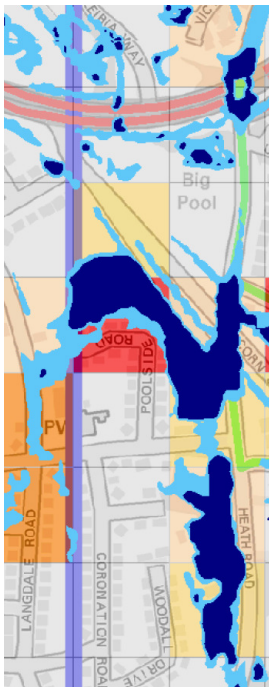

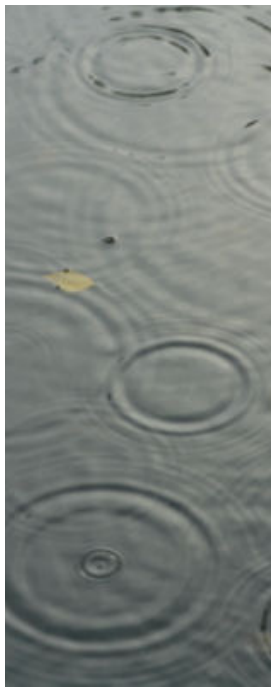
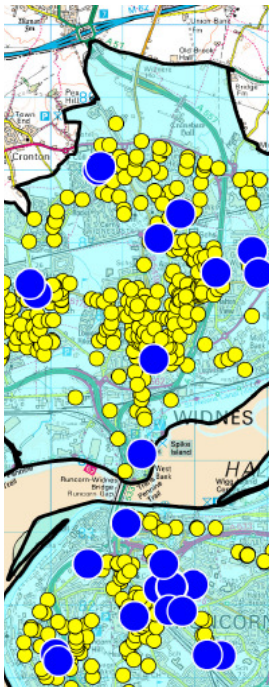

Surface Water Management Plan

Project Report

June 2011
Halton Borough Council

HALTON BOROUGH COUNCIL

Environment Agency

United Utilities

Mott MacDonald

Surface Water Management Plan

Project Report

June 2011

Halton Borough Council

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P2	10/06/2011	D T Webborn/ M Balls	M Balls	F B Tierney	Draft Issue

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Content

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1. Introduction

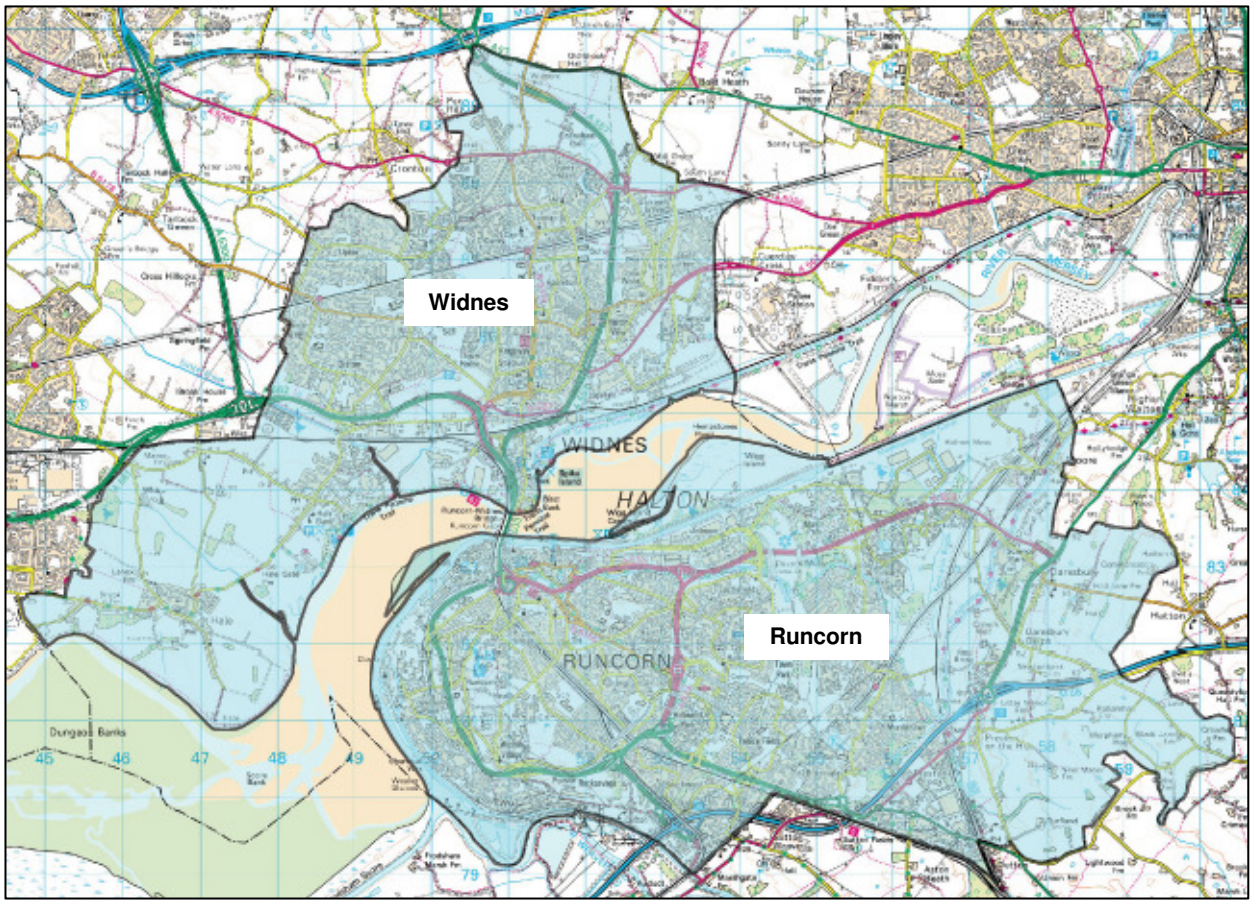
1.1 General

In his review of the summer 2007 floods, Sir Michael Pitt (Pitt, M, 2008)[1] recommended that Local Surface Water Management Plans (SWMP) be prepared and coordinated by local authorities. The SWMPs are intended as a tool for managing all local surface water flood risk and in response to the Pitt Review; the government has reiterated its support for the SWMP approach in high risk areas.

Following recommendations made in the draft Level 2 Strategic Flood Risk Assessment (SFRA) (JBA Consulting, 2010)[2], Mott MacDonald was commissioned by Halton Borough Council to prepare a SWMP for the Halton Borough area. This includes the towns of Widnes and Runcorn, which are ranked 156 and 309 respectively in the National Rank Order of Settlements Susceptible to Surface Water Flooding (DEFRA, 2009)[3].

Halton Borough is located on the upper reaches of the River Mersey estuary, and borders the Liverpool, Knowsley, St. Helens, Warrington and Cheshire West and Chester local authority districts. Figure 1.1 defines the study area.

Figure 1.1: Halton Borough Council SWMP study area



This SWMP has been progressed following the guidance contained in the Surface Water Management Plan Technical Guidance document (DEFRA, 2010)[4], as defined by the SWMP framework wheel shown in Figure 1.2.

Figure 1.2: SWMP framework wheel

Source: DEFRA. 2010. *Surface Water Management Plan Technical Guidance.* © Crown Copyright.

1.2 Background to the Study

1.2.1 General

The following sub-sections identify and develop an understanding of the main sources of surface water flooding in the Halton Borough area. They also give an overview of the region's hydrology and historic incidents of flooding.

1.2.2 Flooding from Surface Water Run-off

Surface water run-off is defined in the Flood and Water Management Act 2010[5] as:

"'Surface runoff' means rainwater (including snow and other precipitation) which –

a) is on the surface of the ground (whether or not it is moving), and
b) has not yet entered a watercourse, drainage system or public sewer."

Surface water flooding generally occurs following periods of intense rainfall, often of short duration. Surface run-off is generated as a result of rainwater not being able to either permeate the ground or enter below ground drainage systems quick enough. This leads to a build up of water on the surface which flows overland until it ponds in localised depressions causing flooding.

In urban areas, flooding from surface water run-off is most likely to be caused by either blocked entrances to the surface water drainage system (gullies, inline drainage channels, combined kerb/drainage systems etc.) or due to the drainage system reaching capacity. Since the ground in urban areas is generally impermeable, water will pond on the surface and cause flooding where it is unable to escape. Flooding from surface water run-off may also occur in rural areas. This is most likely to be caused by saturated ground conditions with water running off green field areas and not being able to enter land drainage systems.

