. This might include a decrease in summer rainfall and an increase in heat waves, and/or an increase in 'flash' rainfall resulting in more flooding, higher sea levels and waterlogged soils. There is therefore a need to build climate adaptability into the maintenance of Wirral's parks, open spaces and coastal facing sites. This will in turn impact on the selection of species for planting, choosing specimens that are resilient to unpredictable weather conditions. Sustainable drainage capacity in parks and open spaces will be increased and there will be a need to improve drainage of sports pitches and a potential need for more irrigation in summer months where funding is available. The strategy also needs to take account of the North West River Basin Management Plan in order to help optimise water quality and ecological status of rivers and streams in parks as well as in Wirral's estuaries. Site management and development will need to accommodate wetter winter conditions and drier/hotter summer conditions, for example better provision of shading. There will also be a need for flexible deployment of staff and resources in response to greater and more unpredictable seasonal variations.

There is potential to improve and promote the environmental sustainability of parks and open spaces and associated buildings and operations, for example, using low emission machinery/vehicles where possible. Wirral's parks and open spaces can play an important role in reducing the borough's carbon and environmental footprint through for example recycling and composting of parks waste, encouraging local food growing; exploring biomass planting and micro-generation of energy if viable and appropriate to sites. In addition, encouraging cycling, walking and public transport use where appropriate.

POLICY 4.2a Parks and open space help alleviate flood risk while protecting their core amenity and recreational uses.

- Seek funding for a Programme of Sustainable Drainage Projects at suitable parks and open spaces and implement where appropriate as part of specific site management and development plans.

[10] Wirral Parks and Open Spaces Strategy: https://www.wirral.gov.uk/sites/default/files/all/Leisure%20parks%20and%20events/parks%20and%20open%20spaces/Wirral%20Parks%20and%20Open%20Spaces%20Strategy%202014-2024.pdf

AECOM understands that Coronation Park was considered as part of the Environment Partnerships (TEP) 'Wirral Resilient Parks' project and that preliminary proposals identified potential opportunities to improve drainage through a combination of:

- Football field drainage;
- A system of swales and ponds;
- Rainwater harvesting; and,
- Underground storage tanks serving the areas of hard standing.

An artist's impression of the potential resilience measures is shown in Figure 5-4.

Figure 5-4 Coronation Park Proposals

Excerpt from the Wirral Resilient Parks Project

On the basis of the recent severe flooding it is therefore recommended that WBC explore opportunities to secure funding to further appraise the preliminary Coronation Park proposals for technical and environmental feasibility.

Though UU has not received any residents' reports of flooding at Cricular Drive from residents, the information collated from the site walkover indicates that the flooding at this location may be attributable to the exceedance of the sewer's 1 in 20 year design capacity. UU should undertake investigations to determine if there are any blockages or features which are likely to reduce its hydraulic capacity. WBC should assist in this through an assessment of the highway drainage system which connects to the central UU sewer.

5.2.3 Central Greasby

A review of internet sources that there have been a number of flooding incidents at this location. On 17th July 2007 Wirral Globe[11] reported that "torrential downpours brought chaos to parts of Greasby this afternoon as roads were flooded after just 30 minutes of rain." The report notes that Arrowe Road was closed, and that internal and external flooding affected properties on Arrowe Road and Rigby Drive. A picture accompanying the report (Photograph 5-9) shows significant flooding in Arrowe Road adjacent to the public footpath leading from Lloyd Drive.

Photograph 5-9 Arrowe Road Flooding (17/7/07)

Images from the Wirral Globe: http://www.wirralglobe.co.uk

On 10th September 2008 Wirral Globe[12] reported that significant flooding had occurred on 5th September 2008 when "15mm of rain fell in just one hour". The report states that properties on The Croft, Rigby Drive, and Lloyd Drive were subject to flooding, with a resident of The Croft noting that it was the second time this year the property had been affected by flooding which was caused by "excess water from a farmer's field". The report suggests that pressure was being put on UU due to incapacity in the main sewers, with a UU spokesman suggesting that the area has a history of land drainage problems rather than a lack of sewer capacity.

On 30th October 2008 the website of MP Ester McVey[13] reported on the setting up of the Greasby Flood Action Group by members of the community. The report suggests that the previous flood event had occurred in September 2008.

On 27th August 2009 Wirral Globe[14] reported that, following flooding affecting properties in Arrowe Road and Rigby Drive in July 2009, UU had taken action to assess the condition of the local public sewers. The report suggested that root ingress and debris were reducing capacity in the sewers in Greasby Road, and that that remedial works had since been carried out.

On 16th August 2012 the Liverpool Echo[15] reported flash flooding following significant rainfall had affected properties on The Croft for the second time in three days, although the precise date of flooding is not recorded. In the report a resident also notes that similar flooding had occurred in July 2007. The picture accompanying the report (Photograph 5-10) shows significant water pooled in the low spot on Rigby Drive, between The Close and the junction with Howell Drive. A resident reports the cause of the flooding to be runoff from the fields at the rear of the residential area.

[11] http://www.wirralglobe.co.uk/news/1551415.Floods_bring_chaos_to_Greasby/

[12] http://www.wirralglobe.co.uk/news/3663210.How_torrents_left_Wirral_awash/

[13] http://www.esthermcvey.com/greasby-flooding-action-group/

[14] http://www.wirralglobe.co.uk/news/4568536.Water_result__Floods_are_over_for_Greasby_householders/

[15] http://www.liverpoolecho.co.uk/news/liverpool-news/families-affected-flash-floods-wirral-3337451

Photograph 5-10 Rigby Drive Flooding (16/8/12)

Images from the Wirral Globe: http://www.wirralglobe.co.uk

The Environment Agency's Updated Flood Map for Surface Water (UFMfSW) indicates this surface water flowpath from the fields adjacent to Greasby Copse (south of Rigby Drive). The surface water mapping shows this flow as routing through a number of properties on Rigby Drive, the Croft and the residential area downstream.

The data review exercise confirmed that this area was affected again during the 2nd September 2015 flooding, with multiple reports on Rigby Drive, the Croft, Arrowe Road and Rylands Hey.

5.2.3.1 Rigby Drive & the Croft

The survey team commenced the site visit investigations by contacting residents on Rigby Drive. Whilst several of the residents were unavailable for comment, one resident stated that the flooding in this area is a result of surface water from the upper catchment around Greasby Copse which converges around the properties around the southern side of Rigby Drive. This consequently exceeds the capacity of the local drainage network and is routed overland through the properties on Rigby Drive to the Croft. A photograph of the flooding in the residents back garden is shown in Photograph 5-11.

The survey team subsequently made contact with residents on The Croft to gather information to further the understanding of the flooding mechanisms and to provide bespoke flood risk resilience advice to the local residents. It was also noted that the residents had implemented a number of resilience measures to protect their property. The consultation with the residents on Rigby Drive confirmed that the overland flow from the upper catchment is routed through the gardens and exceeds the capacity of the local drainage network on the Croft. It should be noted, however, that sewerage networks are not intended or designed to receive land drainage.

Flooding and surface flows from this area may potentially compound the issues around Arrowe Road (which is immediately downslope), though the sewer connectivity has not been confirmed at this stage.

Photograph 5-11 Rigby Drive Flooding (Unknown Date)

Image Courtesy of a Local Resident

5.2.3.2 Arrowe Road

The initial data screening exercise indicated a number of reported flood incidents were present on the junction of Arrowe Road with Tudor Grange. Several of these reported incidents were collated as part of the Environment Agency's drop-in feedback sessions in Moreton following the 2nd September 2015 event.

The survey team attempted to make contact with residents on Arrowe Road, though the majority of them were unavailable at the time of the survey. Whilst the initial attempts were unsuccessful, a pre-arranged visit with an affected resident had been scheduled. Consultation with the resident at Arrowe Road indicated that the historic flooding was a result of a combination sources. Specifically, the resident advised that:

- Arrowe Road directs surface water onto the adjacent pavements due to a perceived lack of highways drainage (gullies) and camber of the road.
- The topography of Arrowe Road acts to convey floodwater to the area adjacent to the junction with Tudor Grange.
- The surface water drainage network converges immediately outside of the resident's property and during severe weather the design standard is exceeded. This network is anticipated to cover a relatively large catchment area up to Greenhouse Farm. This consequently results in localised surcharging of sewers and severe ponding within Arrowe Road.
- Flooding is further exacerbated as a result of heavy traffic flow along Arrowe Road in both directions. This consequently results in the generation of bow waves which increase the flood damage to adjacent properties.

A neighbouring resident provided a number of photographs of the historic flooding to the survey team (Photograph 5-12). UU has confirmed that it has not received any reports of flooding from residents in this area for the 2nd September 2015 flooding.

Photograph 5-12 Arrowe Road Flooding (2/9/15)

Image Courtesy of a Local Resident

The resident stated that the flooding on Arrowe Road has had a severe and repeated impact on a number of properties on Arrowe Road over an approximate 10 year period. Whilst the resident had installed some flood resilience measures (airbrick covers), water continues to ingress into his home via the brickwork and doors during a flood event. The survey team advised on additional resilience that could be potentially adopted at the property.

The perceived local authority inaction during the 2nd September 2015 flooding reportedly led to community led road closures in order to prevent vehicular traffic from generating further bow waves and impacting on property.

5.2.3.3 Rylands Hey

Whilst the initial data review indicated that only one property was affected at this location, the survey team undertook a walkover of this area and spoke two local residents. As a result of this consultation it was apparent that up to five properties at this location were affected as a result of a combination of surface water from the contributing area upstream and ordinary watercourse flooding. This floodwater was routed through and around properties, flowing roughly parallel with the ordinary watercourse and the flooding may have been exacerbated by a culverted section.

The local residents also provided photographic and video evidence of the flood flow route through the properties on the 2nd September 2015. This information was used to indicate an approximate flood flowpath for this at this location.

Photograph 5-13 Surface Water Flowpath at Rylands Hey (1/3/16)

Photograph 5-14 Ordinary Watercourse at Rylands Hey (1/3/16)

5.2.3.4 Flooding Mechanisms

Following a review of the historic flooding information, meteorological conditions, stakeholder consultation and site observations it is anticipated that the flooding within this location was a result of:

- Rainfall on the hillside above Rigby Drive generating a significant amount of surface water due to the catchment area, topography and limited infiltration potential of the soils.
- Surface water then being subsequently routed through The Close and onto Rigby Drive.
- Floodwater was then routed through the gardens of properties on Rigby Drive and into the garden of properties on The Croft.
- Though some surface water would have been lost into the UU sewer network, the volume of floodwater and severity of the weather exceeded the 1 in 20 year design standard of the drainage and was routed overland. It should also be noted that surface water sewers are not designed or intended to take land drainage.
- A large volume of surface water was then conveyed along Howell Drive, with ponding at the junction with Lloyd Drive.
- Flood water was then routed through the gardens and a footpath on Lloyd Drive and onto the properties on Arrowe Road.
- Flooding on Arrowe Road is compounded by surface water from the easterly aspect of Arrowe Road.
- The volume of floodwater on Arrowe Road exceeding the design capacity of the UU sewer network.
- Flooding was exacerbated as a result of heavy traffic flow along Arrowe Road in both directions. This consequently resulted in the generation of bow waves which increased the flood damage to adjacent properties.
- Surface water flows were routed down Tudor Grange onto Circular Drive and subsequently onto Rylands Hey. This was compounded by UU sewers running at capacity due to the severe weather (being greater than a 1 in 20 year return period) and resulted in overland flow running through the gardens and properties on Rylands Hey.

These flooding mechanisms are summarised in Figure 5-2.

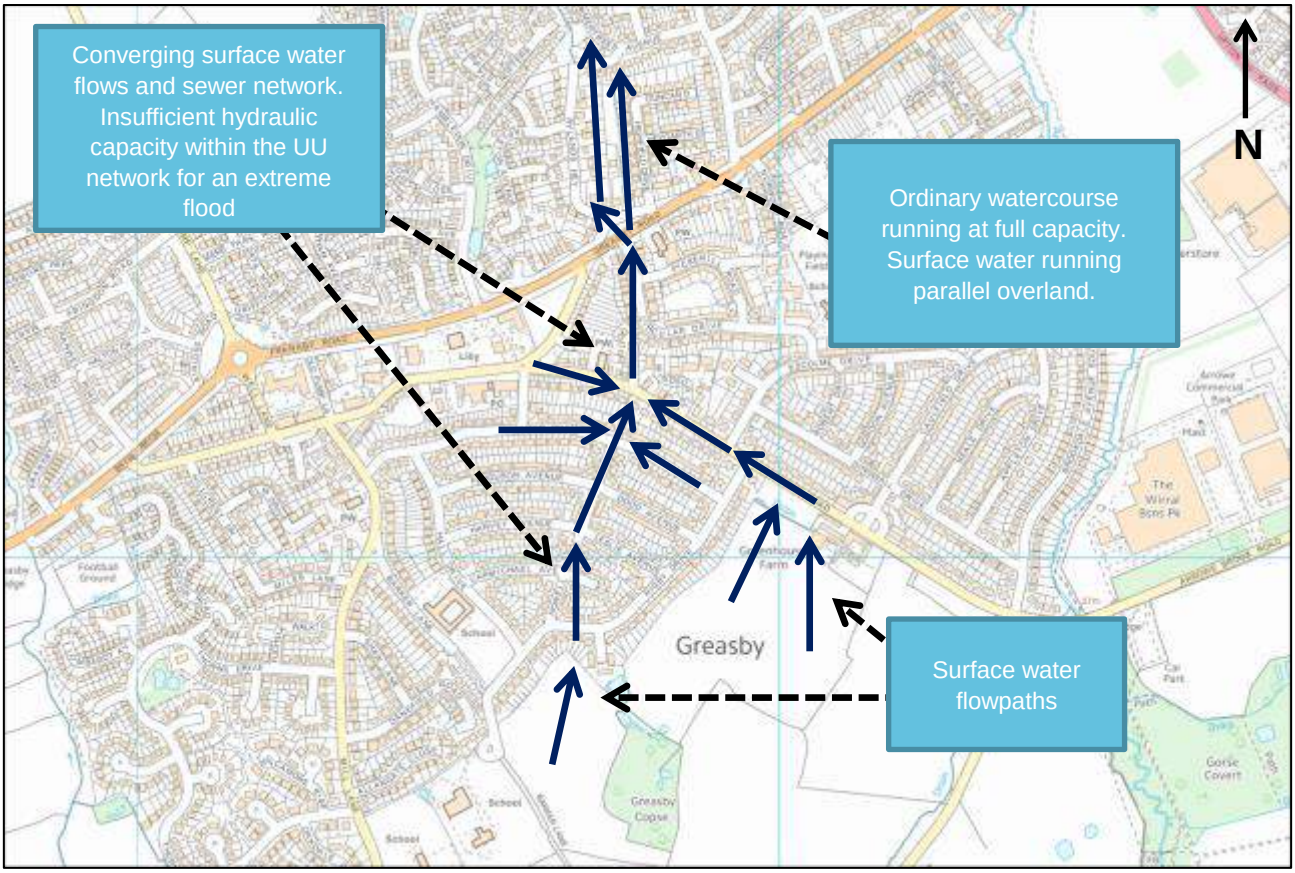

Figure 5-5 Central Greasby Flooding Mechanisms

5.2.3.5 RMA Response to Flooding

Prior to the 2nd September 2015 flooding, WBC commissioned a detailed water modelling study and investigation into this hotspot in February 2014. The investigation created a verified representation of the flooding mechanisms with a hydrodynamic model and analysed a range of potential interventions to potentially mitigate flood risk. The primary solution entailed the interception and storage of surface water flows from the hillside within the fields upstream of Rigby Drive, with a controlled release of surface water into the public sewer via the existing connections.

The modelling determined that a significant volume of storage would be required to deliver a benefit to the properties downstream – i.e. up to 7,700m^3 for a 1 in 30 year plus climate change event. The report therefore concluded that due to the volume of storage required secondary interventions may be required to deliver a feasible mitigation strategy and to reduce the impact of future flood risks.

Based upon the available information AECOM understands that other relevant RMA actions in this area include:

- WBC has commissioned this Section 19 Report to investigate the flooding issues.
- UU has undertaken post-event investigations into the reported flooding to verify the cause of the issues.

5.2.3.6 Recommendations

Several recommendations for further work were made in the Surface Water Modelling Study which WBC and its project partners should consider if there is there is a sufficient partnership funding to advance a capital scheme in this flooding hotspot.

These recommendations for further work are outlined in Table 5-2.

Table 5-2 Excerpt from the Greasby Flood Investigation Report

Consultation and Stakeholder Engagement

The flooding events which have occurred to date have had a significant impact on the local community. There is a general concern and a wish to see action taken. If there is potential to take a scheme forward, it is recommended that public consultation forms a part of the scheme development exercise to engage residents and to obtain buy-in to flood alleviation proposals.

The potential solutions rely on work being undertaken within the fields to the south of the residential area. In order to confirm the feasibility of any solution and to take any potential solution forward, significant engagement with the landowner will be required. It is recommended that initial liaison be undertaken before progressing with further study.

Ongoing liaison and partnership working with both UU and the EA will be required to develop a holistic solution for the surface water flooding. In particular, further liaison with UU would be required as a priority in order to confirm acceptability in principal of the potential solutions, including the potential controlled release of surface water into the public sewer. Further consultation with UU on funding provision for a sewer flooding solution will be a key requirement.

If there is potential to take a scheme forward, the planning division of Wirral Council should be consulted in order to establish the requirements for planning permission for any scheme, in order to identify the likely scope of work required to support any application.

Economic Appraisal

A full economic assessment would be required in order to justify any investment and identify potential sources of funding. Such an appraisal is likely to include for outline costing of potential interventions, cost-benefit analysis, and appraisal of potential funding sources.

As the provision of a holistic solution will require implementation of the UU sewer flooding solution, discussions with UU will be required to confirm the potential for funding of such a scheme. AMP6 funding priorities may or may not be favourable to the scheme, and this should be considered as early as possible to avoid abortive work.

The alleviation of flood risk from watercourses and surface water can attract government funding to either pay for the works in full or as a part of a wider funding package. This source of funding is called Flood and Coastal Erosion Risk Management Grant in Aid (FCRM GiA) – previously known as Flood Defence Grant in Aid. Rules apply to attracting FCRM GiA, as presented on the EA website[16]. The underlying policy aim for the use of GiA is to draw in contributions from others – the wider the funding package the more likely GiA is to be granted.

As part of the overall scheme scoring, Wirral Council would need to demonstrate that a scheme will provide a favourable outcome against some or all of the following criteria:

- The number of households protected against flood risk;
- Positive economic benefit to cost ratio (showing the scheme is an economic investment); and
- Habitat improvement.

Assessment against these criteria is scored in terms of Defra/EA “Outcome Measure” targets. Other funding sources may be also be available and should be considered prior to proceeding with any GiA funding bid. A Project Appraisal Report (PAR) may be required to support any bid for funding.

Surveys and Model Refinement

In order to refine the 2D hydraulic model of the catchment, and to inform further development of potential solutions, the following may be required:

- Survey of pipe connections from drainage ditches to confirm pipe size, invert levels, current condition, connectivity;
- Potential further survey of the public sewerage;
- Ground based topographical survey of the fields where work may be undertaken;
- Threshold survey of properties at risk of flooding;
- Some ground investigation is likely to be needed where significant engineering works are planned (subject to the

[16] https://www.gov.uk/government/collections/flood-and-coastal-defence-funding-for-risk-management-authorities

Council not having access to suitable existing data);

- At this stage it is not clear whether contaminated land is likely to be an issue. This will need to be checked through desk study and then ground investigation if needed.

The scope of any surveys would need to be carefully considered to ensure the critical elements which may constrain the design are understood.

Environmental Assessment

It is important to review the impacts of works, both positive and negative, on the surrounding area. This assessment may include environmental surveys and investigations on how potential impacts could be mitigated or opportunities incorporated within the works. Both the permanent impacts of any scheme and the temporary impacts during construction should be evaluated. The following topics may be amongst those which need to be considered:

- Ecology and biodiversity;
- Air quality;
- Noise;
- Cultural Heritage;
- Landscape and visual impact;
- Socio-economic impact;
- Traffic and transport.

Detailed Design Activities

The detailed design work is dependent on the tasks listed above and will include refinement of the hydraulic modelling to confirm solutions, preparing design specifications, hydraulic calculations, detailed design drawings, agreement of contract procurement methodology, and preparation of tender documents including all CDM Construction Health and Safety Information. A CDM Coordinator will be required for these works as it is assumed the scheme will be notifiable to the HSE.

Potential secondary interventions for consideration included:

- Property Level Urban SUDS
- Street Level Urban SUDS
- Changing Land Management Practice
- Mitigation
- Maintenance
- Flood-Proofing
- Temporary Infrastructure
- Changing Land Management Practice

5.2.4 West Greasby

5.2.4.1 Rowan Close

The survey team managed to speak to three residents at Rowan Close and confirmed that the historic flooding at this location has resulted from both sewers and ordinary watercourses. The sewer flooding had resulted in both wastewater and surface water surcharging out of manholes adjacent to property, resulting in localised property damage. The residents advised that UU had been contacted and subsequently and undertaken post-event work to disinfect and clear up the affected areas. Post-event investigations undertaken by UU confirm that this flooding was a result of the initial rainfall on the 1st September 2015 combined with a blockage of fats, oils and grease within the local sewer network.

On the opposite side of the close a resident concerned with flooding from an ordinary watercourse which is a tributary of the Greasby Brook. This issue was reported as being a result of a tree growing within the unmaintained ordinary watercourse which then traps debris during times of flood. This consequently results in a localised constriction to flow and a backwater effect.

Photograph 5-15 Vegetation Growth within an Unnamed Ordinary Watercourse (1/3/16)

The local resident stated that they had previously voiced concerns about blockage and reduced conveyance within the watercourse. The survey team explained about the different risk management authorities' responsibilities and the riparian ownership issues, though it was unclear who owned the land on the opposite bank of the watercourse. This may need to be confirmed and reiterated at a later stage with subsequent visits to the local residents.

Localised low spots were also observed on the river banks adjacent to the neighbouring properties; blockage in the future may pose a localised fluvial flood risk at this location.

5.2.4.2 Flooding Mechanisms

Following a review of the historic flooding information, meteorological conditions, stakeholder consultation and site observations it is anticipated that the flooding at the Rowan Close was a result of:

- Blockage within the UU sewer network (fats, oils and grease); and,
- Localised ordinary watercourse flooding.

5.2.4.3 RMA Response to Flooding

Based upon the available information AECOM understands that other relevant RMA actions in this area include:

- WBC has commissioned this Section 19 Report to investigate the flooding issues.
- UU has undertaken post-flood clearance and maintenance work on Rowan Close.
- UU has undertaken post-event investigations to verify the cause of the issues.

5.2.4.4 Recommendations

The evidence reviewed as part of this Section 19 Flood Investigation indicates that the flooding at this location was relatively localised and that post-event investigations have already been undertaken. Additional works could include:

- Liaison with local residents and stakeholders to reiterate the importance of not depositing fats, oils and grease down the drain and riparian ownership issues.

5.3 Moreton

5.3.1 Site Overview

Moreton is a village on the north coast of the Wirral Peninsula, Merseyside, England. The village is bisected by the Arrowe Brook, an Environment Agency main river that flows south to north through the residential area. The Arrowe Brook subsequently joins the River Birket downstream of Moreton, where it flows east for 6km to Bidston Great Culvert where water discharges via gravity into the West Float (Birkenhead Docks). The Environment Agency also operate a pumping station at this location as high tides can prevent the River Birket from freely discharging into the West Float. This pumping station has a theoretical maximum rate of 16 m^3/s. Pumping can be required during high tides due to the flat, coastal topography and tide-locking that can occur.

These catchment conditions can result in a significant backwater effect from the lower end of the catchment and as such elevated levels within the River Birket can result in an increased water level within the Arrowe Brook catchment upstream. Subsequently the Environment Agency can issue Flood Warnings and Flood Alerts in Moreton for increased river levels within the lower catchment, as well as for high river levels in the upper catchment.

The Arrowe Brook is crossed by two bridges within the urban area of Moreton: the Town Meadow Lane road bridge and a Railway Bridge at the downstream end of the village. An annotated map of Moreton village and the key features is shown in Figure 5-6.

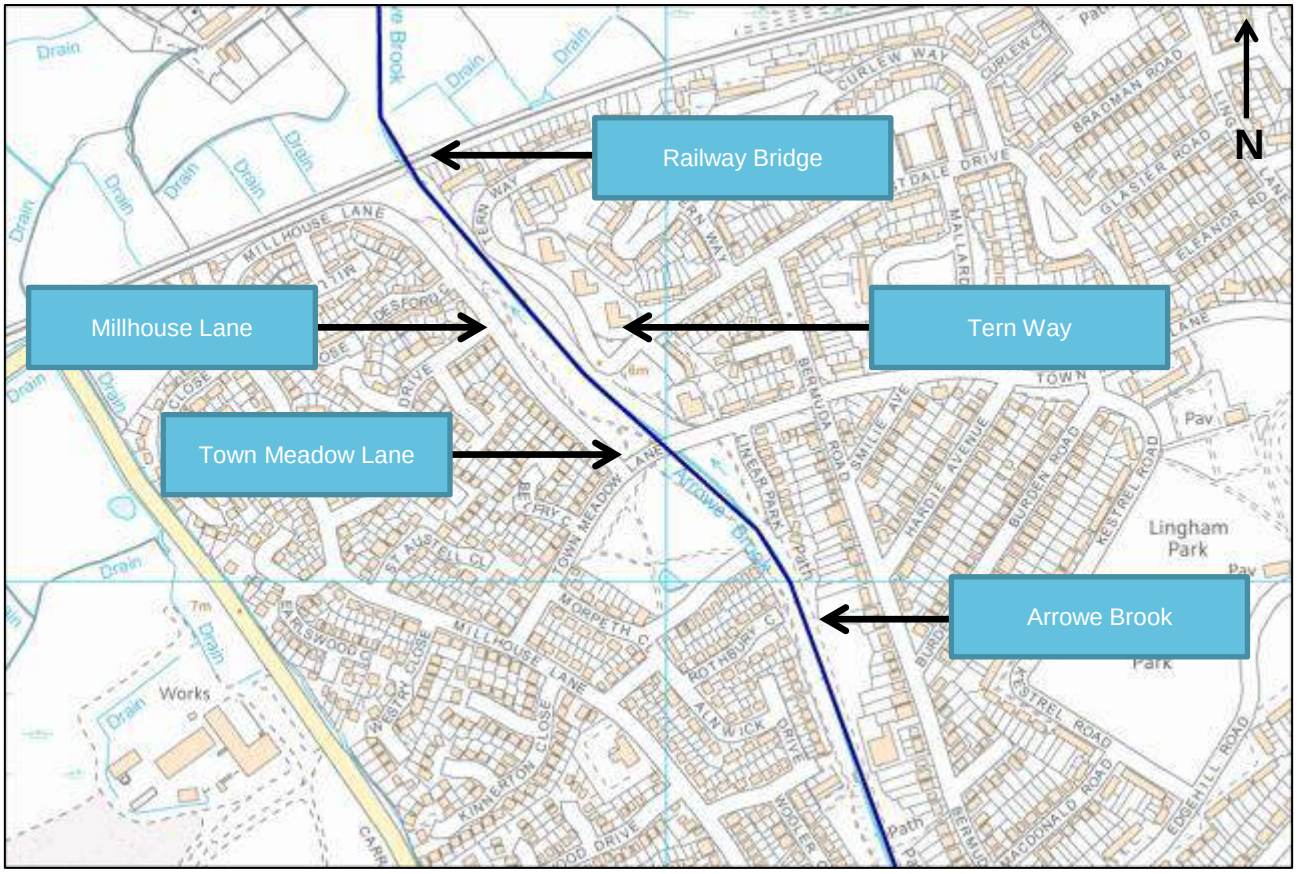

Figure 5-6 Moreton Village; Key Features

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5.3.2 Flooding Timeline

AECOM has reviewed information collated from the consultees and produced an approximate timeline for the 2nd September flooding at Moreton. This has been split into the physical flooding impacts and the flood incident response by emergency responders, RMAs and other relevant agencies. The reconstructed timeline is shown in Table 5-3.

Table 5-3 Moreton Flooding Timeline

Key Timeline Abbreviations			
EA	Environment Agency	MF&R	Merseyside Fire and Rescue
FIDO	EA Flood Incident Duty Officer	ML	Magenta Living
FWDO	EA Flood Warning Duty Officer	MP	Merseyside Police
MFDO	EA Monitoring and Forecasting Duty Officer	NIRS	National Incident Reporting System

Time	Flooding Impacts and Observations	Flood Incident Responses	Source
06:30	EA alarm received for Great Culvert trash screen (downstream of Moreton)	EA Operations team already on location and checking for blockages	EA
06:45	-	-	
07:00	-	-	
07:15	Report of surface water flooding at Oakham Drive	-	MP
07:30	Report of surface water flooding at Millhouse Lane	-	MF&R
07:45	-	Alarm received for Great Culvert trash screen: EA Operations team already on location	EA
08:00	Deep flooding (> 12") reported on Millhouse Lane & Millhouse Close EA alarm received for Great Culvert trash screen (downstream of Moreton)	MP Officer arrives at the scene Reports of flooding reach the EA Flood Incident Duty Officer (FIDO) through the National Incident Reporting System (NIRS)	MP, EA
08:15	-	WBC Highways Officer arrives at the scene	
08:30	-	Reports of flooding arrive at ML contact centre Residents begin requesting sandbags MP Officer requests assistance from WBC	MP
08:45	Extensive surface water flooding Floodwater reaches entrances to property on Town Meadow Lane	WBC Highways Officer completes road closure Police Inspector made aware and looks to secure sandbags MP advises Inrix (traffic link) about flooding MP advises WBC Street Scene about flooding	MP
09:00	Flooding spreads onto Felton Close Gardens on Wastdale Drive are flooded First report of property flooding Moreton	EA operatives arrive at the scene and checking structures for blockages Second NIRS report received by EA FIDO for Town Meadow Lane WBC begins organising further road closures with contractors Additional requests for sandbags from residents M&FR attends site meeting with MP. Both provide advice to residents	MP, MF&R, ML
09:15	EA operations team confirms Arrowe Brook is at capacity and that the adjacent flooding is due to surface water which is unable to effectively drain into the river system	MP Officer awaiting arrival of sandbags ML Property Surveyor and Technician arrive ML establishes 'Emergency Contact Point' at its contact centre	EA, MP, ML
09:30	-	ML Supported Housing Management Team begin acting as co-ordinators for residents	ML

Time	Flooding Impacts and Observations	Flood Incident Responses	Source
		unable to remain in their homes ML begins prioritising residents for re-location ML Technical Staff install pumps in communal areas in an attempt to reduce water levels	
09:45	Town Meadow Lane flooded to a depth of 18" and rendered impassable	WBC Street Scene confirms WBC Highways are assisting with road closures on Town Meadow Lane and Arrowe Road	MP, ML
10:00	Additional property flooding on Tern Way, Wastdale Drive and Town Meadow Lane Internal property flooding is up to a depth of 12"	WBC Street Scene confirms sandbags are unavailable in line with WBC policy EA Monitoring and Forecasting Duty Officer (MFDO) identifies that current forecast shows Flood Warning triggers will not be reached at Greasby Road	WBC
10:15	-	-	
10:30	Reports of external flooding at Meadowbrook Road	EA Site Controller moved onto Meadowbrook Road to investigate reports of flooding	EA
10:45	River levels on the River Birket at the Great Culvert Entrance reach ACT ENHANCE threshold.	EA MFDO Confident Flood Alert threshold will not be reached at the Great Culvert Entrance due to significant channel capacity	EA
11:00	Water level in the garden area of Town Meadow Lane reaches 8" above property thresholds Reports of external flooding on Brookdale Avenue	WBC Call Centre receives reports of flooding of properties on Tern Way	WBC, ML, EA
11:15	-	MF&R assists with evacuation and isolating electrics	MP, MF&R
11:30	Water level at Wastdale Road is approximately 18" above property thresholds	ML isolates gas and electrics in all accessible properties ML attempts to contact WBC Head of Corporate & Community Safety (unsuccessful)	ML
11:45	River levels on the River Birket at the Great Culvert Entrance continue to rise, river levels on the Arrowe Brook at Greasby Road begin to fall	-	
12:00	Property flooding at Carnoustie Close	-	WBC
12:15	Approximately 50+ properties are confirmed as having flooded at Tern Way	Additional pair of EA Site Controllers dispatched to Tern Way MF&R reach decision to begin evacuating properties as water levels continuing to rise	EA
12:30	-	ML request support from WBC EP team	WBC
12:45	-	-	
13:00	EA FWDO confirms tidal levels at Great Culvert Entrance should not be resulting in flooding on the River Birket or Arrowe Brook Majority of the flooding is understood to be surface water flooding at this time	ML attend a join on site meeting with EA and MF&R EA attempts to contact WBC (unsuccessful) WBC Highways confirms WBC sandbag policy with ML EA Flood Incident Room opened WBC Highways contractors arrive at site EA discuss issuing Flood Alert for the Wirral catchment due to surface water flooding even though Flood Alert/ Flood Warning trigger levels have not been reached (a decision is made not	ML, EA, WBC

Time	Flooding Impacts and Observations	Flood Incident Responses	Source
		to issue an alert as surface water not EA remit)	
13:15	-	-	
13:30	-	WBC Council staff put on standby to assist reception centre with relocation: ML primarily leading as most affected residents are ML tenants	WBC
13:45	-	-	
14:00	-	MF&R leave site - unable to do anything further	ML
14:15	-	-	
14:30	Flood Alert threshold for the Wirral catchment is reached at the Great Culvert Entrance	Flood alert issued for Wirral Catchment as trigger level reached at the Great Culvert EA Site Controller confirms properties at Tern Way flooded up to a depth of 24"	EA
14:45	-	-	
15:00	-	-	
15:15	-	-	
15:30	Floodwater begins to recede at Tern Way	--	EA
15:45	-	-	
16:00	-	EA Incident Room closed	
16:15	-	-	
16:30	-	ML Security Team delivers sandbags to affected residents	ML
16:45	-	-	
17:00	-	EA operations teams leave site	EA

5.3.3 Flooding Photographs

Contextual photographs of the flooding at Moreton are shown in Photograph 5-18 through to Photograph 5-21.

Photograph 5-16 Arrowe Brook Looking to Tern Way (2/9/15)

Photograph 5-17 Flooding at Tern Way (2/9/15)

Photograph 5-18 Tern Way Flats (2/9/15)

Photograph 5-19 Wastdale Drive (2/9/15)

Photograph 5-20 Flooding at Tern Way (2/9/15)

Photograph 5-21 Flooding at Tern Way (2/9/15)

5.3.4 Site Observations

The AECOM site walkover on the 2nd of March 2016 prioritised residents and the areas identified within the estimated flood outline produced by the Environment Agency local area team following the event. The Arrowe Brook was observed as being in relatively good condition, with little debris and freely flowing. The watercourse is relatively straight with clearly defined uniform banks on each side of the river. The topography of the adjacent floodplains is flat, with a limited change in level between the bank crests and the neighbouring properties (Photograph 5-22).