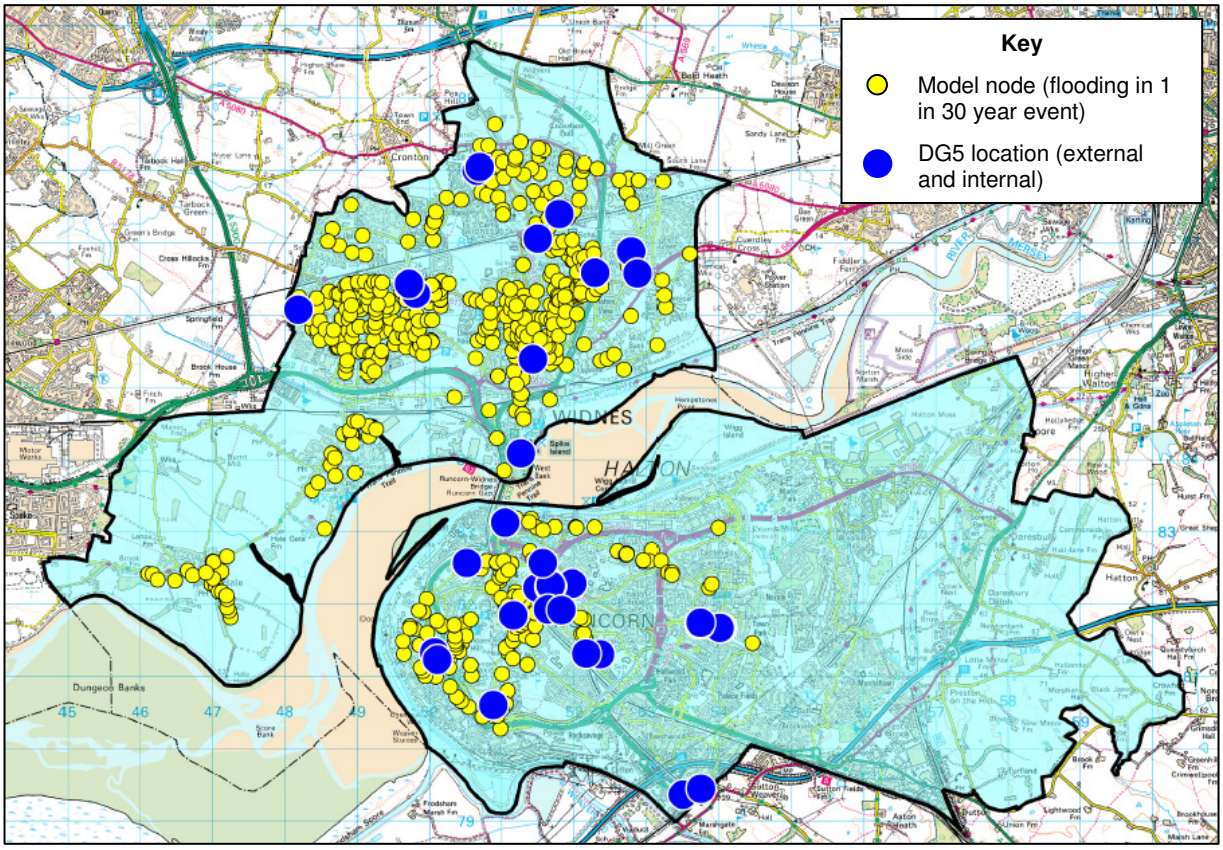
1.2.3 Flooding from Sewers

Surface water run-off in Runcorn and Widnes is conveyed to watercourses by an extensive system of below ground drainage. Flooding from this system occurs, either when it reaches its full capacity and is overwhelmed by the volume of water entering it, or if blockages occur, thus preventing the conveyance of flows and causing the system to back up and overflow.

Figure 2.1 shows outputs from United Utilities sewer network modelling of sewer performance for the 1 in 30 year rainfall event in the Borough of Halton. It indicates the model nodes for which flooding occurs in the 1 in 30 year event, and also shows locations of reported incidents of flooding to properties from sewers as recorded on the DG5 register. DG5 records are split into 'Internal' and 'External'. The 'Internal' DG5 register records incidents where flooding from sewers has entered buildings or passed below a suspended floor. 'External' flooding is therefore defined as 'flooding which is not classed as internal', and includes flooding of gardens, car parking areas and other open spaces.

Flooding from highways and private drainage systems is also a possibility due to inadequate capacity or blockages; however the frequency of such occurrence is unknown. Little has been learned in this study about the location and capacity of highway drainage, and therefore the anticipated spill volumes are not known.

Figure 1.3: Modelled sewer overflows and DG5 records



1.2.4 Hydrology

The Borough of Halton is situated in the upper reaches of the River Mersey estuary, with Runcorn located on the left bank and Widnes on the right. A number of main river's discharge into the River Mersey in the Halton Borough area, including Ditton Brook and Bower's Brook on the Widnes bank, and Keckwick Brook on the Runcorn Bank. The catchment of Ditton Brook covers an area of over 63km^2 and extends into the Liverpool and Knowsley boroughs. Keckwick Brook flows from south to north to the east of Runcorn and drains an area of approximately 14km^2. Other main rivers flowing through the Borough of Halton include Steward's Brook and Ram's Brook, both of which are located on the Widnes bank.

Ordinary watercourses also exist within the borough that flow directly into the River Mersey and Manchester Ship Canal (MSC). The old town of Runcorn is located on a sandstone outcrop and the relatively steep gradients down to the left bank of the MSC are reflected in the land drainage patterns at this location.

1.2.5 Historical Flooding

A number of sources have been utilised to obtain information on historic incidents of surface water flooding as follows:

- Halton Borough Council DRAFT Strategic Flood Risk Assessment (SFRA) (JBA Consulting, 2010)[2]. Mapping included in the draft SFRA incorporates data provided by the Environment Agency, United Utilities and the Highways Agency.
- Recorded incidents of surface water flooding provided by Halton Borough Council.

Drawing 2010s4182 – D016 (JBA Consulting, 2010)[2] is contained in Appendix A and includes historic flood data provided by the Environment Agency, External DG5 information provided by United Utilities, and highway flooding information provided by the Highways Agency. It shows that Environment Agency data records one incident of historic flooding within the Halton Borough boundary adjacent to Ditton Brook. External DG5 location data included on this drawing (also shown in Figure 2.1) shows a total of 35 recorded historical flood locations. The source of these flood incidents is inferred to be from sewers.

The mapping of Historic Flood Areas in Halton, provided by Halton Borough Council, is also included in Appendix A and records the locations of 70 incidents of historic surface water flooding. The locations shown on this drawing include Picow Farm Road as it passes beneath the Liverpool spur of the West Coast Main Line (WCML), Heath Road as it passes beneath the Runcorn Spur Road, and Peel House Lane in Widnes. The historic flood data for these locations has been used to validate the results obtained from the surface water modelling carried out as part of the intermediate risk assessment (Section 3.1.5.2).

1.3 Structure of the Report

The content of this report is structured to broadly follow the stages of the SWMP framework wheel (Figure 1.2) and are as follows:

1. Introduction
2. SWMP Preparation Stage
3. Intermediate Risk Assessment
4. Detailed Risk Assessment
5. Conclusions and Recommendations.

Where detailed methodologies have been developed (e.g. Intermediate Risk Assessment), these are summarised in the main report and described in detail in calculations included in the cross-referenced appendices.

2. SWMP Preparation Stage

2.1 The Requirement for a Surface Water Management Plan

The draft Level 2 SFRA report prepared by JBA Consulting for Halton Borough Council recommends that a scoping SWMP is prepared in partnership with key stakeholders. The SWMP should identify 'hotspot' areas with a high risk of surface water flooding and give possible solutions, recommending whether or not further detailed hydraulic modelling work is required. A review of historical flooding data carried out as part of the SFRA indicates areas within the Halton Borough that are susceptible to repeated incidents of localised flooding from non-fluvial sources. These sources are difficult to separate and as a result, surface water flooding is likely to occur from "a combination of overland flows, sewers and highway gullies backing up and surcharging at manholes, local watercourses overtopping, culverts surcharging and potentially high ground water levels." (JBA, Consulting 2010)[2]. The SWMP should therefore consider these potential sources in identifying areas at high risk from surface water flooding.

2.2 Partnership

Details of the partners involved in the preparation of the Halton Borough Council SWMP are provided in Table 1.1.