Photograph 5-22 The Arrowe Brook in Morton (Looking Upstream) (2/3/2016)

A number of large surface water outfalls (of varying diameter) were also observed along this reach of the Arrowe Brook. Several of these outfalls were visibly blocked at the trash screen and potentially retaining water within the drainage system.

Photograph 5-23 Blocked Surface Water Outfall (2/3/16)

Photograph 5-24 Vacant & Refurbished Flats at Moreton (2/3/16)

A significant number of the ground-floor flats on Tern Way were observed as being vacant or having being recently refurbished. It was not evident from the site walkover if this refurbishment process also included retrofitting flood resilience measures. Given the significant number of vacant properties there was a limited opportunity to engage in dialogue with local residents about the flooding. However, the survey team were able to attend a previously arranged visit with a resident to discuss the flooding that occurred, RMA response and to provide bespoke advice on property resilience measures.

The site walkover identified recent evidence of increased water levels immediately upstream of the Rail Bridge as evidenced by a series of wrack marks just below the crest levels of the river banks (Photograph 5-25). This indicates that the capacity of the Rail Bridge may potentially throttle flows during times of flood which could result in a backwater effect and lateral spilling into the adjacent floodplain.

Photograph 5-25 Arrowe Brook Railway Bridge (2/3/16)

A pre-arranged visit with a local resident at Moreton indicated that the Town Meadow Lane Road Bridge may have acted to constrict flows which could have resulted in a local backwater effect which impacted on the properties upstream.

Following the 2nd September flood event members of the community raised concern about a temporary crossing over the Arrowe Brook downstream of the Rail Bridge in Moreton. At the time of the flooding UU were upgrading the sewer network to alleviate surface and foul water flooding and, as part of this work, had a temporary crossing over the Arrowe Brook which was consented by the Environment Agency.

These temporary crossings are intended to be constructed such that at high flows they overtop. Photographs of the structure are shown in Photograph 5-26 and Photograph 5-27.

Photograph 5-26 Arrowe Brook, UU structure (post-event photograph)

Photograph 5-27 Arrowe Brook, Looking North Across the UU structure, 09:38, 2/9/15

Left image is reproduced from: http://chrisblakeley.com/2015/09/11/did-this-damn-contribute-to-the-floods-in-moreton-last-week/

Right image is courtesy of the Environment Agency

5.3.5 Flooding Mechanisms

The flooding that was experienced in Moreton was a result of several interlinked flooding mechanisms that fall under the remit of multiple RMAs. This section provides a detailed account, description and explanation of the flooding mechanisms.

5.3.5.1 River Flows

As outlined in Section 3.3, the Environment Agency operates a gauging station on the Arrowe Brook at Acton Lane. This station is located approximately 800m upstream of the flooding that occurred in Moreton. This gauging station enables the Environment Agency to estimate river flow based upon river level (stage) and a series of mathematical equations that describe the hydraulic properties of the gauging site.

Based upon the observations recorded during the 2nd September flood event, the Environment Agency estimate that the recorded peak water level on the Arrowe Brook corresponds with a river flow of 11.7 m^3/s. This is stated as being approximately equivalent to a 1 in 75 year fluvial return period on the Arrowe Brook. This is also the largest observed flow since records began at the site in 2006.

5.3.5.2 Modelling and Mapping Studies

River Modelling

The Environment Agency has a hydraulic model of the Arrowe Brook catchment. This is a computational model of the rivers, Fender, Birket, Arrowe Brook and other tributaries within the catchment. It should be noted that this model was designed specifically to map the fluvial flood risk from these watercourses and therefore has the following limitations:

- It does not represent the risk of flooding from surface water (i.e. rainfall falling directly on Moreton)
- It does not represent the risk of flooding from surface water drainage network (i.e. sewers running at capacity)
- It does not represent the interaction between river and the surface water drainage network (i.e. sewers flooding because they are unable to discharge due to high river levels).

The hydraulic model of the Arrowe Brook catchment has been used to create the Environment Agency's Flood Zone map for Moreton (Figure 5-6). Critically, the mapping shows that a 100 year flood event is modelled as remaining within the central channel area, whilst 1000 year river flows would be anticipated to flood large parts of the adjacent urban area.

Given that the observed flood flows on the Arrowe Brook on the 2nd September can be approximated to a 1 in 75 year river flow, the modelling and mapping studies indicate that this would not have been sufficient to cause the Moreton flooding in isolation.

Surface Water Mapping

Whilst the management of surface water falls under the remit of WBC as the LLFA, the Environment Agency has also produced the national Updated Flood Map for Surface Water in its Strategic Overview role in flood risk management. This mapping has been designed to indicate areas that may be at risk of surface water flooding for 30 year (high risk), 100 year (medium risk) and 1000 year (low risk) storms. It is important to note that this is national mapping product and does not represent reflect local detailed sewer drainage networks and is not designed to represent the risk of fluvial flooding from watercourses.

The Environment Agency's Updated Flood Map for Surface Water is shown in Figure 5-8. This mapping shows that several of the roads around Moreton are considered to be at high risk of surface water flooding from a 30 year storm event (including parts of Oakham Drive, Millhouse Lane, Town Meadow Lane and Tern Way). The mapping also shows that a significant proportion of the study area is at risk of flooding from surface water in a 100 year storm.

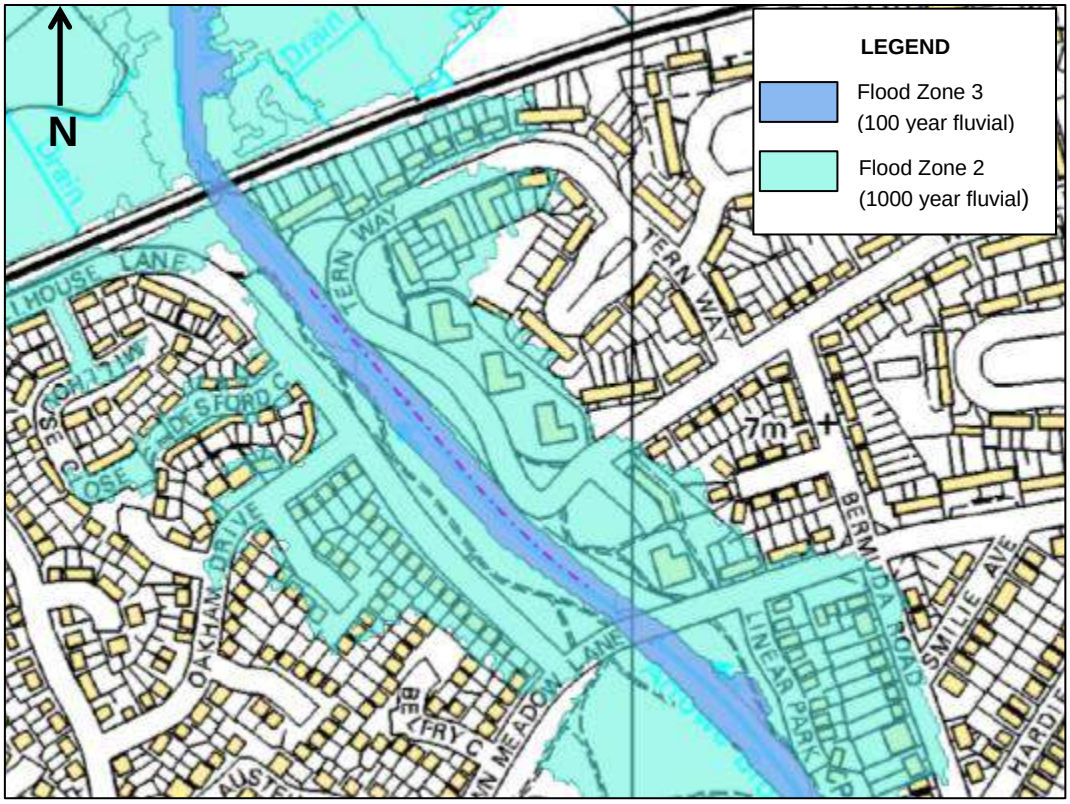


Figure 5-7 Environment Agency Flood Zone Map

Figure 5-8 Environment Agency Flood Map for Surface Water

5.3.5.3 Combined Mechanisms

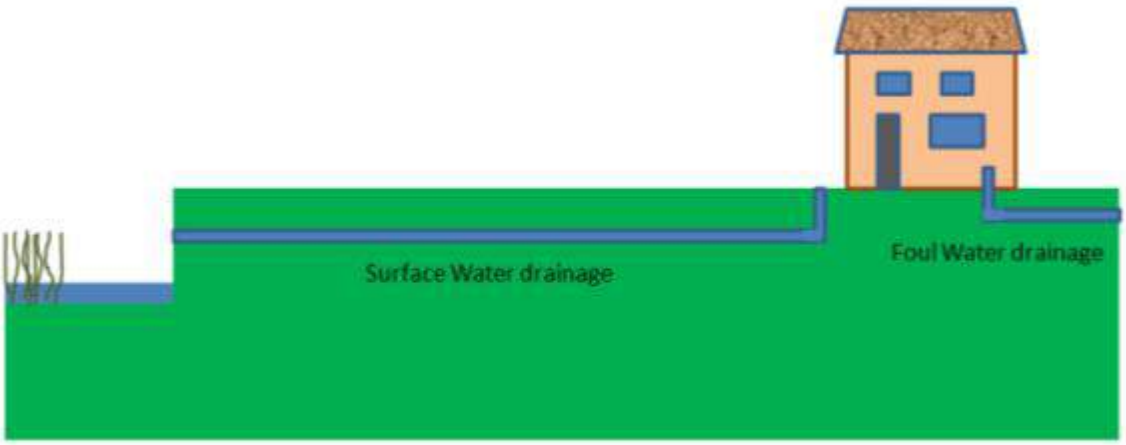
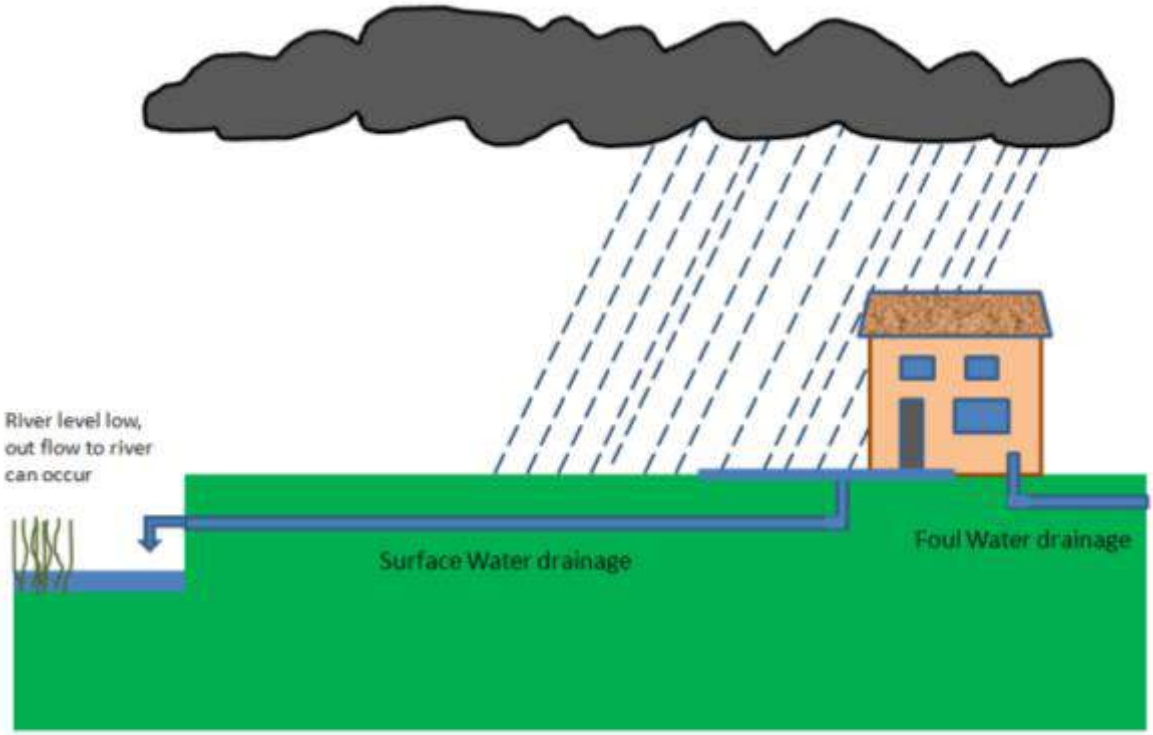
The recorded gauge data, models and mapping reviewed in the previous section demonstrates that the 2nd September 2015 in Moreton cannot be attributed to a single causative factor (i.e. the flooding was not just the result of large river flows on the Arrowe Brook). The flooding observations documented in the reconstructed Moreton timeline (Table 5-3) supports this conclusion; surface water flooding on Oakham Drive and Millhouse Lane was reported from 08:00 whilst the water level in the Arrowe Brook was still within the river banks.

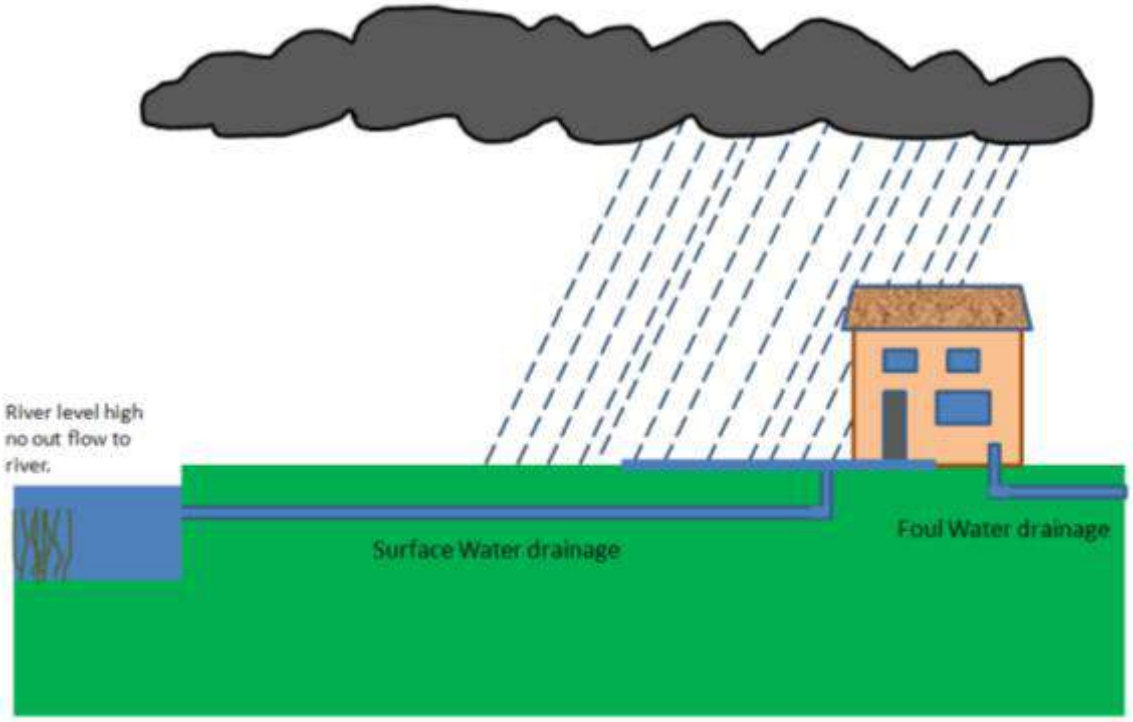
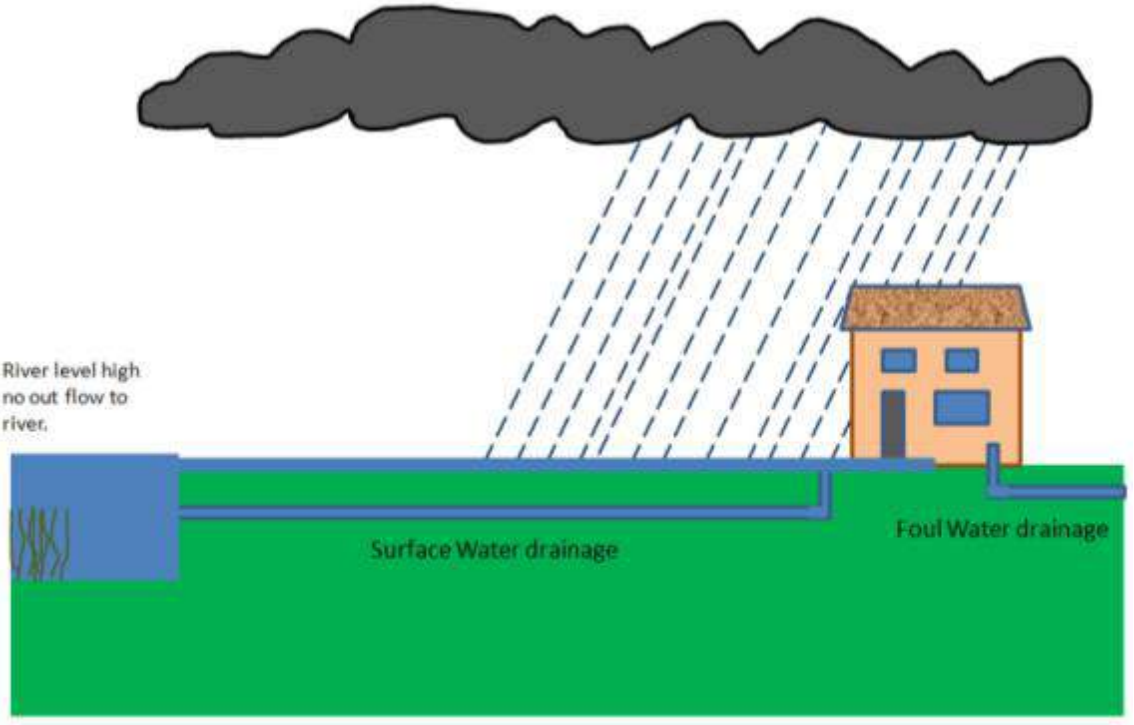
It is therefore concluded that the flooding was a result of a combination of the following flooding mechanisms:

1. Severe rainfall over a 48 hour period over the Arrowe Brook and River Birket hydrological catchments.
2. A progressive and gradual increase in the water stored within the catchments due to the flat coastal landscape and constrained outfall to the Mersey Estuary at the Great Culvert. This resulted in a backwater effect that restricted the ability of the River Birket to freely discharge at its downstream end near the Wallasey Float. This is supported by recorded levels at the Davis Road and Fornall Bridge gauging stations.
3. The initial pulse of rainfall on the 1st September reducing the capacity of the soils within the river catchments to absorb rain that subsequently fell on the 2nd September.
4. The second pulse of rainfall on the morning of the 2nd September resulting in a flood peak of 11.7m^3/s on the Arrowe Brook (approximately equivalent to a 1 in 75 year fluvial return period).
5. Intense rainfall falling directly on the urban area, exceeding the 1 in 20 year design standard of the UU surface water drainage network and resulting in severe surface water flooding.
6. Rising water levels within the Arrowe Brook preventing the UU surface water drainage network from freely discharging into the watercourse, resulting in ‘backing up’ and compounding the surface water flooding.
7. The Tern Way Bridge and Railway Bridge acting as a partial throttle on river flows on the Arrowe Brook, resulting in a localised backwater effect within Moreton.
8. All of the above items acting in tandem, resulting in a combination of surface water and fluvial flooding in Moreton.

The Environment Agency has provided a series of illustrations that demonstrate how some of these combined flooding mechanisms can occur (Table 5-4 overleaf)

Table 5-4 Flooding Mechanisms

Ref.	Flooding Mechanism
1	 Typical drainage network
2	 Flood Mechanism 1 : 'Pluvial' or surface water. Rainfall rate is greater than surface water network capacity and surface water ponding/flooding can occur.
	Graphics courtesy of the Environment Agency

Ref.	Flooding Mechanism
3	 Flood Mechanism 2 : Surface Water : Rainfall rate less than surface water network capacity but surface water outlet 'backed up' and surface water ponding/flooding can occur.
4	 Flood Mechanism 3 : River/surface combined: Rainfall rate less than surface water network capacity but surface water outlet 'backed up' and surface water ponding/flooding can occur, and river out of bank too.
	Graphics courtesy of the Environment Agency

5.3.5.4 Impact of the United Utilities Structure

Following the 2nd September flood event members of the local community raised concern that the temporary UU structure downstream of Moreton may have exacerbated the flooding that occurred.

In order to investigate the potential impacts associated with the as-built design of the structure the Environment Agency has used the hydraulic model of the Arrowe Brook to quantitatively assess the impacts. This investigation has used two versions of the hydraulic model of the Arrowe Brook (one with the UU structure and one without) for a series of return periods, including the 10, 20, 75 and 100 year design events. The modelling shows that both the Rail Bridge and the Town Meadow Lane Bridge cause a constriction to flow and result in an increase in water levels at either structure. In relation to the UU structure, the modelling investigation states:

> *"This 1D model has shown that the UU structure increases water levels upstream at Tern Way by 250mm to 150mm at the lower return periods (i.e. 10 to 20 year return periods).* ***At the higher return periods there are no differences observed from the structure****. This is because the catchment is very flat and the downstream boundary is the control"*
>
> Excerpt from the Environment Agency Flood Investigation Report: Wirral, September 2015, Version 2.0

As the observed flows on the Arrowe Brook can be approximated to a 75 year flood event, the hydraulic modelling therefore implies that the UU structure would not have had a significant impact on the peak river levels in the Moreton area.

United Utilities Flood Modelling Investigations

In addition to the investigative modelling works undertaken by the Environment Agency, UU also commissioned an independent report to understand whether the temporary crossing on Arrowe Brook had led to the flooding in Moreton on the 2nd September 2015. The modelling looked at scenarios with and without the temporary crossing in place. The report concludes that the flooding would have occurred without the structure in place due to the severe weather and rainfall event that was experienced.

5.3.6 Flood Warnings

Under the Land Drainage Act 1991 and the FWMA 2010 the Environment Agency has permissive powers to issue flood warnings communities at risk of flooding. It should be noted that is a permissive power and is not a statutory duty.

The areas of Moreton that were affected by flooding on 2nd September 2015 are covered by the Environment Agency's Flood Warning Service. The Flood Warning Area is Moreton Brook (ME08 Arrowe Brook at Moreton West[17]). This Flood Warning Area is intended to provide residents with warning of potential fluvial flooding from the Arrowe Brook. It should be noted that this FWA is not intended to provide warning of other sources of flooding (such as that arising from surface water, ordinary watercourses, sewers and groundwater).

At the time of the flood event the flood warning service at Moreton was based on a simple trigger model that used the 15 minute interval data from the level gauge at the Greasby Road gauge. Under these procedures the Environment Agency would have issued Flood Warnings to the Moreton FWA (ME08) once the river level exceeded a predefined threshold at this location.

The Environment Agency did not issue a Flood Warning for the Moreton FWA as the predefined threshold level at the Greasby Road gauge was not met. This was correct in terms of the flood warning procedures at the time as the recorded flows on the Arrowe Brook would not have been sufficient to cause flooding in Moreton in isolation. The recorded river levels for Greasby Road and the associated trigger levels for issuing a Flood Warning are shown in Figure 5-9.

A Flood Alert was later issued at 14:26 BST for the Birket catchment as river levels on the River Birket exceeded the Flood Alert threshold at the Great Culvert. The Flood Alert was therefore issued approximately 4.5 hours after the fluvial peak in Moreton.

[17] Arrowe Brook at Moreton West: http://apps.environment-agency.gov.uk/flood/34681.aspx?area=013FWFME8&page=1&type=Fwacode

Figure 5-9 River Levels and Flood Warning Trigger Levels at Greasby Road (2nd September 2015)

Graphic courtesy of the Environment Agency. Levels are to local gauge datum and are not to mAOD.

As Section 5.3.5.3 concludes, the flooding that occurred in Moreton was not solely attributable to the river levels within the Arrowe Brook; the flooding resulted from a combination and interaction of surface water, sewerage and fluvial flooding mechanisms. Though surface water and sewer flooding do not directly fall under the remit of the Environment Agency, it has since revised its flood warning procedures to include an additional threshold level at the Acton Lane gauging station. This additional threshold level is now being used to provide Moreton with a targeted flood warning service.

5.3.7 RMA Response to Flooding

Beyond the immediate incident response other relevant RMA actions in this area include:

- The Arrowe Brook was last maintained by the Environment Agency in April 2015. The maintenance included vegetation clearance, debris removal and routine grass cutting. Prior to the flooding incidient it was due to be maintained again (mechanical cut and de-weed) during the autumn of 2015.
- Environment Agency operations staff were inspecting for and clearing blockages before and during the flood event. Priority grid run clearances were carried out prior to flooding due to previous heavy rainfall on the 1st September.
- Though the Environment Agency's Flood Warning trigger level at Greasby Road did not reach the predefined threshold, a Flood Alert was later issued when levels at the Great Culvert were met. This was correct in terms of the flood warning procedures at the time of the event.
- The Environment Agency's post incident response commenced immediately following the event and over the following weekend, with teams out supporting the community, gathering data and checking our assets.
- A drop in session was also held at Moreton Community Centre on Wednesday 16th September 2015, with representatives from WBC, EA and UU on hand to speak to residents about cleaning up the damage, emergency planning and how to prepare for any future floods.
- The Environment Agency have undertaken post-event analysis on the criticality of the rainfall and hydraulic modelling to verify the potential effect of the consented temporary works crossing on the Arrowe Brook downstream of Moreton
- Following the 2nd September 2015 flooding the Environment Agency has since revised its flood warning procedures to include an additional threshold level at the Acton Lane gauging station. This additional threshold level is now being used to provide Moreton with a targeted flood warning service
- WBC has commissioned this Section 19 Report to investigate the flooding issues, with emphasis on the community concern about the consented temporary works crossing
- UU has undertaken post-event investigations to verify the cause of the sewer flooding issues in the area

5.3.8 Recommendations for Action

The following recommendations for action are made for the Moreton area:

- Wirral MBC, the EA and United Utilities should work together to produce an integrated fluvial and surface water model to cover this area of the Wirral. This model would better simulate the interactions between the rivers, sewer and surface water networks to enable us to better understand flooding mechanisms. It is understood that the RMAs are currently considering this modelling as part of a larger project covering the whole Wirral area that is currently scheduled to start in 2017.
- Following the flooding members of the public expressed concern about the consented structure over the Arrowe Brook. Whilst this structure had been granted an Environmental Permit by the Environment Agency, this had not been communicated to WBC prior to the event. WBC as the LLFA and the EA should work together to increase communications in relation to where Environmental Permits and Ordinary Watercourse Consents have been granted in Wirral.
- WBC, EA and UU should continue to engage with the residents in Moreton to improve the community's understanding of the combined flood risk and how to take measures to increase their resilience and preparedness for flooding in the future.

5.4 North Cheshire Trading Estate, Prenton

5.4.1 Site Overview

The North Cheshire Trading Estate is located between the M53 motorway, the A552 and the Prenton Brook (an Environment Agency main river). Access to the trading estate can only be obtained via a minor road off the Junction 3 roundabout of the M53. Whilst the North Cheshire Trading Estate does not contain any residential properties, access and egress was inhibited by fluvial flooding of the Prenton Brook during the 2nd September 2015 event.

A site location map is shown in Figure 5-10.

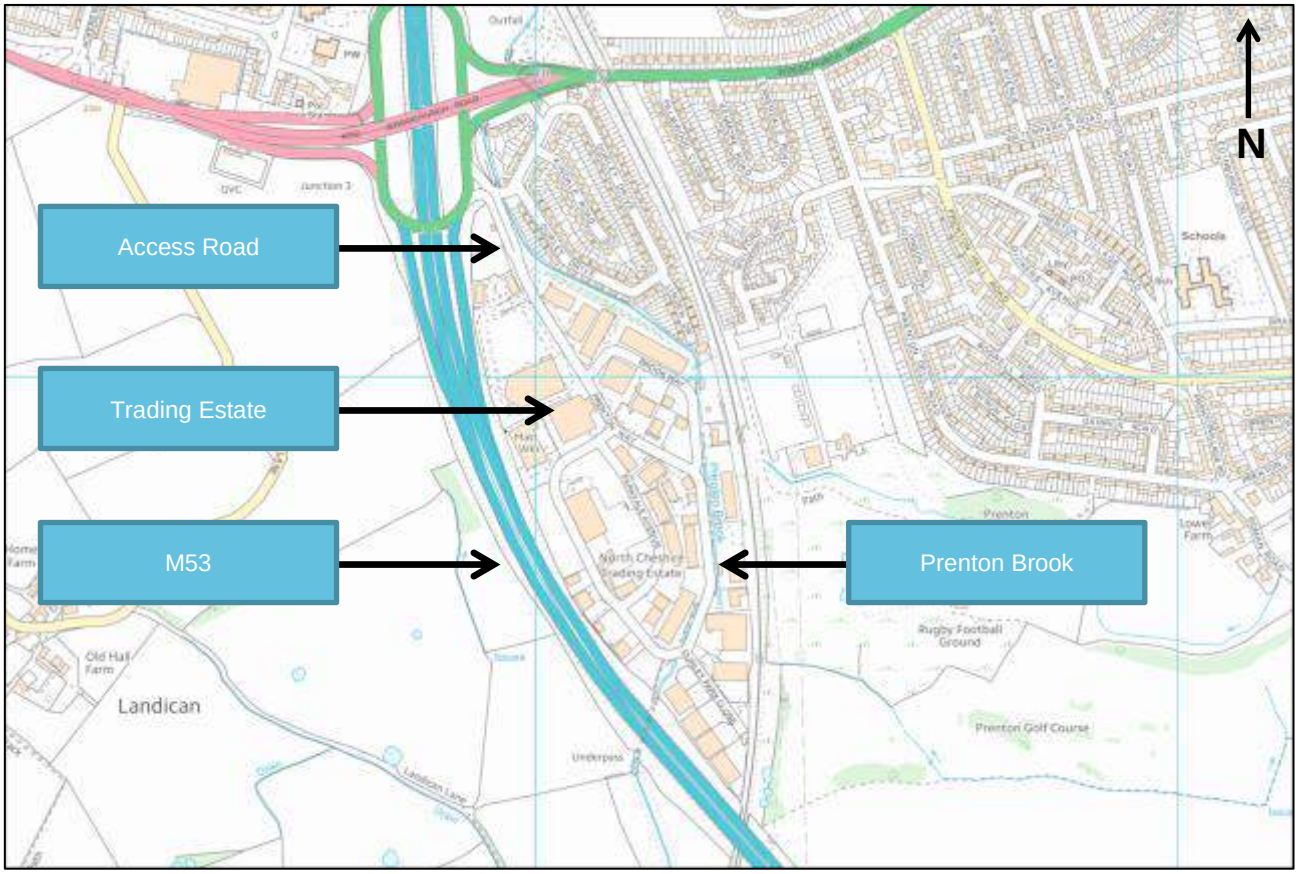


Figure 5-10 North Cheshire Trading Estate, Prenton

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SP Energy Networks operates a major office at the North Cheshire Trading Estate. This serves a number of functions:

- It is the 24 hour control room which serves the electricity distribution network for 1.5m homes and businesses in Merseyside, Cheshire and North Wales.
- It is the local depot for engineering and industrial staff for the network in the Wirral and Chester area.
- It is the centre of design and planning activities for the Merseyside and North Wales Electricity Board area.

As part of the scope of this Section 19 Flood Investigation AECOM has consulted with SP Energy Networks to gather any relevant information about the flooding at this location. SP Energy Networks advised that solitary access road into the North Cheshire Trading Estate was impassable for approximately 4 hours and that this had a major impact on its operations. Night staff were unable to leave the estate and replacement staff were unable to relieve them. Depot and head office staff were unable to get in to start their normal working day. It is understood that the flooding at the North Cheshire Trading Estate did not result in any internal flooding.

An approximate timeline of the flooding was produced by SP Energy Networks and is shown in **Table 5-5**.

Table 5-5 North Cheshire Trading Estate: SP Energy Networks Flooding Timeline

"7am. Road was impassable. Police had closed the access road to all vehicles at some point (unable to confirm time from our staff).

7:15am. Control room staff had alerted managers to the problem and managers started to alert staff on route to work. We use a cascade system.

8:40am. I spoke to the EA in Warrington to find out what the EA view was on the flooding. The EA was unaware of the difficulties at this location until the call but had staff on the Wirral who were going to attend to see if there were any blockages to clear.

9am. Our depot and design teams were activating to temporarily run their operations from our training centre in Hoylake.

For the control room, the night staff were continuing to work on, but we were wanting to make a decision on moving to our back-up location in Wrexham. We were also concerned about how to get the staff home. Police on the road block had no information as to when the road would be passable. We tried to contact the Wirral BC civil contingencies team both in their office and on mobiles. Mobiles were unobtainable (network busy) and staff were struggling to get into the office. Spoke to WBC before 10am.

9:45am. Staff persuaded the police to allow a high wheel base 4 wheeled drive vehicle to set-up a shuttle through the flood and a few staff were able to get into the estate that way.

10am. EA advised that there was no blockage causing the flood, just the volume of water coming down Prenton Brook. The flow was reducing and waters were starting to recede and access should be possible within the hour.

10:30am. Road became passable and business gradually recovered to normal during the rest of the morning. Updated WBC that our situation was relieved."

Flooding timeline courtesy of SP Energy Networks

SP Energy Networks have also provided photographs of the access road flooding at the North Cheshire Trading Estate as shown in Photograph 5-28 and Photograph 5-29.

Photograph 5-28 Flooding on Prenton Way (2/9/15)

Photograph 5-29 Flooding on Prenton Way (2/9/15)

Images Courtesy of SP Energy Networks

5.4.2 Site Observations

The survey team undertook a walkover of the estate, starting at the southern aspect just short of where the Prenton Brook is culverted beneath the M53. The watercourse, which flows south to north, is maintained channel which is covered by horizontal screens along the majority of its length. There was evidence that Environment Agency operatives had recently undertaken channel clearance and debris removal.

Standing surface water was observed in the road located immediately north of the junction with the Prenton Way Business Units. This is also located at a low spot in the topography of Prenton Way between the M53 and the remainder of the Trading Estate. This low spot is also adjacent to an open section of the Prenton Brook which has a relatively shallow embankment relative to the water level in the channel.