Table 2.1: Halton Borough Council SWMP partnership steering group

Partner	Role	People	Contact
Halton Borough Council	Local Authority	Dave Cunliffe John Gill Adrian Bratby	Policy and Resources Directorate, Policy Planning and Transportation Department, Rutland House, Halton Lea, Runcorn, Cheshire, WA7 2GW **Tel:** +44(0) 151 906 3727
Mott MacDonald Ltd	Consultant	Malcolm Balls David Webborn	Spring Bank House, 33 Stamford Street, Altrincham, Cheshire, WA14 1ES **Tel:** +44(0) 161 926 4000
Environment Agency (Northwest)	Environment Agency	Ben Lukey	Appleton House, 430 Birchwood Boulevard, Warrington, Cheshire, WA3 7WD **Tel:** +44(0) 1925 543 439
United Utilities plc	Water Authority	Brian Morrow	Haweswater House, Lingley Mere Business Park, Great Sankey, Warrington, Cheshire, WA5 3LP **Tel:** +44(0) 1925 678 469

2.3 Scope

2.3.1 Aims and objectives

The steering group have determined the long term aims and objectives of the Halton Borough SWMP as follows:

- Identify and map surface water flood risk areas across the Halton Borough, irrespective of source, and engage the community and all stakeholders to share this knowledge.
- Determine the consequences of surface water flooding on people, property, infrastructure and the environment, both now and in the future, in order to establish priorities for the management of flood risk.
- Develop and implement an effective communication plan to enable an understanding of flood risk in Halton Borough and to encourage stakeholder and community involvement in the identification of mitigation measures.

- Develop a strategy to inform spatial planning and the strategic planning of drainage provision in large new developments in Halton Borough.
- Develop and implement an action plan identifying flood risk management and improve co-operation and co-ordination for better working relationships between partners to the SWMP in support of Halton Borough Council's roles and responsibilities under the Flood Risk Management Regulations 2009[6] and the Flood and Water Management Act 2010[5].
- Integrate with neighbouring Lead Local Flood Authorities' SWMPs to promote the wider management of flood risk.
- Regularly review the appropriateness of SWMP data and modelling to ensure that information continues to be accurate and relevant, and enables the preparation of flood risk maps for Halton Borough.

It is however recognised that the SWMP is a live document and that, at this stage, the process is incomplete; refer to Section 2.3.4.

2.3.2 Engagement Plan

Mott MacDonald and Halton Borough Council have prepared a Communications and Engagement Plan that identifies stakeholders outside of the Halton SWMP Steering Group affected by the outcomes of this study. These stakeholders include the following groups:

- Owners and/or operators of essential infrastructure. Essential infrastructure includes power and communications infrastructure, food distribution, government offices, emergency services, health infrastructure, transportation and utilities.
- Other stakeholders, including local authorities, industry & commerce, housing associations and the public.

The Communications and Engagement Plan sets out how knowledge and awareness of flood risk in the Borough of Halton is to be communicated and monitored, thereby helping to ensure that the right information gets to the right people at the right time. The Engagement Plan should be read in conjunction with this report.

2.3.3 Information Availability

To assist the development of this study, information has been made available to Mott MacDonald by Halton Borough Council, the Environment Agency and United Utilities. This information is recorded in the incoming document and drawing register contained in Appendix E. Following a review of the data received, further Geographic Information Systems (GIS) data was required to build a two dimensional hydraulic model as part of the risk assessment. This was provided by Halton Borough Council and Geomatics. A complete list of relevant data used in the modelling and analysis stages of this study is provided in Section 3.1.2.

2.3.4 Level of Assessment

The SWMP Technical Guidance document[4] recommends that a risk-based approach be adopted to assess surface water flooding in order to ensure the most cost effective use of available budgets and resources. The Risk Assessment stage of the SWMP is broken down into three assessment levels that operate at different geographical scales and levels of detail. They are defined in Table 3-2 of the guidance and are as follows:

- Strategic Assessment
- Intermediate Assessment
- Detailed Assessment

In line with the SWMP Technical Guidance[4], it was agreed that the strategic level of assessment was not appropriate for the Halton Borough Council SWMP, since this level is applicable to counties and large conurbations. Accordingly, it was agreed with the steering group that the project would start with the intermediate assessment and progress to detailed assessment. From the outset, it was however expected

that budget constraints would limit the scope of the assessment either by geographic area, or by the level of detail of the risk assessment. The steering group concluded that a borough wide study should be carried out initially in order to identify the priority areas. At the conclusion of this study, it is considered that the intermediate assessment has been completed and a first stage of the detailed assessment carried out for the whole of Halton Borough. This first stage of the detailed assessment involved an in-the-field review of the incidence of surface water flooding in high risk locations identified in the intermediate assessment. This has lead to recommendations for specific detailed assessments for a prioritised short list of areas susceptible to surface water flooding.

3. Intermediate Risk Assessment

3.1 Methodology

3.1.1 Overview

The intermediate level of surface water flood risk assessment provides a suitable starting point for the risk-based approach to assessing surface water flood risk in Halton Borough. This is appropriate for boroughs or large towns, and is suitable for identifying 'hotspot' areas of high surface water flood risk for carrying through to the detailed assessment level. A Geographic Information Systems (GIS) based approach was adopted in order to carry out the intermediate risk assessment; the details are contained in Appendix B and summarised below:

- Initial work utilised existing surface water modelling data in the form of the Environment Agency Areas Susceptible to Surface Water Flooding polygons, together with property point data and essential transport infrastructure polygon data to develop a GIS-based flood impact scoring system using a grid of 100m x 100m cells. Visits to circa forty identified flood risk sites across the borough were conducted on the 21/02/2011 and 22/02/2011 in order to validate the flood impact scoring system (Section 3.4.4). Identified problems in the GIS methodology were then resolved.
- It was agreed that a 2-D hydraulic model of the Halton Borough area should be built using TUFLOW in order to combine 1 in 30, 100 and 200 year rainfall data with 1 in 30 year sewer overflow data obtained from United Utilities (Section 3.1.3). The 1 in 30 year sewer overflows were used as they are the highest return period event data available and the sewerage models were not available in order to generate the higher return period sewer overflow data.
- Flood depth, hazard and velocity polygon data for each of the modelled return period events was extracted from the model results for input into the GIS-based scoring system. Flood maps for flood depth, hazard and velocity were produced.
- For each return period event, a flood impact score was calculated for each cell based on the overlap of property (or infrastructure) polygons and flood depth and flood hazard. Flood depth and hazard impact maps were produced for property, with separate flood depth impact maps produced for essential transport infrastructure (Section 3.1.4).
- Flood risk scores were calculated from the impact scores derived for each modelled return period event. Flood depth and hazard risk maps were produced for property and used to identify 'hotspot' areas of high surface water flood risk for investigation in the detailed assessment.

3.1.2 Data

A wide range of data has been utilised in order to carry out the intermediate and detailed risk assessments. Where possible, existing information provided by Halton Borough Council, United Utilities and the Environment Agency has been used. All data and information received for use in preparing this SWMP is recorded in the incoming document register contained in Appendix D.

3.1.2.1 Mapping and LiDAR Data

- 1:1,250 Ordnance Survey background mapping. Source: Halton Borough Council
- 1:50,000 Ordnance Survey background mapping. Source: Halton Borough Council
- Ordnance Survey Mastermap – Topography Layer MapInfo polygon data. Source: Halton Borough Council
- 2m resolution Digital Terrain Model (DTM) LiDAR data. Source: Environment Agency/Geomatics
- Halton Borough boundary MapInfo polygon data. Source: Halton Borough Council

3.1.2.2 Hydrological Data

- Flood Estimation Handbook (FEH) catchment data. Source: Centre for Ecology and Hydrology

3.1.2.3 Existing modelling data

- Areas Susceptible to Surface Water Flooding (AStSWF) MapInfo polygon data. Source: Environment Agency
- Public sewer model MapInfo point and polyline data. Source: United Utilities
- Areas of historic flooding MapInfo polygon data. Source: Halton Borough Council

3.1.2.4 Existing infrastructure data

- Property MapInfo point and polygon data. Source: Halton Borough Council
- Essential transport infrastructure MapInfo polygon data. Source: Halton Borough Council
- Culvert data for Runcorn. Source: Halton Borough Council

3.1.3 Hydraulic Modelling

Calculations 1.0, 2.0 and 3.0 (Appendix C) give in-depth descriptions of the inputs and approach used to develop a 2-D TUFLOW model for Halton Borough, combining rainfall and sewer overflows. The modelling approach is summarised as follows:

- **Input data:** Sewer overflow hydrographs were derived for the 1 in 30 year event from node spill volumes extracted from United Utilities model data (Calculation 1.0). Rainfall profile data for Runcorn and Widnes was derived for the 1 in 30, 100 and 200 year events using the Revitalised FSR/FEH Rainfall Runoff method and FEH catchment descriptors (Calculation 2.0).
- **Geometry:** Four TUFLOW models with 2m grid spacing were built in order to model the whole Halton Borough area. For each model, the geometry was principally defined using 2m resolution DTM LiDAR data and Halton Borough boundary data. Other information, including OS Mastermap data, was used to define material roughness and rainfall adjustment regions within the model. Bridges and culverts were inserted manually into the model through adjustment of the model elevation data. All geometric data was handled using MapInfo as described in Calculation 3.0.
- **Boundary conditions:** Upstream boundary conditions were defined by the model inflows. The model inflows were assigned a location by way of MapInfo .tab files (point data for sewer nodes, polygon data for rainfall areas). A normal depth downstream boundary with a slope of 0.001 was applied to land/coast (River Mersey estuary) boundaries, whereas a glass wall boundary was used to define 'upstream' land boundaries.
- **Run data:** Each of the four models was run for each return period being assessed (1 in 30, 100 and 200 year events). Each model was run for two hours with a time step of 1 second.
- **Output data:** Model output data for flood depth, hazard and velocity was extracted and converted using Vertical Mapper into MapInfo .tab format. This data was then prepared for use in the flood impact and risk analysis process and processed to produce the updated 'Borough of Halton Surface Water Flood Maps (BHSWFM); see Appendix A.1. The BHSWFM now supersede the AStSWF and the Flood Map for Surface Water (FMfSW).