The survey team also observed an access bridge to Durley Drive over the Prenton Brook. The soffit level of this structure is relatively low compared to the deck level of the access road. Based upon these observations it was considered that this structure could potentially impact on the conveyance of flow during high water levels. This could potentially lead to a backwater effect which could result in lateral spilling over the low bank levels. Blockage of this structure could exacerbate flood risk, though the active Environment Agency operations teams found no evidence of a blockage occurring during the 2nd September 2015 flooding.

Photograph 5-30 Low spot on the Prenton Way (3/5/15)

Photograph 5-31 Access Bridge to Durley Drive

Photograph 5-32 The Prenton Brook

5.4.3 Flooding Mechanisms

Following a review of the historic flooding information, meteorological conditions, stakeholder consultation and site observations it is anticipated that the flooding at the North Cheshire Trading Estate was a result of:

- A significant volume of fluvial floodwater being routed through the Prenton Brook.
- River level exceeding the capacity of the open sections of the Prenton Brook, particularly around the northern aspect of the North Cheshire Trading Estate where the gradient of the channel reduces.
- A low spot in the topography of the Prenton Way acting to retain fluvial floodwater until the flood peak had passed
- Potentially a backwater effect from the Access Bridge to Durley Drive, though this would need to be confirmed via a river modelling study.
- Surface water compounding the fluvial flooding, particularly if the UU surface water sewer outfalls to the Prenton Brook were unable to drain due to elevated water levels within the watercourse.

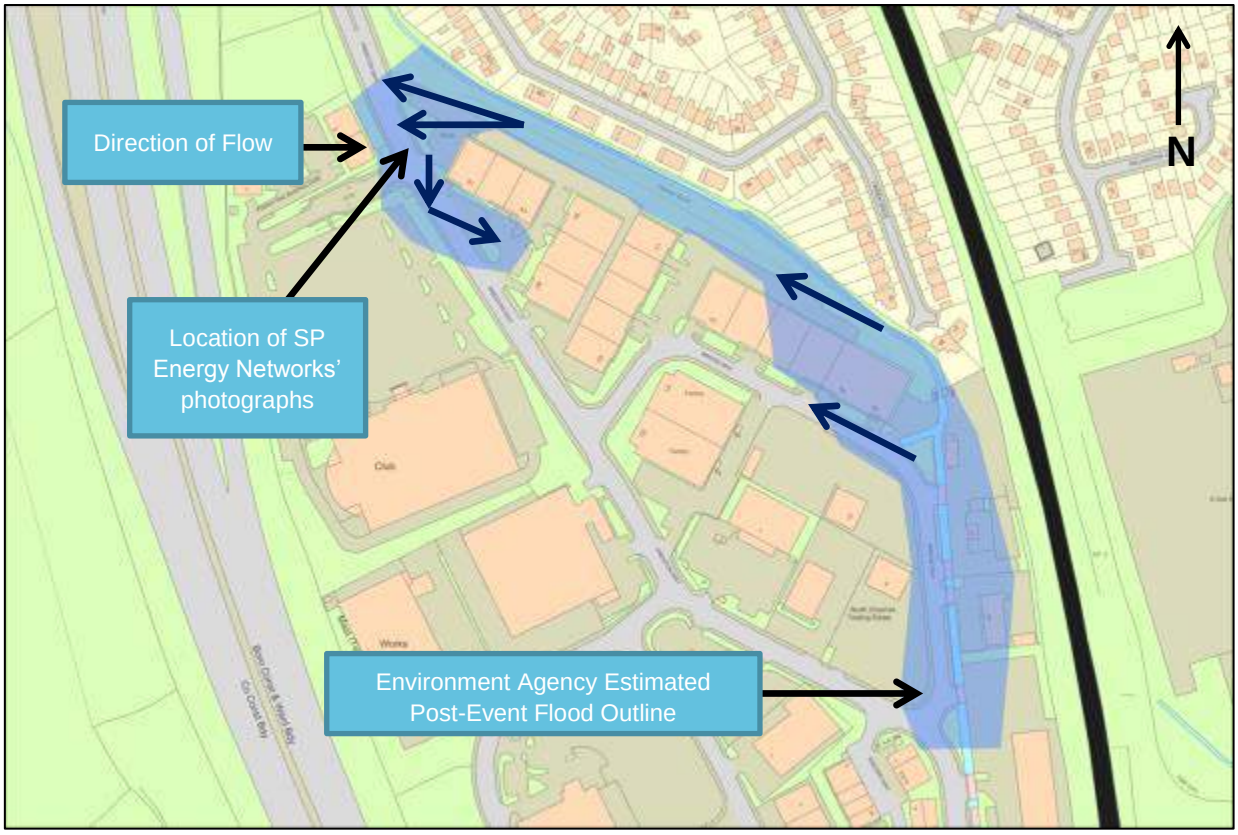


Figure 5-11 Flooding Mechanisms at the North Cheshire Trading Estate

5.4.4 RMA Response to Flooding

Based upon the information collected as part of the scope of this Flood Investigation it is understood that the RMA and emergency response at this location was as follows:

- Merseyside Police were called out shortly after the overtopping and preventing cars from entering the estate and later prevented all access/ egress after being advised by the Environment Agency. The M53 was closed for approximately 30 minutes.
- An Environment Agency operations team was dispatched to inspect the watercourse for blockages following notification of the flooding
- The Environment Agency organised a Multi-Agency Meeting on the 12th November with business from the North Cheshire Trading Estate. This was also attended by representatives from WBC and UU.
- Environment Agency operatives have since been on site undertaking maintenance works (Photograph 5-33)

Photograph 5-33 Environment Agency Operations Team

5.4.5 Recommendations

During times of flood access and egress to the site may be impossible due to the boundaries created by rising floodwater, the M53 and the Prenton Brook. Whilst implementing alternative access routes may be technically and economically challenging, WBC should look to undertake a feasibility study to determine if access and egress can be feasibly improved (i.e. via a pedestrian footbridge). This study may present further opportunity for Partnership Working with SP Energy Networks and other business on the North Cheshire Trading Estate.

Both WBC and the EA should also look to liaise with the landowners and commercial businesses on the North Cheshire Trading Estate to develop emergency flood planning that details aspects such as:

- How staff will be protected;
- A register of staff who may require assistance in the event of a flood;
- Key contacts at the RMAs and emergency services;
- How hazardous equipment will be managed; and,
- Road closure procedures.

The Environment Agency may wish to consider implementing telemetry on the Prenton Brook (i.e. a level gauge) and the use of a trigger level to provide Flood Warnings to the commercial businesses on the North Cheshire Trading Estate.

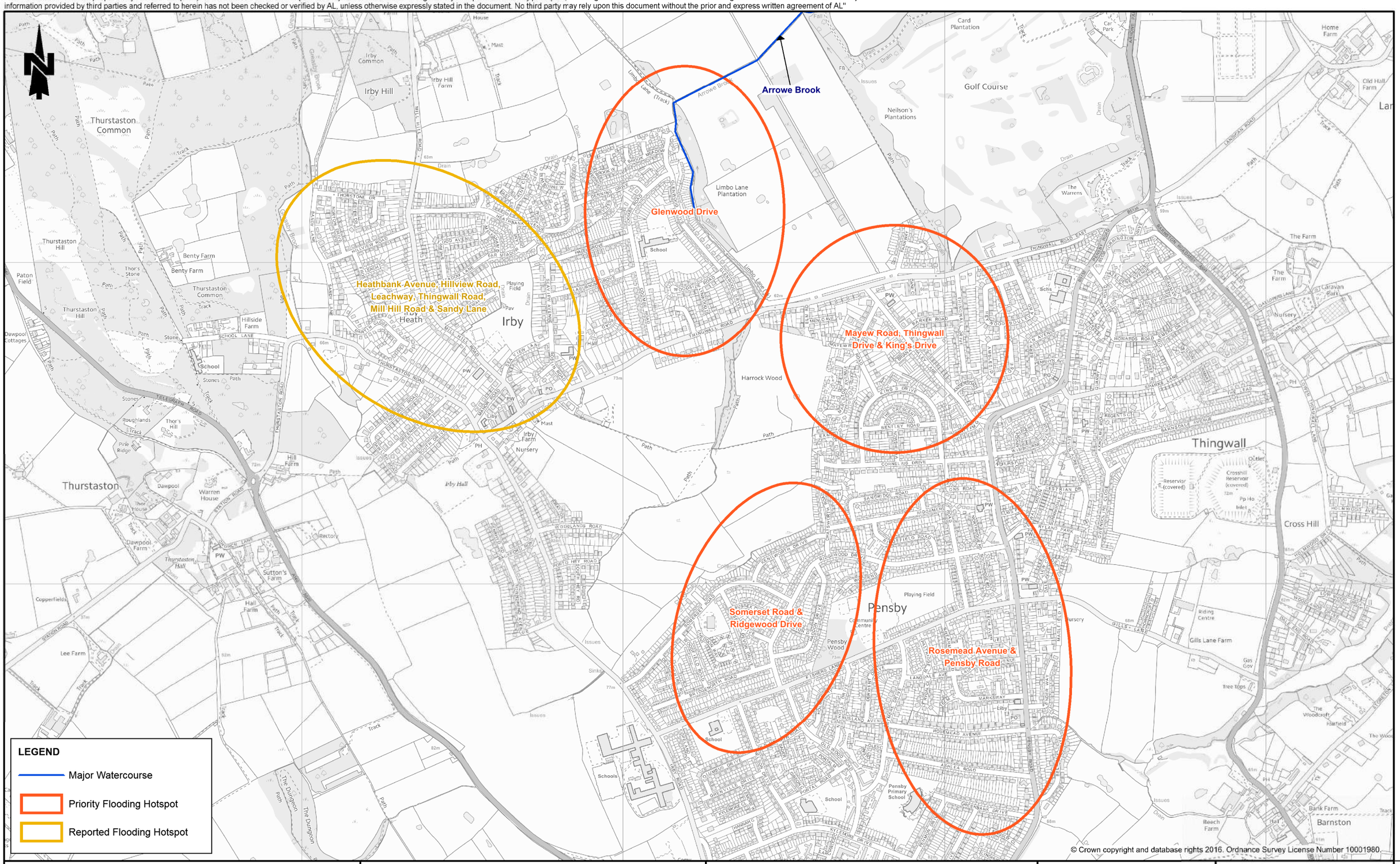
It may also be necessary to review the Environment Agency Flood Zone Maps for the Prenton Brook as these do not presently show the risk of fluvial flooding from the watercourse which was observed during the flood event.

5.5 Irby, Pensby and Thingwall

Irby, Pensby and Thingwall are three neighbouring villages in the centre of the Wirral Peninsula.

The stakeholder consultation and data review described in Section 4 identified multiple reports of property and highway flooding during the 2nd September 2015 event. The majority of these issues relate to surface water, sewers and ordinary watercourses. The main rivers were not reported as having caused any flooding issues within this location.

The data review has been used to delineate flooding hotspots, as shown in Figure 5-12.



Client: WIRRAL

Project: SECTION 19 FLOOD INVESTIGATION 22ND AUGUST AND 2ND SEPTEMBER 2015

Title: IRBY, PENSBY & THINGWALL FLOODING HOTSPOTS

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Design:	AB	GIS:	AB
Chk'd:	RJ	App'd:	RJ
Date:	22-03-2016	Scale:	1:11,000@A3

No. FIGURE 5-12 Rev: 0

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5.5.1 Glenwood Drive, Irby

The initial data screening indicated three potential flooding hotspots on Glenwood Drive. No visual evidence of flooding was apparent at all three locations along the road during the site visit. Local residents indicated that there are minor surface water pooling issues on the pavement at the southern end of the estate. This is not anticipated to be a major issue that results in an impact on property or vehicular access. No residents were available to comment on the second grouping of reported incidents midway along Glenwood Drive.

There was some evidence of localised waterlogging at the third grouping at the north of the estate which may be attributable to surface water shedding from the main highway onto the adjacent common land. One resident indicated that minor external flooding had occurred historically but otherwise declined to comment further.

UU has stated that their investigations into the area have confirmed that the flooding was a result of the 1 in 20 year design standard of the sewers being exceeded due to the exceptional severity of the weather, resulting in the external flooding of the highways shown in Figure 5-13.

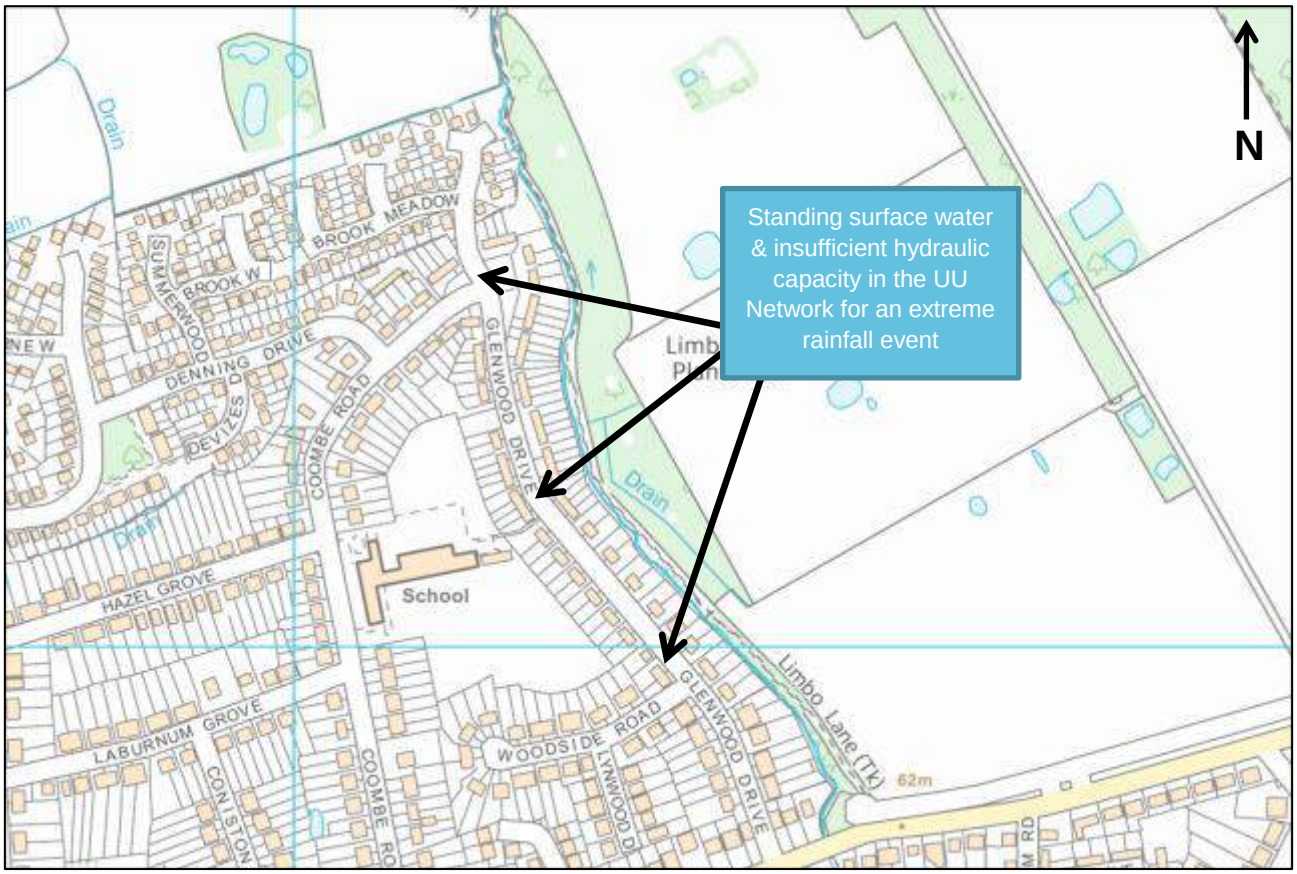


Figure 5-13 Irby Flooding Mechanisms

5.5.2 Mayew Road, Thingwall

The data screening exercise in Section 4 highlighted that UU records indicated a number of reported incidents on Mayew Drive in Pensby. The survey team were successful in speaking to one local resident who indicated that Mayew Road is unadopted highway and that it receives surface water from the adjacent highway during intense rainfall.

As no formal drainage is present on the unadopted highway the surface water flow is routed onto the neighbouring properties due to the gradient and the topography. Whilst this has not resulted in internal flooding historically, the resident indicated that there are issues with damp and that they had installed local drainage measures on the drive to compensate.

Photograph 5-34 Unadopted Highway on Mayew Road (2/3/16)

5.5.3 Thingwall Drive, Thingwall

The AECOM survey team attended a pre-arranged visit with two residents on Thingwall Drive. The residents provided an account of the repeat flooding that occurs on Thingwall Drive (which included the 2nd September 2015 flood event). The residents advised that the flooding is a result of surface water exceeding the capacity of the local drainage network which subsequently ponds in a topographic low point outside their property.

The residents advised that the flooding has occurred approximately 10 times in the last 15 years and has resulted in severe stress and property damage. The residents advised that they had implemented a number of resilience and emergency mitigation measures (pumps, air brick covers) themselves.

The residents confirmed that whilst the majority of the flooding just affects their property, the 2nd September 2015 event affected a number of their neighbours and required UU to pump out floodwater. UU has stated that their investigations into the area have confirmed that the flooding was a result of the 1 in 20 year design standard of the sewers being exceeded due to the exceptional severity of the weather, resulting in the external flooding of highway.

The survey team spoke about additional flood resilience measures that could be potentially implemented, though it was apparent that the greatest issue was the slope, topography and localised low spots of the pavement immediately outside of the resident's property. A resident also provided photographs of flooding at the other end of Thingwall Drive (Photograph 5-36) which also confirms that the surface water issues are prevalent elsewhere along the estate.