3.1.4 Flood Impact and Risk Analysis

3.1.4.1 Overview

The flood impact and risk analysis was undertaken as part of the intermediate assessment, in order to identify 'hotspot' areas of high surface water flood risk. The flood impact analysis was carried out following the development of a GIS-based scoring system, which aimed to assign each 100m x 100m grid cell a flood impact score for each modelled return period event. This flood impact score was based on the number and type of buildings affected by surface water flooding, as defined by output from the surface

water modelling. Impacts were identified where property polygons are overlaid by the polygons of flood depth or flood hazard; the severity of the impact being related to the magnitude of the flood depth or flood hazard lying on the property polygon. For both flood depth and flood hazard, the flood impact scores for the three return period events tested were combined to give an overall flood risk score. 'Hotspot' areas could then be determined for the detailed assessment.

3.1.4.2 Flood Impact Scoring

The procedure for calculating flood impact scores for each cell, return period and flood measure (depth or hazard) is described in Calculation 4.0 (Appendix C).

In summary, the total impact of flooding score ($\sum I_p$) for an individual cell may be calculated as follows:

Flood Depth

$$\sum I_p = i_1 k_1 n_{11} + i_1 k_2 n_{12} + i_1 k_3 n_{13} + ... + i_3 k_6 n_{36}$$ (Equation *[Calc]* 4.6.1)

Flood Hazard

$$\sum I_p = i_1 k_1 n_{11} + i_1 k_2 n_{12} + i_1 k_3 n_{13} + ... + i_5 k_6 n_{56}$$ (Equation *[Calc]* 4.6.2)

Where:

i = surface water flood risk vulnerability index (depth or hazard)
k = property vulnerability to flooding index (based on property type, e.g. for residential dwellings k = 5, for schools (municipal infrastructure) k = 50)
n = number of properties in sub group

3.1.4.3 Flood Risk Scoring

The procedure for calculating flood risk scores for each cell from the total impact of flooding score is described in Calculation 4.0 (Appendix C).

In summary, the flood depth and hazard risk score (R_p) for a given return period event and individual cell may be calculated as follows:

$$R_p = \sum I_p \times P$$ (Equation *[Calc]* 4.1.1)

Where:

$\sum I_p$ = total impact of flooding score for a given return period event

P = probability of annual occurrence expressed as a percentage

The average flood depth/hazard risk score ($\overline{R}$) for an individual map cell was therefore calculated as follows:

$$\overline{R} = \frac{R_{30} + R_{100} + R_{200}}{P_{30} + P_{100} + P_{200}}$$ (Equation *[Calc]* 4.1.2)

3.1.5 Validation

3.1.5.1 Overview

A series of modelling and impact assessment validation tests were carried out as follows:

- **Hydraulic modelling:** Comparison of modelled flood extents with recorded incidents of historic flooding.
- **Flood Impact assessment:** Site walk over survey to confirm that the flood impact scores assigned to each individual map cell using the flood impact scoring system give a valid representation of what impact is likely to occur during an actual flood.

3.1.5.2 Hydraulic Modelling Validation: Comparison with Recorded Incidents of Historic Flooding

Mapping information has been used to compare modelled flood extents with recorded incidents of historic flooding. The Historic Flood Areas in Halton mapping provided by Halton Borough Council (Appendix A.5) records 70 reported incidents of surface water flooding across the borough (as stated in Section 2.5). Figures 3.1, 3.2 and 3.3 show modelled 1 in 30 year flood depth data for the following sites:

- **Figure 3.1:** Peel House Lane, Widnes (NGR: SJ 519 868)
- **Figure 3.2:** Picow Farm Road, Runcorn (NGR: SJ 508 827)
- **Figure 3.3:** Heath Road, Runcorn (NGR: SJ 518 824)

Figures 3.1-3.3 show that for the sites considered in this model validation test, the recorded incidents of surface water flooding fall within the modelled flood depth polygons. The approximate areas of the recorded flooding incidents are all less than the 1 in 30 year shallow flooding polygon (0.1m). This indicates that the annual exceedence probability for the reported flood events was greater than 3.33% (1 in 30 years).

In addition, during the Site Inspection Survey (Section 3.1.5.3), the first action was to review the flooded extent in relation to the local topography and assess the likelihood of this flood extent occurring. Our conclusions were that the flood maps give a reasonable representation of the location and likely extent of flooding.

Figure 3.1: Comparison of historic flooding event with modelled surface water flooding on Peel House Lane (extract from Drawing 282945/NWD/MCH/101)

Figure 3.2: Comparison of historic flooding event with modelled surface water flooding on Picow Farm Road (extract from Drawing 282945/NWD/MCH/101)

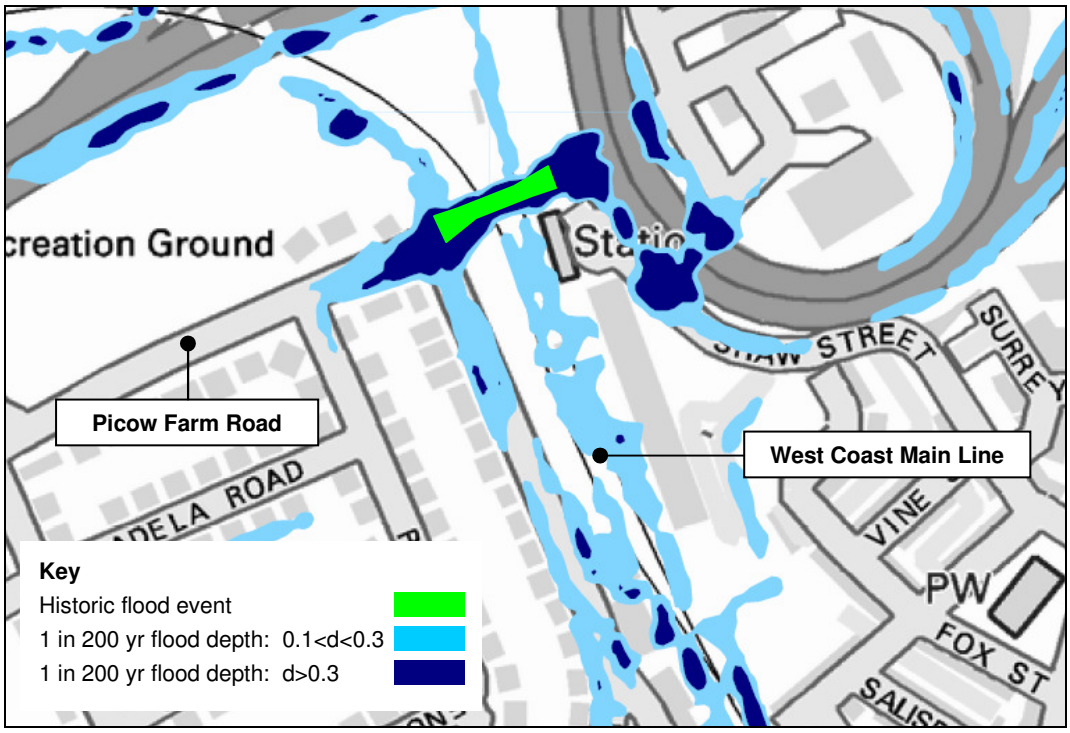
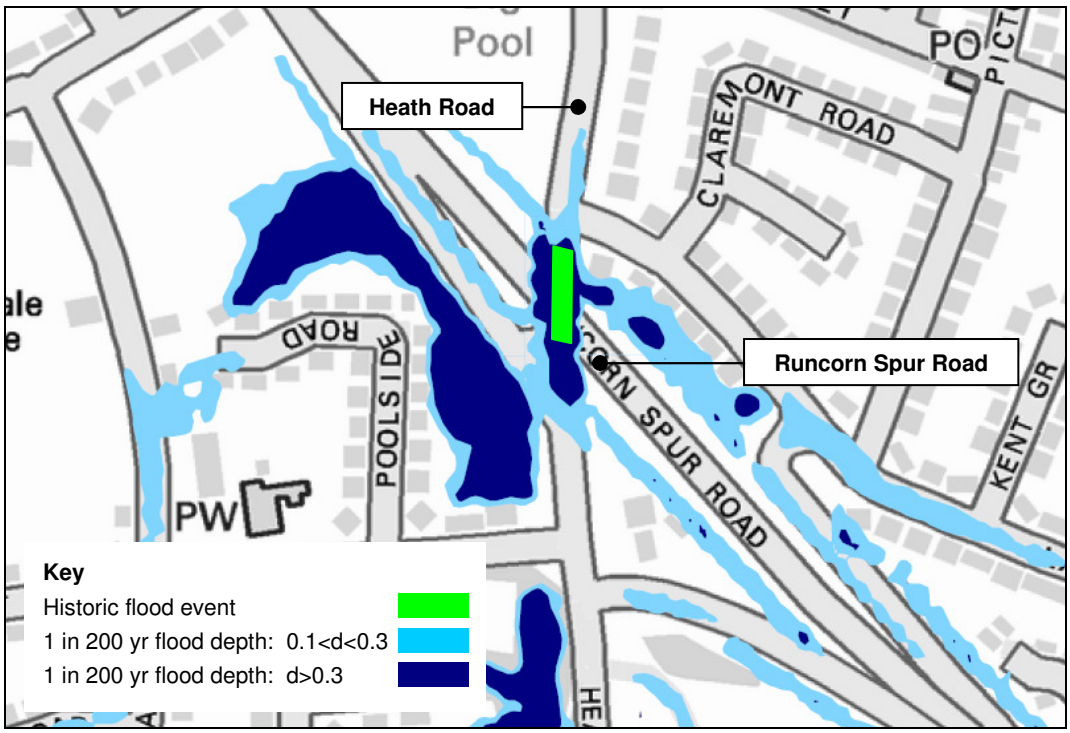