Photograph 5-35 Surface Water Flooding at Thingwall Drive (Unknown Date)

Image Courtesy of a Local Resident

Photograph 5-36 Surface Water Flooding at Thingwall Drive (2/9/15)

Image Courtesy of a Local Resident

5.5.4 King's Drive, Thingwall

The survey team spoke to two residents on King's Drive. The first resident indicated that there had been no flooding, however, the second stated that the fire service had been called out following major rainfall (though they could not remember the date that this occurred). The resident advised that the fire service had been in attendance to pump water out of the road, though they had not had any flooding issues since then.

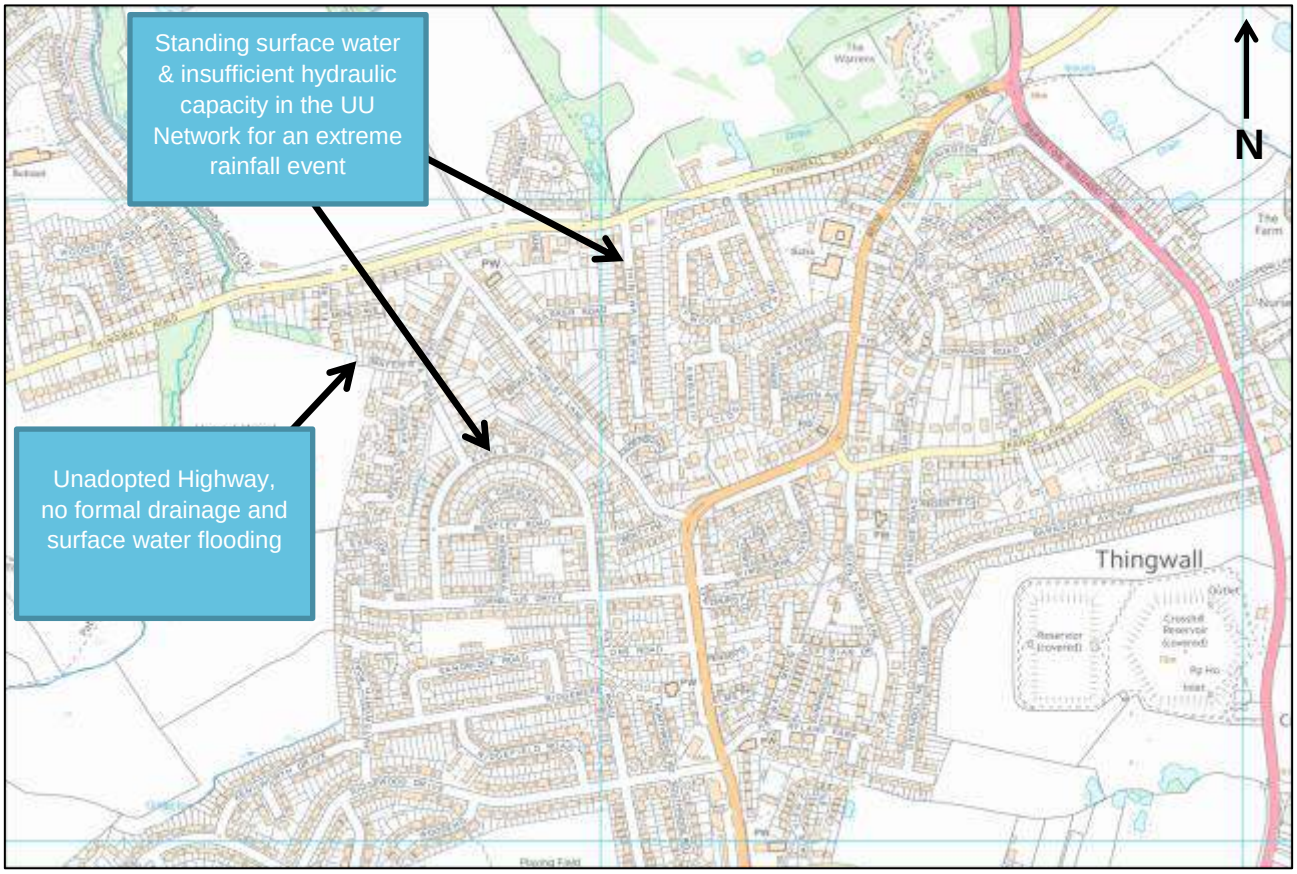


Figure 5-14 Thingwall Flooding Mechanisms

5.5.5 Somerset Road, Pensby

The survey team started the walkover at Somerset Road with a pre-arranged visit at a resident who had been affected by flooding historically. The resident indicated that she awoke in the night due to disruption outside and was surprised to find that her home was completely surrounded by surface water. It was understood to be a result of the capacity UU sewer network being exceeded which consequently led to surface water being conveyed along Somerset Road and flowing down the drive to her home which is significantly below road level. The resident confirmed that UU have been active in retrofitting property resilience measures both for her and her neighbours further up the road following the event. These measures were relatively comprehensive, including waterproofed brickwork, non-return valves and flood doors.

Dialogue with additional residents confirmed UU has been particularly active along the road following the flooding, implementing additional resilience measures and undertaking further maintenance and clearance along Somerset Road.

UU has stated that their investigations into the area have confirmed that the flooding was a result of the 1 in 20 year design standard of the sewers being exceeded due to the exceptional severity of the weather, resulting in the external flooding of highway.

Photograph 5-37 Somerset Road (3/3/16)

Photograph 5-38 Ridgewood Drive (3/3/16)

5.5.6 Ridgewood Drive

The survey team attended another pre-arranged visit with a resident on Ridgewood Drive who confirmed that the historic flooding issues were very similar to those that occurred on Somerset Road (the adjoining road). Following heavy rainfall water exceeds the capacity of the local drainage network and results in external flooding around a number of properties in this area. The resident stated that the flooding had not resulted in any internal property damage.

5.5.7 Rosemead Avenue / Pensby Road

The survey team undertook a visual inspection of the land around Rosemead Avenue and attempted to make contact with a number of local residents, though none were available to comment. The visual inspection indicated that the junction of Rosemead Avenue with Pensby Road is at a low spot in the topography and that a number of the gullies were full of standing water. A significant amount of water was heard moving beneath a manhole, potentially indicating the presence of a storm drain or culverted watercourse. The design standard of the surface water sewer network at this location may well be exceeded following heavy rainfall.

UU has stated that their investigations into the area have confirmed that the flooding was of a blockage in a private asset.

5.5.8 Flooding Mechanisms

Following a review of the historic flooding information, meteorological conditions, stakeholder consultation and site observations it is anticipated that the flooding across this area was a result of:

- The 1 in 20 year hydraulic capacity of the surface water sewers being exceeded due to the intensity of the 2nd September rainfall.
- Localised variations in highways topography (i.e. at Thingwall Drive and Somerset Road) routing floodwater towards properties.

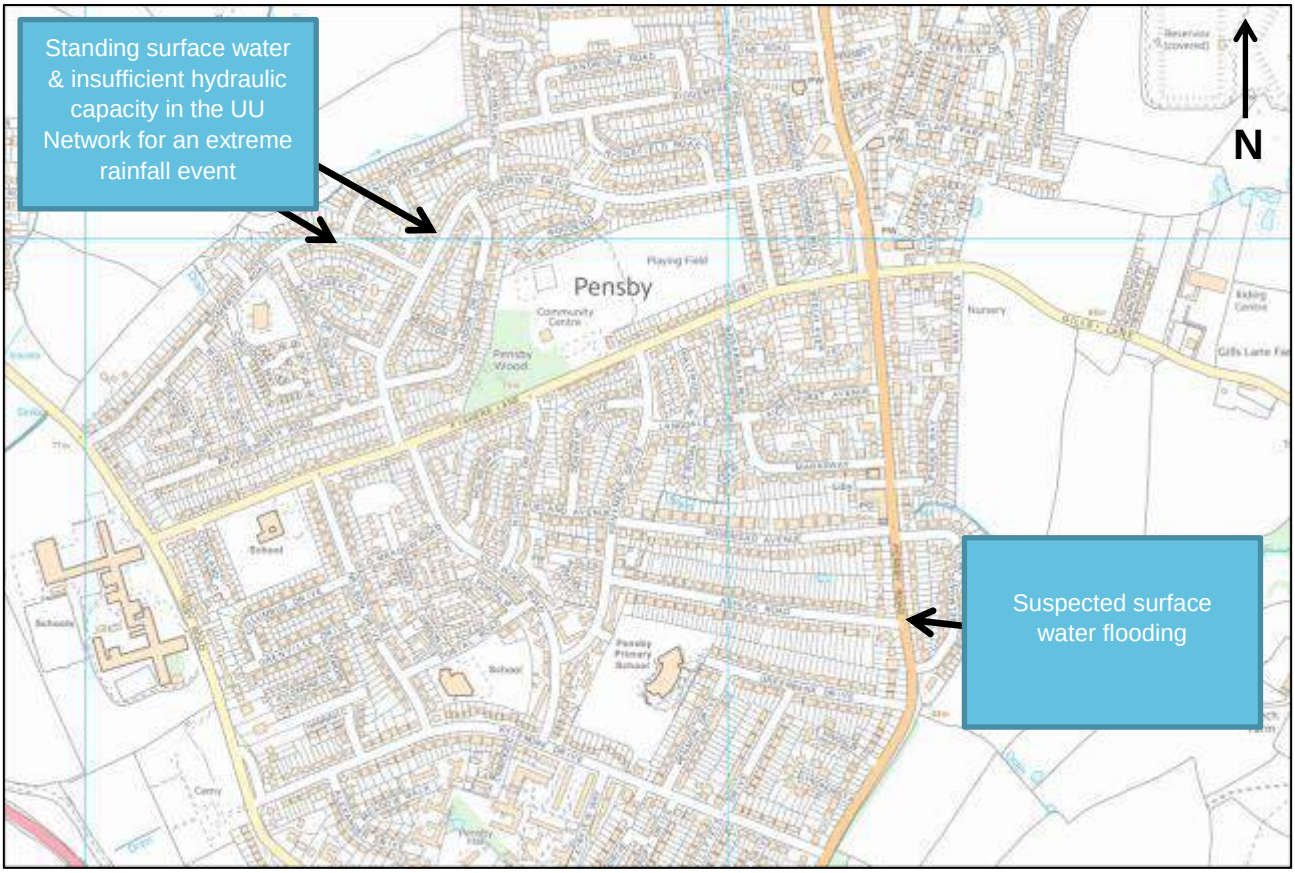


Figure 5-15 Pensby Flooding Mechanisms

5.5.9 RMA Response to Flooding

Based upon the available information AECOM understands that other relevant RMA actions in this area include:

- WBC has commissioned this Section 19 Report to investigate the flooding issues.
- UU has investigated all flooding incidents that were reported to UU and has undertaken a verification exercise to understand the issues and flooding mechanisms. This included site visits and CCTV survey to determine if there were any blockages in the network. Any blockages encountered during the investigations were cleared to ensure that the sewer has maximum capacity.
- UU has undertaken post-flood clearance, maintenance and refurbishment works on Somerset Road.
- UU dispatched an operations team to Thingwall Drive to pump floodwater out of homes during the 2nd September flooding.

5.5.10 Recommendations

The most likely cause of flooding in this area is related to the 1 in 20 year design standard of the UU sewerage network being exceeded by the severity of the weather. WBC Highways and UU should review the road drainage infrastructure in this area to ensure it is adequate to cope with expected volumes of surface water runoff.

Given the frequency of the repeated flooding at Thingwall Drive both WBC and UU should investigate whether any additional mitigation measures can be put in place to reduce the impact of flooding (for example local topographic raising of kerbs and highway may reduce the risk of internal property flooding).

5.6 Other Affected Areas

Based upon a review of social media and internet news websites, it is understood that significant flooding was also experienced across the following locations between the 22nd August and the 2nd September 2015.

- Heswall;
- West Kirby; and,
- Brimstage.

Based upon the verified flood investigation provided by UU the majority of these isolated instances relate to the severity of the weather exceeding of the 1 in 20 year design standard of the UU sewer network. Relevant photographs from news outlets are shown below. This was also compounded by localised ordinary watercourse and Main River flooding at discrete locations (i.e. the Clatter Brook in Dibbinsdale).

Photograph 5-39 Road Closures (2/9/15)

Photograph 5-40 Highway Flooding in Heswall (2/9/15)

Photograph 5-41 Brimstage Flooding (2/9/15)

Images from the BBC http://www.bbc.co.uk/news/uk-england-merseyside-34127828

5.7 Flooding Incident Summary – 2nd September

The physical aspects of the 2nd September flooding incident can be effectively summarised as follows:

- The rainfall over the 1st and 2nd of September was severe, amounting to 93mm in 48 hours,
- This depth of rain over the 48 hour period can be approximated to a 1 in 86 year storm return period.
- The ground conditions across Wirral were saturated, resulting in rainwater being unable to infiltrate into the ground
- The majority of the flooding resulted from rain falling directly on the urban area and flooding surfaces.
- The intensity of the rainfall exceeded the 1 in 20 year design standard of UU sewers.
- River levels were elevated across the Wirral river catchments and this inhibited the ability of the UU sewer network to move floodwater away from urban areas.
- River levels exceeded the capacity of the river channel at some locations, resulting in flooding mechanisms that combined with the preceding surface water and sewer flooding.
- The topography of the Wirral Peninsular is very flat and resulted in entire river systems and drainage networks 'backing up' from the downstream end.
- The flat topography also exacerbated the surface water flooding as it resulted in excessive ponding in urban areas.
- The flooding that occurred was widespread.
- Whilst the contributing rain fell over 48 hours, the onset of the flooding was rapid, with little lead-time for residents, RMAs and emergency responders.

6 RMA Response – Strategic Overview

The data review undertaken in Chapter 4 of this Section 19 Flood Investigation report demonstrates the magnitude and widespread extent of the flooding that occurred on the 22nd August and 2nd September 2015. To summarise, a total 452 reports of flooding have been documented between these two dates. Of the 452 reports, 73 were confirmed as corresponding with internal property flooding that occurred during the 2nd September 2015 incident.

Chapter 5 of this Section 19 Flood Investigation details the complexity of the flooding mechanisms responsible for the property damages and disruption that occurred during 2nd September flooding incident. The evidence and observations reviewed in Chapter 5 demonstrate that the flooding impacts cannot be attributed to one singular root cause, but instead resulted from multiple sources and a combination of flooding mechanisms acting dynamically across the Wirral Peninsular.

Given the combination and extent of the flooding mechanisms on the 2nd September 2015 flood incident it is clear that all RMAs and emergency services had a role to play in the response to the events. This Chapter of the Flood Investigation therefore focuses on the flood incident response at the strategic scale and serves to detail how events unfolded, what worked well and what lessons can be learned to improve flood risk management in Wirral in the future. This review and account of the flooding incident response has been informed through consultation with the RMAs, partners, stakeholders and Wirral residents.

6.1 Flood Incident Response – Core Themes

The following core themes characterise the flooding and flood incident response that occurred on the 2nd September 2015:

- There was limited (if any) warning before the flooding occurred.
- When the flooding did occur it happened very rapidly, leaving little lead time to mount an effective response.
- Information about the scale and severity of the flooding was slow to surface and reach key decision-makers.
- The RMA and emergency response was impacted by the gradual exchange of information and finite availability of resources.
- Misconceptions about roles and responsibilities of the different agencies impacted on the effectiveness of the flood incident response and the resilience of the affected communities.

The following sub-headings elaborate on the core themes outlined above.

6.1.1 Limited Warning

Section 3.6 of this Flood Investigation identifies how there were few weather warnings in the days preceding the 2nd September 2015 flood event. On the 1st of September 2015 the Met Office Chief Meteorologist and the Flood Forecasting Centre determined that there was a low risk of minor flooding impacts. The level of risk was not considered to be sufficiently high for a Met Office National Severe Weather Warning Service rain warning, and was equivalent to a GREEN ('very low') flood risk on the Flood Forecasting Centres' Flood Guidance Statement.

Whilst the Flood Guidance Statement on the 1st September 2015 acknowledged that heavy showers across parts of the north-west of England may have resulted result in localised river and surface water impacts, no formal warnings were issued. The lack of weather warnings reflects the technical challenge associated with predicting very localised, intense rainfall and the consequent surface water flooding that heavily characterised the 2nd September flooding incident.

Though the Environment Agency holds permissive powers to issue flood warnings, the Flood Warning service is designed to provide guidance and warnings in relation to main rivers and not from other sources of flooding (i.e. that arising from surface water, ordinary watercourses, sewers and groundwater). Though the river flow on the Arrowe Brook did later contribute towards the combination of flooding mechanisms in Moreton, the flooding at this location began several hours earlier with the onset of intense surface water and sewer flooding.

As a consequence of the intensity and distribution of the rainfall (i.e. being difficult to predict and capture within contemporary warning systems) there was very little advance warning for residents, emergency responders and the RMAs. Consequently the flood incident response was slow to mobilise which resulted in considerable strain on the resources of the emergency responders. For example, Merseyside Police received no flood warnings but dealt with 17 separate flood related incidents, with up to 15 separate police patrols being deployed by 21:00.