Figure 3.3: Comparison of historic flooding event with modelled surface water flooding on Heath Road (extract from Drawing 282945/NWD/MCH/101)



3.1.5.3 Flood Impact Assessment Validation: Site Inspection Survey

Site walk over surveys were carried out over two days on the 21/02/2011 and 22/02/2011, in order to carry out validation inspections at selected sites in Widnes and Runcorn respectively. The inspections were carried out by David Webborn and Rob Galloway, with Geoff Bolton present for the first seven site inspections in Widnes (all Mott MacDonald).

The purpose of the inspections was to assess whether or not the impacts derived for the relevant map cell(s) by the flood impact scoring system correctly represented site conditions. 20 sites were identified in Widnes, and 18 in Runcorn as a suitable sample of locations at which to undertake the validation inspections using the AStSWF mapping. The selected flooding sites included residential areas, industrial areas and sites along essential infrastructure, including major highways and railways. Each site was assessed according to a set list of criteria, in order to confirm whether or not the impact of flooding for the 1 in 30 year event was valid, given the location and depth of flooding in relation to surrounding buildings and infrastructure.

On completion of the site inspection surveys, it was confirmed that the 1 in 30 year impact of flooding analysis conducted using hydraulic model data and GIS was correct for the majority of sites. However for some cells it was found that the actual impact of flooding was not as indicated in the mapping analysis. The problems identified at individual sites during the validation inspections have been grouped into the four scenarios as described in Table 3.1. Table 3.1 also describes the suggested approach to resolve the identified problems in each case. For all scenarios the identified problems have been resolved using the suggested approaches, utilising GIS techniques in MapInfo.

In addition, other sites were highlighted where further investigation is required in order to determine areas that flood and the potential impacts of the flooding as follows:

- **Widnes Area 19:** Cells in this area are flagged with an impact of flooding score greater than 75 as flooding appears to encroach onto the A557. The site inspections revealed that the majority of flooding

in this area follows the course of Bower's Brook, which is situated in a steep sided valley to the east, and approximately 3m below the road surface. At the point at which the AStSWF map shows flooding on the road surface, the brook is in culvert. A subsequent review of the BHSWFM, which supersedes the AStSWF maps, shows that flooding along the course of Bower's Brook will not affect the A557. This should however be investigated further, as the source of flooding in this case is fluvial, and therefore is not best shown on the BHSWFM.

- **Runcorn Area 18:** Cells in this area are flagged with an impact of flooding score between 5 and 35 due to the AStSWF map showing flooding in the vicinity of properties adjacent to the Bridgewater Canal. On the AStSWF map it is unclear as to whether this flooding is indicated within the canal or if it does occur adjacent to the banks, therefore affecting the properties. The BHSWFM shows that flooding does occur on the banks of the canal and is shown to affect property in the area. The 1 in 30 year flood impact map based on the BHSWFM flags the cells in this area with a similar flood impact score; between 5 and 35.

Other areas highlighted as requiring further investigation are because it was not possible to access these areas during the site walkover. Detailed notes taken during the site visits are contained in Appendix C.

Table 3.1: Problem scenarios identified during validation inspections

Scenario	Description	Example Areas	Photograph	Action to resolve
1	Essential infrastructure situated on overbridge above flooded area.	Widnes: 15, 16 Runcorn: **2**, 3, 4, 6, 7, 15		Break road/rail polygon as it crosses on overbridge.
2	Essential infrastructure situated on embankment above flooded area, infrastructure polygon includes land below embankment crest.	Widnes: 4, **9** Runcorn: 9, 10, 11		Reduce area covered by infrastructure polygon (e.g. for railways, use tracks only and not land owned by Network Rail).
3	Flooded area appears to not encroach on essential infrastructure/properties, yet cell is still flagged.	Widnes: **7**		Check area covered by infrastructure/property polygons and adjust as necessary.
4	Flooding on slip roads for junctions between major roads (essential infrastructure) and minor roads.	Runcorn: **15**		Remove slip roads where junction is with minor road from essential infrastructure polygons.

3.2 Results

The results of the intermediate assessment are presented on the suite of maps included in Appendix A. The suite of maps contains four series of maps as follows:

- **100 Series – Flood Maps (see Appendix A.1):** Model output polygon data for flood depth, hazard and velocity. For each flooding descriptor, three maps are included for the 1 in 30, 100 and 200 year events. The accompanying guidance note "What are the Borough of Halton Surface Water Flood Maps?" is also included in Appendix A.
- **200 Series – Flood Impact Maps (Property) (see Appendix A.2):** Flood impact scores for flood depth and hazard, displayed on the grid of 100m x 100m cells using a colour coding system (Calculation 4.0). The 200 Series displays flood impact scores for property, with three maps included for the 1 in 30, 100 and 200 year events for both flooding descriptors.
- **300 Series – Flood Impact Maps (Essential Transport Infrastructure) (see Appendix A.3):** Flood impact scores for flood depth, displayed on the grid of 100m x 100m cells using a colour coding system (Calculation 4.0). The 300 Series displays flood impact scores for essential transport infrastructure, with three maps included for the 1 in 30, 100 and 200 year events.
- **400 Series – Flood Risk Maps (Property) (see Appendix A.4):** Flood risk scores for flood depth and hazard displayed on the grid of 100m x 100m cells using a colour coding system (Calculation 4.0). The 400 Series displays flood impact scores for property, with three maps included for the 1 in 30, 100 and 200 year events for both flooding descriptors.

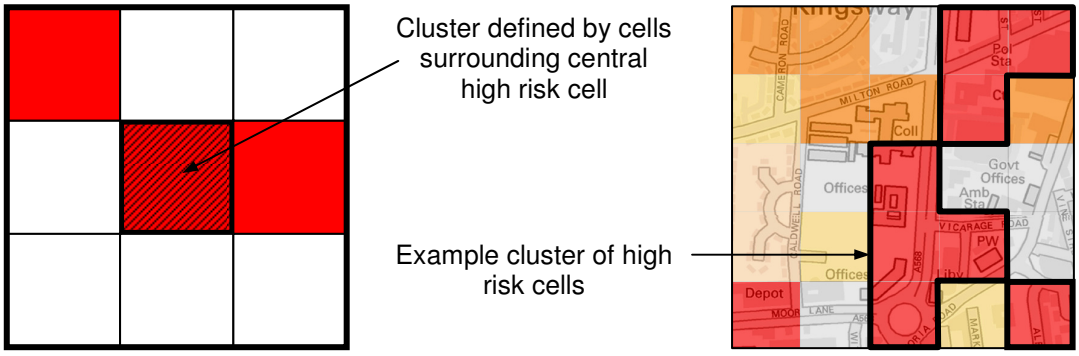
Two separate mapping series have been used to present the flood impact scores for property and essential transport infrastructure, with only flood depth impacts being considered for essential transport infrastructure. This approach was taken to ensure clarity in the mapping and, hence, facilitate the identification of 'hotspot' areas of high surface water flood risk to property. It is anticipated that the indicated flood impacts on essential transport infrastructure will be separately followed up with Network Rail, the Highways Agency and Halton Borough Council.

3.3 Discussion

3.3.1 Property

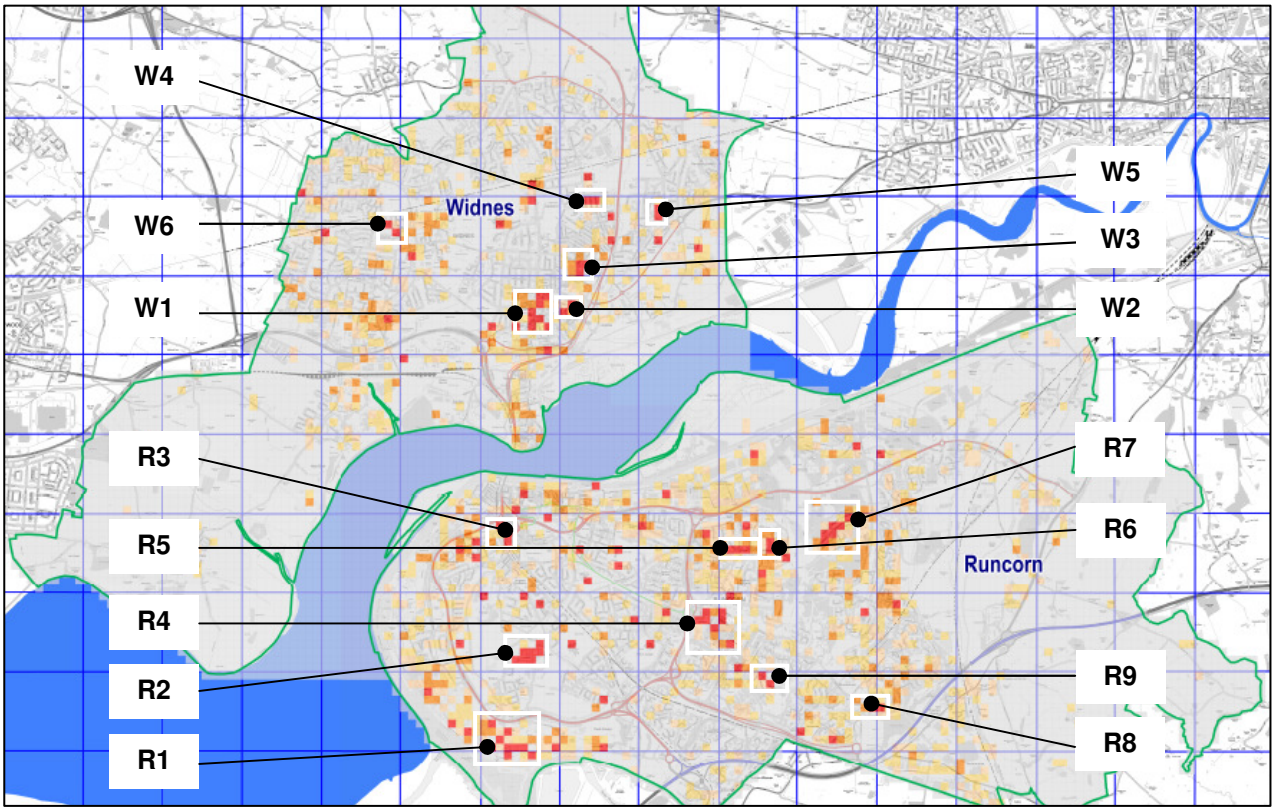
The flood depth and hazard risk maps for property (400 Series Maps) combine the impact scores for the 1 in 30, 100 and 200 year events and identify a number of areas in the Borough of Halton where properties are at a high risk from surface water flooding. From the flood depth risk map, a total of fifteen 'hotspot' areas have been identified, comprising clusters of high risk cells (Flood Depth/Hazard Risk score > 75). The clusters are defined as being two or more adjacent cells scoring greater than 75 as demonstrated in Figure 3.4.

Figure 3.4: Classification of high risk cell clusters identifying 'hotspots' of high surface water flood risk



The locations of the fifteen 'hotspot' areas identified from the flood depth and hazard risk mapping are shown in Figure 3.5. These are areas where the perceived risk of surface water flooding to property is greatest and have accordingly been carried forward to the preliminary detailed assessment as discussed in Section 4 of this report.

Figure 3.5: 'Hotspot' areas identified in Widnes and Runcorn (extract from Drawing 282945/NWD/MCH/401)

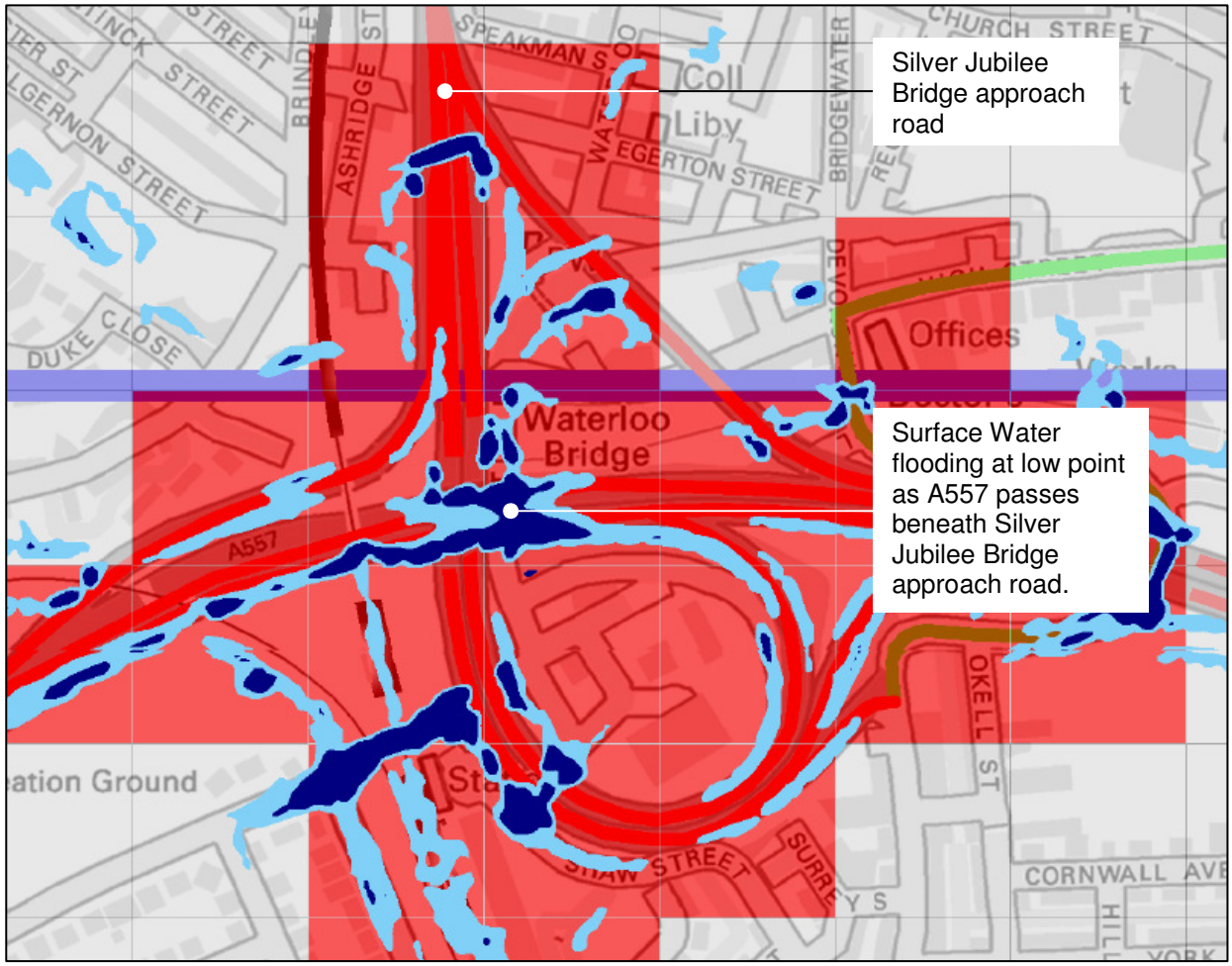


3.3.2 Essential Transport Infrastructure

Due to the high property vulnerability to flooding index applied to all essential transport infrastructure (motorways, trunk roads and railways), any flooding of this infrastructure returns a flood impact score for the relevant cell greater than 75. The flood impact maps for essential transport infrastructure show that a significant portion of these critical transport links that pass through the borough are at high risk from surface water flooding.