6.1.2 Rapid Onset

As the majority of the flooding on the 2nd of September 2015 resulted from surface water there was very little lead time between the first signs of flooding and property damages occurring. If the Moreton incident timeline (Table 5-3) is used as a case study, it can be seen that the first reports of potential flooding reached Merseyside Police at 07.17 and the first confirmed report of internal flooding occurred at 09.10 (just under two hours later). Consequently there was a very narrow window of time for RMAs and emergency responders to effectively undertake the following:

- Identify there was a significant flooding incident occurring,
- Mobilise resources with which to assist residents and stakeholders; and,
- Contact other RMAs and emergency responders in line with emergency planning protocols.

This issue was further compounded by challenges relating to the exchange of information between residents, stakeholders, RMAs and emergency responders.

6.1.3 Exchange of Information

Given the lack of flood warnings and limited effective lead time that preceded the flooding the RMAs involved were initially unware of the significance and severity of the flood event. WBC, for example, was not aware of the number of residential properties that were affected until much later in the day on the 2nd of September 2015. As a consequence of this WBC did not call for a major incident during the flooding which would have involved WBC using their resources to support the emergency services in line with the major incident plan.

The issue arose because information about the flooding incident was slow to reach key decision-makers. This resulted in little on-site presence from WBC and limited interaction between the RMAs. This can be attributed to the following key factors:

- Many residents were unsure how to report flooding and/ or which authority they should be reporting the flooding to.
- The WBC communications team was under-resourced on the day and the contact centre was unable to cope with the volume of calls. Many queries were received via Twitter which WBC was unable to progress due to the lack of resources.
- Several RMAs and stakeholders were unaware of WBC's single point of contact numbers and were using the Council's main switchboard for emergency calls
- A significant number of Magenta Living tenants reported the flooding to the Magenta Living call centre, though not necessarily the Environment Agency, UU or WBC.
- There was no consultation or dialogue between the Environment Agency and WBC on the day of the event; both agencies were uncertain how the other was approaching the event.
- WBC contacted Merseyside Fire and Rescue and the Police early in the day and the feedback received suggested no major issues and emergency responders were coping well.
- WBC was unaware of Magenta' Livings involvement and the evacuations until midday.
- WBC took the approach that the rain would stop and the flooding would alleviate whilst individual agency business continuity events would kick in.

6.1.4 Resource Availability

As the sections above outline, resources were stretched during the 2nd September flooding incident. Both the WBC communications team and the Magenta Living call centre received a high number of flood-related calls and were unable to cope with the volume. Emergency responders coped well, though a strain was placed on their resources as there was no call for a major incident.

WBC had few resources available with which to support residents on site. Whilst WBC had contractors (such as Biffa) assisting, many residents did not realise they were effectively representatives of WBC.

6.1.5 Misconceptions – Roles and Responsibilities

Following the onset of flooding many residents and emergency responders maintained the perception that WBC would supply sandbags to help protect properties from flooding. WBC's current policy has been not to supply sandbags to the public following a decision by Elected Members several years before the 2nd September 2015 flooding incident. Many residents were therefore unaware of this policy and had little in the way of flood resilience measures with which to reduce the impact of the flooding.

In addition to the above, there was inter-agency confusion about who was co-ordinating the multi-agency response and the respective roles and responsibilities within each agency. This resulted in WBC, EA and UU largely acting in isolation on each other on the day of the flooding.

6.1.6 Positive Observations

Whilst there were several contributing factors which inhibited and slowed the effectiveness of the multi-agency incident response, the following items have been identified as positive observations that should be noted:

- All RMAs and agencies were proactive in their individual response with the information and resources available.
- Magenta Living worked well to assist vulnerable residents evacuate flooded properties.
- 6 Environment Agency operations teams worked effectively to keep watercourses flowing and free of blockages.
- The Environment Agency's Press Office provided excellent additional public-facing support.
- Emergency services were on site and provided invaluable assistance to residents from the onset of flooding.
- All RMA's have consequently worked together in a collaborative partnership and provided post-event community support to affected residents.
- All RMA's have been proactive in undertaking site specific post-event investigations.
- The EA has modified flood warning procedures with additional trigger levels for Moreton.
- UU has implemented flood mitigation at a number of the properties affected by sewer flooding.
- UU has commissioned an independent report to understand whether the temporary crossing in Arrowe Brook contributed to the flooding in the Moreton area.

6.2 Lessons Learnt and Moving Forwards

Following a review of the information supplied by the RMA's, project partners and data collected from the site visits the following strategic areas which could be potentially improved in the future have been identified:

- Communications and Contingency Planning (i.e. Multi-Agency Flood Plans);
- Community Resilience; and,
- Understanding of Integrated Flooding Mechanisms;

This section of the report identifies strategic recommendations which could be potentially carried forward into an Action Plan by the relevant RMAs. A table of specific recommendations is also documented within Chapter 8.

6.2.1 Communication and Multi-Agency Flood Planning

Following the 2nd September flooding all of the RMA's and agency partners identified a need for more clearly defined lines of communication between the relevant parties during the flood event. In several instances RMA's and other partner agencies attempted to make contact via central switchboards which were overwhelmed by the volume of calls from local residents. It is therefore recommended that the RMAs and first responders continue to co-operatively develop their multi-agency flood response plan in line with the recommendations of the Civil Contingencies Act (2004).

Whilst more generic major incident plans are already in place for Wirral, a specific Multi-Agency Flood Plan would help address the complex and diverse nature of flooding and the consequences that arise which often requires a comprehensive and often sustained response from a wide range of organisations. WBC has already begun this process following the 2nd September flooding with the preparation of a draft Severe Weather Contingency Plan.

The Multi-Agency Flood Plan should look to include representatives from all relevant departments and agencies in order to consider all the consequences and impacts (short, medium and long term). WBC should consider contributions from relevant departments including Emergency Planning, Highways, Drainage, Social Services and Environmental Health. A representative from the Environment Agency's Flood Incident Management team should also be a member of the working group to provide flood risk and flood warning advice and information. Contributions from Category 2 responders are critical in terms of considering assets and infrastructure in the floodplain that may be impacted by floodwater.

The Multi-Agency Flood Plan should detail communications arrangements (both internally and with the public), key points of contact, the location of control centres, resources availability, roles and responsibilities, environmental considerations, health and safety considerations, methods for sharing information about vulnerable people, plans for critical infrastructure, training and key records to maintain into the future. The plan should also identify and develop the 'trigger points' which outline metrics that would initiate the emergency response.

All RMAs should review their procedures and processes for data collection during and after a flood event, ensuring that reports of flooding are captured in a manner which can be shared rapidly and easily documented within WBC's flooding geo-database.

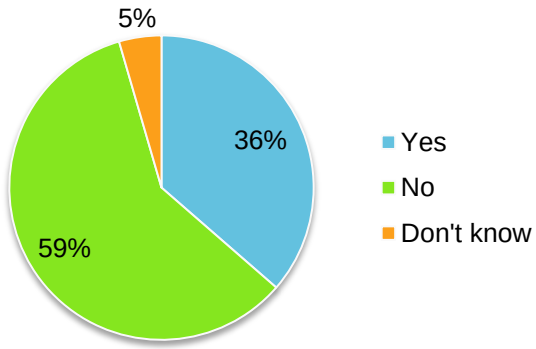
WBC should also look at contingency planning for its main communication switchboard and whether this can be linked into the Environment Agency's Extended Floodline Capability Service during an emergency situation.

The flooding of the sole access and egress route at the North Cheshire Trading Estate has highlighted the need for co-operative contingency planning at this location. Whilst it understood that SP Energy Networks is currently looking at Business Continuity for repeat events, it is recommended that this process is undertaken through consultation with WBC, the Environment Agency and the emergency responders to develop contingency plans and key points of contact for repeat events. It is also recommended that WBC's Traffic Management Plan is also revised to indicate where roads are susceptible to flooding and to develop road closure plans at these locations (potentially with input from local Flood Wardens and Flood Action Groups).

6.2.2 Community Resilience

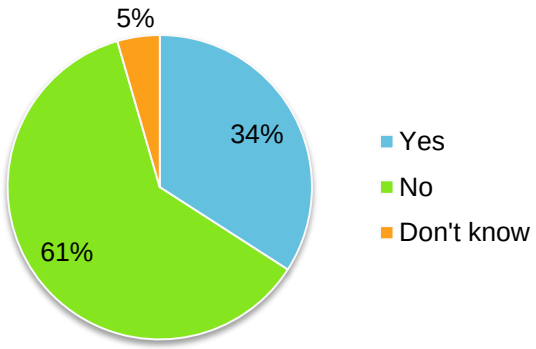
The flood survey questionnaires used in the data collection phase of this Section 19 Flood Investigation (Appendix A) asked residents to complete a number of questions about their potential preparedness for flooding. A summary of the results of this survey are shown below.

Do you know how to find out if you might be at risk of flooding?



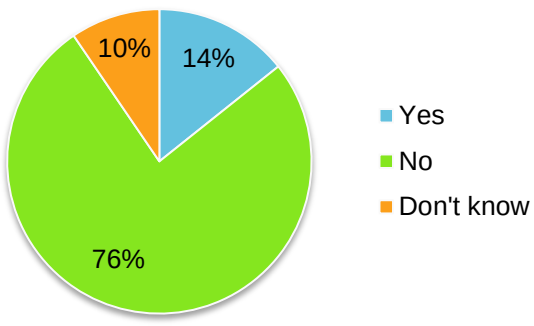
44 respondents

Do you know how to receive flood warnings?



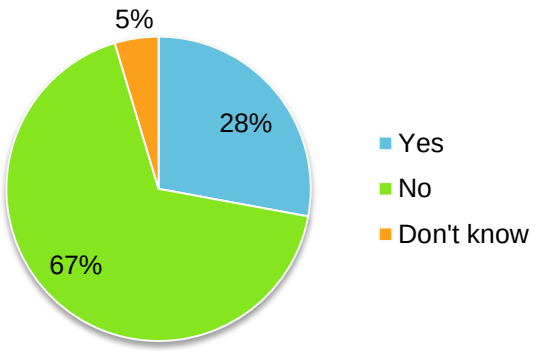
44 respondents

Do you have a personal flood plan?



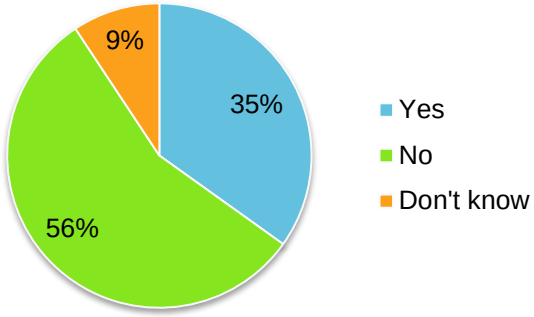
42 respondents

Do you know how you could improve your property's flood protection?



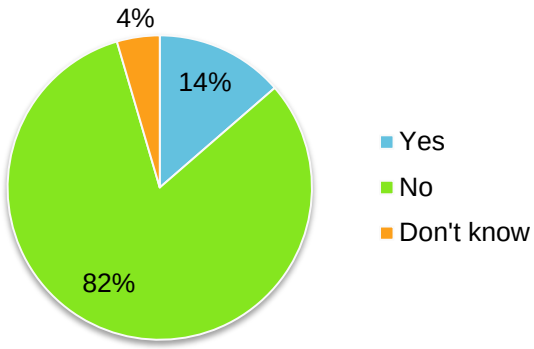
43 respondents

Do you know how to report flooding?



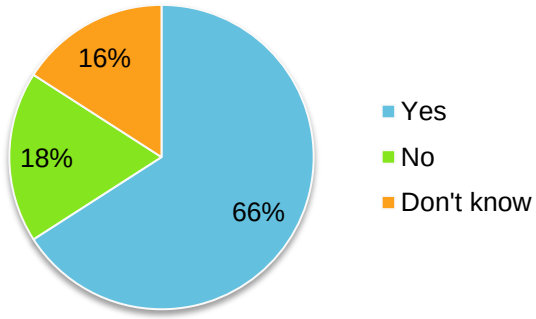
43 respondents

Do you know where to get help during a flood?



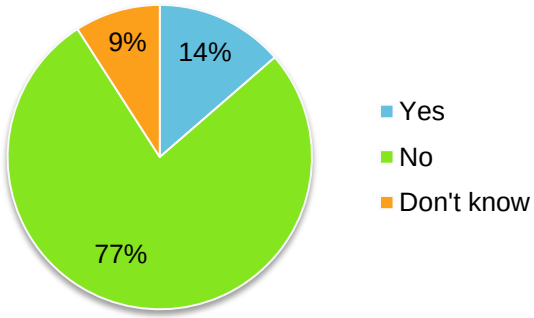
44 respondents

Do you think you would need additional help during a flood?



44 respondents

Do you know where to get help after a flood?



44 respondents

The results above clearly demonstrate that many of the affected residents are uncertain how to find out more information about flood risk, how to improve the resilience to flooding or how to obtain additional support if needed. Based upon these findings and experience of residents during the flooding events, the RMAs should look to provide a co-ordinated approach to improving community-level resilience across Wirral by engaging and consulting with local residents in the known flooding hotspots and high risk areas in accordance with the Central Government's Strategic National Framework on Community Resilience[18].

Stakeholder engagement should place emphasis on increasing the community's awareness of flood risk and local actions that can be undertaken to improve community-level preparedness for flooding (i.e. through helping individuals produce personal flood actions plans[19]). Personal flood action plans should also detail mechanisms for reporting flooding, thereby minimising the potential delay between a flood event occurring and the key RMA personnel and decision-makers from being notified.

Where possible stakeholder consultation should include a face-to-face element; preliminary feedback from residents suggested that the multi-agency feedback session at the Moreton community centre on the 25th September was well

[18] Strategic National Framework on Community Resilience [Accessed 21/3/2016]: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/60922/Strategic-National-Framework-on-Community-Resilience_0.pdf

[19] Personal Flood Plans [Accessed 21/3/2016]: https://www.gov.uk/government/publications/personal-flood-plan

received and afforded an opportunity for a clear, transparent line of dialogue with the relevant RMAs. These public-facing sessions also afford an opportunity to provide advice on property level resilience measures, as well as funding mechanisms and potential contractors for procuring these works.

RMAs should also support the development of local flood action groups (such as the Greasby Flood Action Group) through the consultation, provision of advice and other resources. Training could also be provided to local 'Flood Wardens' which are volunteers who help raise awareness of any flood risks in their community, help pass on flood warnings when they are issued, help prepare for flooding and to assist vulnerable people both during and after flooding has occurred.

It is recommended that WBC review its current position on the provision of sandbags. Whilst it is unlikely that WBC would have been able to effectively distribute sandbags to all of the residents affected by the rapidity of the 2nd September 2015 flooding, it is recommended that this policy is reviewed and the outcome heavily publicised. If, after this review, WBC retains the policy not to supply sandbags to residents, consultation and community engagement should explicitly acknowledge this and ensure that at-risk communities are aware of the need to improve the resilience of their properties before a flood event occurs. WBC has previously issued Flood Advice[20] leaflets to residents at risk and it is recommended that this practice is repeated in the areas at risk of flooding. This would also provide residents with greater direction about options for obtaining help during and after a flood event occurs.

Other potential quick wins to improve community level resilience could include:

- Hosting a 'flood fair' in a community space to help inform and empower local communities.
- Promoting an awareness of flood risk and improving the communities understanding of what to do/ who to contact in the event of a flood (though helping residents to develop personal emergency plans)
- Developing a flood toolkit to help empower the creation of resilient communities.
- Provision of monitoring equipment (i.e. trigger alarms on ordinary watercourses).
- Developing a road closure scheme with the local flood wardens and WBC Highways department to close roads at pre-determined locations when certain triggers are met.

6.2.3 Understanding Integrated Flooding Mechanisms

Whilst a Flood Alert was issued for Moreton on the 2nd September 2015 in line with the Environment Agency's flood warning procedures, the Flood Alert was issued effectively four hours after the flooding had occurred in Moreton. As Section 5.3.5.3 concludes, this situation arose because the flooding in Moreton was a result of a combination of flooding mechanisms, with surface water preceding any fluvial overtopping of the Arrowe Brook.

Following the 2nd September 2015 flooding the Environment Agency has since revised its flood warning procedures to include an additional threshold level at the Acton Lane gauging station. This additional threshold level is now being used to provide Moreton with a targeted flood warning service. Whilst improvement will likely benefit the Moreton community in the future, it should be noted that Flood Warnings are not intended to indicate a risk of flooding from surface water or sewers.

The combined flooding mechanisms that occurred in Moreton highlights the need to continue developing the understanding of combined flooding mechanisms which occur across the entire Wirral area. It recommended that the EA and UU consider the development of a fully integrated catchment model (i.e. one which links sewers, watercourses and surface water) to further improve the understanding of flood risk over Wirral. This evidence base would create a more informed understanding of the flood risk hazard and help determine whether further investment is required to reduce flood risk.

[20] Flood Advice [Accessed 21/3/2016]: https://www.wirral.gov.uk/sites/default/files/all/communities%20and%20neighbouhoods/Emergencies/Flooding/Flood%20Advice%20Leaflet.pdf

7 Flood Investigation Outcomes

This section of the flood investigation report aims to outline a summary of the responses from each of the RMAs which operate within the WBC administrative area and the suggested actions for further management of flood risk in the future.

7.1 Wirral Borough Council

7.1.1 WBC as Lead Local Flood Authority

As the LLFA, WBC has conducted this flood investigation report in response to the flood incidents arising between the 22nd August and the 2nd September 2015. This report has been compiled through collaborative working with relevant RMAs and stakeholders. This flood investigation report will be published, at which time relevant RMAs and stakeholders will be notified. In addition, WBC will coordinate with RMAs for further work and investigations in the future and will work collaboratively with local communities to address flooding issues.

7.1.2 WBC as the Highways Authority

WBC as the Highways Authority is responsible for the maintenance of the highways across the borough. During the 2nd September 2015 flooding WBC Highways brought in additional resources in via a Highway Maintenance Contractor to manage and remove flood water from public highways. Highways Inspectors were also dispatched to site in order to assess and arrange road closures where this was appropriate.

Following the 22nd August and 2nd September flooding, WBC Highways has undertaken further investigations to determine if there are potential operational problems, particularly in the areas around Whitehouse Lane, Heswall and Bromborough Road and Bebington. WBC Highways has also undertaken the following other actions:

- Developed a root cutting schedule identified as a result of further investigations.
- Undertaken road sweeping at Moreton to remove flood debris from highway.
- Organised Highway inspectors to follow up on flooding issues reported to WBC via the CRM system. Gullies have been checked for operational problems and have been rectified where issues were found.
- Liaison with householders who requested additional assistance due to their perception that the highway alignment had caused flooding.
- WBC Highways representatives have also attended the Multi-Agency Flooding De-Brief, Moreton Community Drop-Ins and the North Cheshire Trading Estate Multi-Agency meeting.

7.1.3 WBC as a Category 1 Responder

As a Category 1 Responder, WBC has utilised knowledge of recent flooding incidents to begin drafting the Multi-Agency Emergency Response plan for flooding and severe weather.

7.2 Environment Agency

Following the flooding incidents the Environment Agency has undertaken detailed investigations into the flooding event and undertaken hydraulic modelling to understand the flooding mechanisms in Moreton. Though the majority of the flooding at Moreton was a result of surface water, the Environment Agency has since revised its flood warning procedures to include an additional threshold level at the Acton Lane gauging station. This additional threshold level is now being used to provide Moreton with a targeted flood warning service.

The Environment Agency has attended the Multi-Agency Flooding De-Brief, Moreton Community Drop-Ins and the North Cheshire Trading Estate Multi-Agency meeting and undertaken door-to-door surveys in areas affected by the flooding.

7.3 United Utilities

Following the 22nd August and the 2nd September 2015 flooding, UU has investigated all flooding incidents which were directly reported to them. This involves verifying each incident and determining the flooding mechanism. Investigations are site specific but can include the following: site walk around, CCTV surveys and collating information from residents and other organisations such as the Met Office, the Environment Agency and the Local Authority. Any defects that were found (such as blockages) were resolved, whilst any longer term hydraulic issues were recorded and prioritised for future investment. UU has also provided flood mitigation to some of the properties that were impacted.

UU has attended various flooding debrief meetings with the Environment Agency and WBC to review the flooding that occurred on the 22nd August and 2nd September. UU continues to meet this organisation routinely as part of their flood partnership responsibilities. In addition UU attended the public event to talk to concerned residents about the flooding.

In addition to the above, UU has also commissioned an independent report to understand whether the temporary crossing in Arrowe Brook contributed to the flooding in the Moreton area.

8 Next Steps

WBC's role as LLFA is to coordinate the management of flood risk within their administrative area. It is suggested that the recommendations made within this report are formulated into an Action Plan by the relevant RMAs which can be monitored and discussed at the operational flood group meetings.

If, following a review of this Flood Investigation Report and liaison with RMAs, flood risk is considered to be unacceptable at a site WBC should investigate potential capital schemes which could provide flood alleviation within these areas. A follow-up meeting should be held with RMAs to discuss potential options to be taken forward.

8.1 Actions – Strategic

The assessment of flooding mechanisms and the flood incident response highlights several actions that could be applied across the borough. These are detailed in Table 8-1 below.

Table 8-1 Recommended Actions - Strategic

ID	Action	Lead RMA (Support)[21]	Area to be Implemented
1	Action Plan: WBC as the LLFA should look to develop an action plan that outlines timescales and milestones for delivering the site-specific and strategic recommendations made within this report.	WBC (EA, UU)	Boroughwide
2	Multi-Agency Flood Plan: WBC should continue to develop its Severe Weather Plan with sustained input from RMAs and partner agencies.	WBC (EA, UU)	Boroughwide
3	Wirral MBC, the EA and United Utilities should work together to produce an integrated fluvial and surface water model covering the Wirral. This model would better simulate the interactions between the rivers, sewer and surface water networks to enable a better understanding flooding mechanisms. It is understood that the RMAs are currently considering this modelling as part of a larger project covering the whole Wirral area and that is currently scheduled to start in 2017.	EA, UU, WBC	Boroughwide
4	Communication: Continue to encourage residents to report issues of flooding. Outline who this should be reported to (WBC, UU, EA), and what mechanisms are available to report (phone, email, mobile app etc.). Additional information could be made available through the council website. This would be used to ensure as many records as possible are noted.	WBC (EA, UU, residents, business owners)	Boroughwide
5	Communication: WBC to look at increasing their call centre capability and potential opportunities to link this with the Environment Agency's Floodline service.	WBC	Boroughwide
6	Records: Ensure systems are set up at the council to efficiently record details of flooding. This is needed to gather as much information as possible about each incident at the time of flooding. This will be essential in ensuring the correct flooding mechanisms are understood.	WBC	Boroughwide
7	Stakeholder engagement and community resilience: All three RMAs to work proactively with the local communities to improve awareness of flood risk and resilience to subsequent events. Emphasis should be placed on preparing for flooding before an event happens.	WBC, EA, UU	Boroughwide

[21] EA = Environment Agency, AW = Anglian Water

ID	Action	Lead RMA (Support)[21]	Area to be Implemented
8	Sandbag Policy: WBC should look to review its sandbag policy and heavily publicise the outcome of this review to residents, emergency responders and project partners.	WBC	Boroughwide
9	Community flood groups: As a quick win, WBC could work with residents to ensure flood risk is understood and to develop local flood groups. The formation of local flood groups would be beneficial in disseminating information and managing local flood risk.	WBC (EA, UU, residents, businesses)	Borough wide
10	Review flood warning procedures in light of the potential hydraulic influence between sub-catchments and joint-probability events.	EA	Moreton
11	Implement SuDS: As part of the investigation, the implementation of SuDS has been suggested as part of a long term approach to reducing the pressure on the surface water drainage network. This may potentially afford a significant benefit at Coronation Park where large volumes of runoff affected properties during the 2nd September 2015 flooding. Further investigation into the feasibility of such schemes would need to be examined prior to implementation.	WBC (residents & businesses)	Boroughwide
12	Property level protection and resilience measures: As a quick win, residents should consider implementing property level protection where necessary.	Residents and businesses (WBC)	Boroughwide.
13	In areas with a single incident of flooding, WBC should prioritise investigations should flooding occur again in the future.	WBC (EA, UU)	Boroughwide
14	WBC and the EA should work together to increase communications in relation to where Environmental Permits and Ordinary Watercourse Consents have been granted.	WBC, EA	Boroughwide

8.2 Actions – Site Specific

Suggested site-specific actions for the RMAs have been highlighted within each of the areas investigated within Chapter 5 and Chapter 6. For ease of reference these are reproduced again Table 8-2 below.

Table 8-2 Recommended Actions – Site Specific

ID	Action	Lead RMA (Support)[22]	Area to be Implemented
1	WBC should look to improve the drainage and surface water attenuation at Coronation Park. This may reduce flood risk to residents on Brookdale Close, Joan Avenue and Greasby Road. These resilience improvements could be potentially undertaken in tandem with other works to improve the amenity of the park in line with the objectives of WBC's Wirral Parks and Open Spaces Strategy.	WBC (UU)	Coronation Park, Greasby
2	UU should undertake investigations at Circular Drive to determine if there are any blockages or features which are likely to reduce its hydraulic capacity.	UU (WBC)	Circular Drive, Greasby

[22] EA = Environment Agency, AW = Anglian Water

ID	Action	Lead RMA (Support)[22]	Area to be Implemented
	WBC should assist in this through an assessment of the highway drainage system which connects to the central UU sewer.		
3	WBC and UU should consider undertaking further appraisal at the Central Greasby flooding hotspot (in line with the recommendations made in Greasby Surface Water Modelling Study)	WBC (UU, EA)	Greasby Central Flowpath
4	UU should continue to liaise with local residents and stakeholders to reiterate the importance of not depositing fats, oils and grease down their respective drains.	UU (WBC)	West Greasby, Boroughwide
6	All RMAs should continue to engage with the residents in Moreton to improve the community's understanding of the flood risk and how to take measures to increase their resilience and preparedness for flooding in the future.	EA, WBC, UU	Moreton
7	WBC should look to undertake a feasibility study into improving access and egress. This study may present further opportunity for Partnership Working with SP Energy Networks and other business on the North Cheshire Trading Estate.	WBC	North Cheshire Trading Estate
8	The flooding of the sole access and egress route at the North Cheshire Trading Estate has highlighted the need for co-operative contingency planning at this location. It is recommended that this process is undertaken through consultation with WBC, the Environment Agency and the emergency responders to develop contingency plans and key points of contact for repeat events.	WBC (EA, residents, businesses)	North Cheshire Trading Estate
9	WBC Highways and UU should review the road drainage infrastructure at Thingwall Drive to ensure it is adequate to cope with expected volumes of runoff. Both WBC and UU should consider whether any additional mitigation measures can be put in place to reduce the risk of repeat flooding on Thingwall Drive. Local topographic raising of kerbs may reduce the risk of internal property flooding if sewer capacity cannot be increased.	WBC, UU	Thingwall Drive

8.3 Actions - Quick Wins

The following potential community-level quick wins have been identified within this Section 19 Flood Investigation:

- Provision of PLP surveys for residents affected by flooding.
- Provision of capital resources to support, empower and facilitate community resilience and local flood action groups.
- Hosting a 'flood fair' in a community space to help inform and empower local communities.
- Promoting an awareness of flood risk and improving the communities understanding of what to do/ who to contact in the event of a flood (though helping residents to develop personal emergency plans and disseminating flooding leaflets).
- Developing a flood toolkit to help empower the creation of resilient communities.
- Training volunteer community 'flood wardens' and fostering other flood groups.
- Provision of monitoring equipment (i.e. trigger alarms on ordinary watercourses – though this would likely have to be done in tandem with the EA to avoid any overlap/ confusion about flood warnings).
- Developing a road closure scheme with the local flood wardens and WBC Highways department to close roads at pre-determined locations when certain triggers are met.

9 Useful Contacts

KEY FLOODING CONTACT DETAILS
The following gives guidance on whom to contact about various types of flooding. Always contact the emergency services first (**999**) if you or a family member is in immediate danger.
Flooding from Public Sewer
UNITED UTILITIES • Report sewer flooding **0345 6723 723** • http://www.unitedutilities.com/ **WELSH WATER** • Report sewer flooding **0800 085 3968** **(24 hour service)** • http://www.dwrcymru.com/en/my-wastewater/sewer-flooding.aspx
Flooding from a Burst Water Mains
UNITED UTILITIES • Report a leak **0800 330033** • http://www.unitedutilities.com/ **WELSH WATER** • Report a leak **0800 281 432** **(24 hour service)** • http://www.dwrcymru.com/en/My-Water/Report-a-Leak.aspx
Flooding from the Public Highway, Drains or Ordinary Watercourses (Non-Main River)
WIRRAL BOROUGH COUNCIL • Council switchboard **0151 606 2000** **(Mon-Fri, 8:45am – 5pm)** • To report a flooding emergency **0151 606 2004** **(Mon-Fri, 8am – 5pm)** **0151 647 7810** **(out of hours)**
Flooding from a Main River
ENVIRONMENT AGENCY • General enquiries **03708 506 506** **(Mon-Fri, 8am – 6pm)** • Incident hotline **0800 80 70 60** **(24 hour service)** • Floodline **0345 988 1188** **(24 hour service)** • General enquiries email enquiries@environment–agency.gov.uk

USEFUL WEB RESOURCES

The following web links contain useful information about being prepared, understanding flood risk and reporting drainage issues to Wirral Borough Council.

Being Prepared

Prepare for a flood and get help during and after:

https://www.gov.uk/prepare-for-a-flood/get-help-after-a-flood

Be ready for flooding:

http://www.nationalfloodforum.org.uk/wp-content/uploads/Ready-For-Flooding-26-11-14.pdf

Make a personal flood plan:

https://www.gov.uk/government/publications/personal-flood-plan

Prepare your property for flooding:

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/451622/LIT_4284.pdf

Understanding Flood Risk and Flood Warnings

Check current flood warnings and river levels:

https://www.gov.uk/check-if-youre-at-risk-of-flooding

Sign up for flood warnings:

https://www.gov.uk/sign-up-for-flood-warnings

Reporting a Flood

Report flooding from a public highway to Wirral Borough Council:

https://www.wirral.gov.uk/communities-and-neighbourhoods/emergencies/flooding/report-flood

Report a problem with a drain or a grid (also known as a gully):

https://www.wirral.gov.uk/parking-roads-and-travel/roads-and-pavements/grids-and-drains

Appendix A. Flood Survey Questionnaire

Wirral Borough Council Section 19 Flood Investigation - Flood Survey Questionnaire

22nd August 2015 and 2nd September 2015

As Lead Local Flood Authority, Wirral Borough Council has a responsibility to record and report flood incidents as detailed within Section 19 of the Flood and Water Management Act (2010).

This questionnaire is intended to help Wirral Borough Council and its project partners with understanding and investigating the flooding that occurred between the 22nd August 2015 and the 2nd September 2015.

There are no right or wrong answers to the following questions. Please respond to all the questions in accordance with your own personal experience where possible.

If you do not know or do not want to answer any of the questions please leave them blank and move on to the next question.

Under NO circumstances will your personal details be given to any other organisation other than Wirral Borough Council, United Utilities and the Environment Agency.

Your Details

Name (Optional)	
Contact Details (Optional)	
House Number	
Postcode	

Your Experience of Flooding

Have you been affected by flooding previously?	Yes	No
Were you affected by flooding on the 22nd August 2015?	Yes	No
Were you affected by flooding on the 2nd September 2015?	Yes	No

What was affected by the flooding?	Internal	External

What was the source of the past flooding? (if known)					
River	Surface Water	Sewers	Groundwater	Other	Don't Know
Please provide any specific details about the flooding below.					

Flood Warning		
If you were affected, did you receive any warning?	Yes	No
If "Yes", who gave you the flood warning? *Please tick all that apply.*		
Environment Agency		
Police		
Fire Service		
Wirral Borough Council		
Flood Warden		
Neighbour/ Friend		
Other		

Did you receive any assistance during the flooding? *Please tick all that apply.*	
Environment Agency	
Police	
Fire Service	
Wirral Borough Council	
Flood Warden	
Neighbour/ Friend	
Other	

Preparing for Flooding		
Do you know how to find out if you might be at risk of flooding?	Yes	No
Do you know how to receive flood warnings?	Yes	No
Do you have a personal flood plan?	Yes	No
Do you know how you could improve your property's flood protection?	Yes	No
Do you know how to report flooding?	Yes	No
Do you know where to get help during a flood?	Yes	No
Do you think you would need extra help during a flood?	Yes	No
Do you know where to get help after a flood?	Yes	No
Do you know where to find out more information about flooding?	Yes	No

Recommendations / Suggestions
Is there anything which you think could be done to reduce the risk of flooding in your area?
Is there anything which you think could have been done better before the flooding?
Is there anything which you think could have been done better during (or after) the flooding?

KEY FLOODING CONTACT DETAILS

The following gives guidance on whom to contact about various types of flooding. Always contact the emergency services first (**999**) if you or a family member is in immediate danger.

Flooding from Public Sewer

UNITED UTILITIES

- Report sewer flooding **0345 6723 723**
- http://www.unitedutilities.com/

WELSH WATER

- Report sewer flooding **0800 085 3968** **(24 hour service)**
- http://www.dwrcymru.com/en/my-wastewater/sewer-flooding.aspx

Flooding from a Burst Water Mains

UNITED UTILITIES

- Report a leak **0800 330033**
- http://www.unitedutilities.com/

WELSH WATER

- Report a leak **0800 281 432** **(24 hour service)**
- http://www.dwrcymru.com/en/My-Water/Report-a-Leak.aspx

Flooding from the Public Highway or Drains

WIRRAL BOROUGH COUNCIL

- Council switchboard **0151 606 2000** **(Mon-Fri, 8:45am – 5pm)**
- To report a flooding emergency **0151 606 2004** **(Mon-Fri, 8am – 5pm)**
  0151 647 7810 **(out of hours)**

Flooding from a Main River

ENVIRONMENT AGENCY

- General enquiries **03708 506 506** **(Mon-Fri, 8am – 6pm)**
- Incident hotline **0800 80 70 60** **(24hour service)**
- Floodline **0345 988 1188** **(24 hour service)**
- General enquiries email **enquiries@environment–agency.gov.uk**

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Make a personal flood plan:

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Report flooding from a public highway to Wirral Borough Council:

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Report a problem with a drain or a grid (also known as a gully):

https://www.wirral.gov.uk/parking-roads-and-travel/roads-and-pavements/grids-and-drains

Any Questions? *Please contact* ***highwayasset@wirral.gov.uk***

About AECOM

AECOM (NYSE: ACM) is a global provider of professional technical and management support services to a broad range of markets, including transportation, facilities, environmental, energy, water and government. With approximately 100,000 employees around the world, AECOM is a leader in all of the key markets that it serves. AECOM provides a blend of global reach, local knowledge, innovation, and collaborative technical excellence in delivering solutions that enhance and sustain the world's built, natural, and social environments. A Fortune 500 company, AECOM serves clients in more than 100 countries and has annual revenue in excess of $6 billion.

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