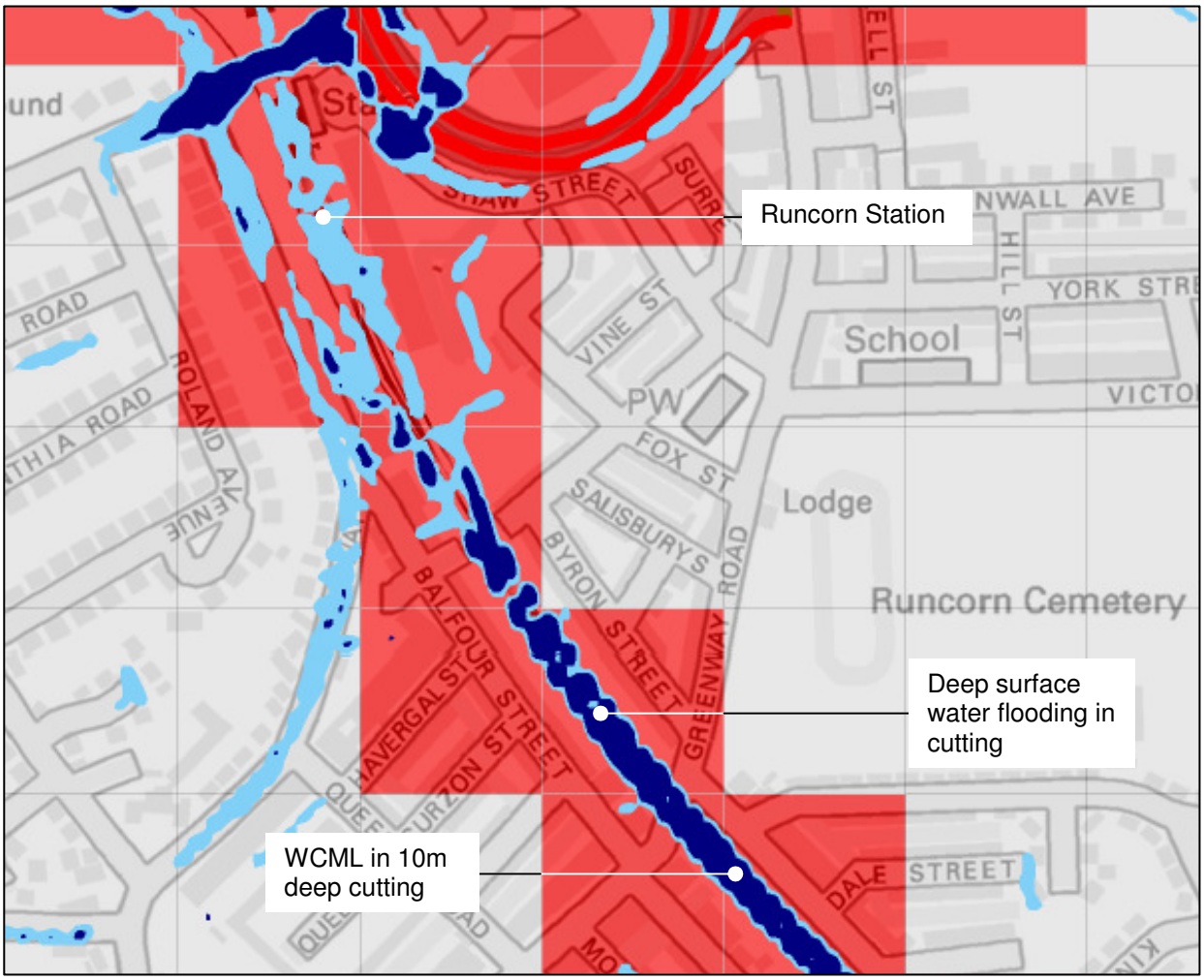
The system of trunk roads in Widnes and Runcorn, connected by the Silver Jubilee Bridge that crosses the River Mersey and MSC, form a major strategic transport link in the Northwest of England. The crossing of the River Mersey is the only crossing for twenty miles and the connecting trunk road network links the M56 motorway to the south with the M62 and A561 routes into Liverpool to the north. Consequently, flooding of these routes during extreme rainfall events is likely to have significant impacts, particularly on the movement of emergency services, and could result in major disruption. The flood impact maps for essential transport infrastructure show that significant lengths of the A533 between the Silver Jubilee Bridge and the M62 are affected by surface water flooding. Similarly, significant interchanges on the Runcorn ring road become inundated from overland flows. Figure 3.6 is an extract from the 1 in 30 year flood depth impact map for essential transport infrastructure. It shows that a large area of deep flooding may be expected to form at a low point on the A557 as it passes beneath the approach road to the Silver Jubilee Bridge.

Figure 3.6: Predicted surface water flooding on A557/Silver Jubilee Bridge interchange in Runcorn (extract from Drawing 282945/NWD/MCH/301)



The flood depth impact maps for essential transport infrastructure also show that significant stretches of the national rail network within the borough are affected by surface water flooding. In general, flooding of the rail network occurs where the railways pass through cuttings. The cuttings act to intercept overland flows, which are then channelled along the railway lines whilst they remain in cutting, to low points in the long profile. This occurs on the Liverpool to Warrington line as it passes through Widnes, and also on the Liverpool spur of the WCML in Runcorn. Figure 3.7 shows part of the WCML in Runcorn. At this location it sits in a 10m deep cutting. Overland flows are intercepted by the cutting and flow north towards Runcorn station where the railway exits the cutting.

Figure 3.7: Predicted surface water flooding on West Coast Main Line (Liverpool spur) (extract from Drawing 282945/NWD/MCH/301)



The flood depth impact maps for transport infrastructure demonstrate that there is a high risk of flooding from surface water to significant stretches of important road and rail links within the Borough of Halton. It is therefore recommended that this data be made known to the relevant parties responsible for the operation of this infrastructure, including the Highways Agency and Network Rail. Where appropriate, detailed assessments of the areas identified as being at a high risk of surface water flooding may then be carried out.

4. Detailed Risk Assessment

4.1 Methodology

Fifteen 'hotspot' locations (Figure 3.5) where the risk of surface water flooding to property (excluding essential transport infrastructure) is deemed to be high were identified for further investigatory work from the intermediate assessment. Further investigations into these 'hotspots' have taken place as part of a 'preliminary' detailed assessment. The preliminary detailed assessment aims to complete the following objectives:

- Confirm the level of flood risk to each individual site as determined from the intermediate assessment.
- Identify actions that should be implemented in order to reduce the level of flood risk at each locality.

The following approach was adopted in order to carry out the 'preliminary' detailed risk assessment:

- Site walk over surveys were carried out at each of the 'hotspot' locations identified in the intermediate assessment.
- For each site, it was confirmed whether or not the modelled depth and extents of flooding as shown on the flood risk map for property was likely to occur in reality. The number of properties likely to be affected by the flooding was also checked.
- Where relevant, the contribution to any surface water flooding by overflowing manholes was noted using data obtained from the United Utilities drainage network model data.
- The impact of flooding on property was assessed through the observation of property thresholds and possible flow routes round buildings. Property threshold levels were compared with the indicative flood depths shown on the flood risk map for property. Building layouts, the locations of boundary walls, road kerbs and access paths were assessed in order to determine potential flow outlets, diversion routes and blockages that would not have been resolved in the DTM.
- Following confirmation of the level of flood risk in each location, suitable actions to reduce this risk were recommended, and prioritised according to the perceived level of flood risk. Where evident, the parties responsible for implementing these actions were identified.

4.2 Findings

Site walk over surveys were carried out over two days on the 16/05/2011 and 17/05/2011, in order to carry out preliminary detailed assessment inspections at the fifteen 'hotspot' sites. The inspections were carried out by Dr. Malcolm Balls and David Webborn of Mott MacDonald, with Adrian Bratby present for Halton Borough Council.

Table 4.1 presents a summary of the actions arising from these inspections. The hotspots have been prioritised according to the perceived level of flood risk. Detailed notes of the findings from the site inspections are contained in Appendix D. The Figures referred to in Table 4.1 are extracts from the flood risk map for property showing each 'hotspot' cell cluster, and are also contained in Appendix D.

It is recommended that for all identified 'hotspots', owners of properties identified as being at risk from surface water flooding are informed of the risk and provided with information on how they can help mitigate it.

Table 4.1: Detailed Assessment – Prioritised list of actions

Priority Level	'Hotspot'	Property affected	Action	Summary
High	**W4** (Fig. D.4) Peel House Lane/St. Anne's Rd	12	• Local drainage system improvements. • Re-model ground levels. • Improve property flood resilience.	Flooding to properties contributed to by overflows from surface water drainage system. Confirm capacity and condition of installed attenuation tank.
High	**R8** (Fig. D.14) Compass Close	21	• Prioritise gulley cleaning. • Re-model existing ground levels. • Improve property flood resilience.	Flooding in low point in Compass Close will inundate surrounding houses. Threshold levels below surrounding ground levels in some cases.
Medium	**W1** (Fig. D.1) Kingsway/ Milton Road	2	• Re-model existing ground levels to divert flow away from buildings. • Improve property flood resilience.	Police Station and Leisure Centre (Loading Bay) have minimal thresholds and will be affected by adjacent flooding.
Medium	**W2** (Fig. D.2) Brynn Street/ Quinn Street	25	• Prioritise gulley cleaning. • Re-model existing ground levels. • Improve property flood resilience.	Flooding in low point at junction between Brynn Street and Quinn Street.
Medium	**W4** (Fig. D.4) Fairhaven Road	14	• Local drainage system improvements. • Re-model ground levels. • Improve property flood resilience.	Flooding to properties contributed to by overflows from surface water drainage system. Manhole at bottom of dip in road overflows.
Medium	**W6** (Fig. D.6) Cradley/ Radnor Drive	15	• Develop hydraulic model to map SW flooding of school and neighbouring properties.	Modelling will utilise topographic surveys and be used to inform measures to contain/direct flood water to open areas in the school and away from buildings and neighbouring properties on Cradley and Radnor Drive.
Medium	**R5** (Fig D.11) Castlefields Avenue South	39	• Inform property owners. • Re-model existing ground levels. • Improve property flood resilience.	Houses adjacent to steep embankment with thresholds <50mm. It is possible that road kerbs at the top of embankments will direct overland flows along the roads.
Medium	**R6** (Fig. D.12) Castlefields Avenue South	30	• Re-model existing ground levels. • Inform future re-development. • Improve property flood resilience.	Houses adjacent to steep embankment with thresholds 0-150mm. Potential for channelling of flood flows through passageways and along footpaths. New developments have not fixed problem with houses having 0mm thresholds.
Medium	**R7** (Fig. D.13) Bridgeway/ Lockgate	118	• Inform property owners. • Re-model existing ground levels. • Improve property flood resilience.	Houses adjacent to embankment with 180mm thresholds. Further investigation required into what happens to properties at the bottom of Lockgate West.
Low	**W1** (Fig. D.1) Kingsway/ Milton Road	8	• Inform property owners. • Re-model existing ground levels. • Improve property flood resilience.	Depressions identified at locations outside council offices, pavements on roundabout and ASDA superstore. Further investigation into likely flow paths around buildings required.
Low	**W3** (Fig. D.3) Bradley Way	21	• Re-model existing ground levels. • Improve property flood resilience.	Deep flooding likely to affect buildings with thresholds up to 500mm.
Low	**R1** (Fig. D.7) Cow Hey Lane	13	• Confirm building threshold levels.	Unable to access industrial works during site visit. Flooding impact and risk need to be confirmed.
Low	**R4** (Fig. D.10) Halton Lea	13	• Inform property owners. • Re-model existing ground levels.	Flooding occurs at various locations, including office buildings and the ASDA superstore at Halton Lea. Threshold levels of plant room facilities likely to be affected by flooding.

Source: Appendix D, Table D1.

5. Conclusions and Recommendations

5.1 Summary

This SWMP project has followed the guidance contained in the Surface Water Management Plan Technical Guidance document (DEFRA, 2010)[3], and in it's current form the preparation and intermediate risk assessment phases of the framework wheel have been completed. From the initial scope set out in the introduction to this report, the intermediate assessment has utilised hydraulic modelling tools and a GIS based approach to identify and map surface water flooding and flood risk across the Borough of Halton. The production of flood impact and risk maps has enabled the consequences of surface water flooding on people, property and infrastructure to be determined.

Having assessed the human impact of surface water flooding throughout the Borough of Halton, areas of high surface water flood risk have been identified and investigated further as part of a 'preliminary' detailed assessment. This has established priorities for the management of flood risk and has produced a series of actions that should be considered in completion of the detailed risk assessment and in the options phase of the SWMP framework.

5.2 Conclusions

Surface water flooding in the Borough of Halton is characterised by a large number of small areas of flooding spread around the borough; there is no single large area of flooding. Some of the flood areas are coincident with or adjacent to property and/or infrastructure and this will have impacts upon the local populace.

A methodology has been developed to identify the impact of flooding on property and infrastructure in order to highlight hotspots where surface water flooding can be expected to have the most significant impacts.

5.3 Recommendations

The recommended actions arising from the preliminary detailed assessment undertaken in this study may be summarised as follows:

1. Inform property owners and other stakeholders identified as being at high risk from surface water flooding and work with them to mitigate this risk.
2. Implement solutions to flooding problems in high priority areas. Suggested solutions include prioritising gulley maintenance in these areas, re-modelling of local ground profiles to help direct flooding away from building entrances, improving the local drainage system where necessary and improving the flood resilience of vulnerable properties (see Table 4.1).
3. At specific locations conduct further investigations, including detailed hydraulic modelling, in order to confirm the flood risk levels identified in the intermediate assessment.
4. Complete the final stages of the SWMP framework wheel.
5. Tie in Action 1 with Communications and Engagement Plan
6. Develop options and proposals for implementation
7. Review and update SWMP periodically to reflect change in infrastructure, property etc.
8. Develop sewer network modelling to identify spill flows in more extreme flood events (e.g. 1 in 100 and 200 year events) and update flood maps and impact and risk assessments.

6. References

1. Pitt, M. (2008) The Pitt Review: Learning Lessons from the 2007 Floods

2. Jeremy Benn Associates (JBA) Consulting (2010) *DRAFT Strategic Flood Risk Assessment for Halton Borough Council*

3. Department for the Environment, Food and Rural Affairs (DEFRA) (2009) *National Rank Order of Settlements Susceptible to Surface Water Flooding*, Crown Copyright

4. Department for the Environment, Food and Rural Affairs (DEFRA) (2010) *Surface Water Management Plan Technical Guidance*, Crown Copyright

5. Flood and Water Management Act (2010) Crown Copyright

6. Statutory Instruments (2009) *Environmental Protection: The Flood Risk Regulations*, Crown Copyright

Appendices

Appendix A. Mapping

A.1. Flood Maps (100 Series)

Guidance Note: What are the Borough of Halton Surface Water Flood Maps?

Flood Depth Map 1 in 30 Year (282945/NWD/MCH/101)

Flood Depth Map 1 in 100 Year (282945/NWD/MCH/102)

Flood Depth Map 1 in 200 Year (282945/NWD/MCH/103)

Flood Hazard Map 1 in 30 Year (282945/NWD/MCH/104)

Flood Hazard Map 1 in 100 Year (282945/NWD/MCH/105)

Flood Hazard Map 1 in 200 Year (282945/NWD/MCH/106)

Flood Velocity Map 1 in 30 Year (282945/NWD/MCH/107)

Flood Velocity Map 1 in 100 Year (282945/NWD/MCH/108)

Flood Velocity Map 1 in 200 Year (282945/NWD/MCH/109)

Interactive Flood Map (282945/NWD/MCH/110): An interactive flood map combining all the data presented on drawings 282945/NWD/MCH/101-109 is available electronically. Data is presented in layers which can be switched on and off as required. The interactive flood map also includes the locations of the sewer model nodes flooding in the 1 in 30 year event.

A.2. Flood Impact Maps: Property (200 Series)

Flood Depth Impact Map 1 in 30 Year (282945/NWD/MCH/201)

Flood Depth Impact Map 1 in 100 Year (282945/NWD/MCH/202)

Flood Depth Impact Map 1 in 200 Year (282945/NWD/MCH/203)

Flood Hazard Impact Map 1 in 30 Year (282945/NWD/MCH/204)

Flood Hazard Impact Map 1 in 100 Year (282945/NWD/MCH/205)

Flood Hazard Impact Map 1 in 200 Year (282945/NWD/MCH/206)

A.3. Flood Impact Maps: Essential Transport Infrastructure (300 Series)

Flood Depth Impact Map 1 in 30 Year (282945/NWD/MCH/301)

Flood Depth Impact Map 1 in 100 Year (282945/NWD/MCH/302)

Flood Depth Impact Map 1 in 200 Year (282945/NWD/MCH/303)

A.4. Flood Risk Maps: Property (400 Series)

Flood Depth Risk Map (282945/NWD/MCH/401)

Flood Hazard Risk Map (282945/NWD/MCH/402)

Clusters of High Risk Map (282945/NWD/MCH/403)

A.5. Historic Flood Mapping

Strategic Flood Risk Assessment Historical Flooding Map (2010s4182 – D016, © JBA Consulting, 2010)

Historic Flood Areas in Halton (© Halton Borough Council, 2009)

Appendix B. Calculations

Appendix C. Flood Impact Scoring Validation

Appendix D. Preliminary Detailed Assessment

D.1. Detailed Site Inspection Notes

D.2. 'Hotspot' Cluster Maps

D.2.1. Widnes

Figure D.1: Widnes Area 1 (Kingsway/Milton Road)

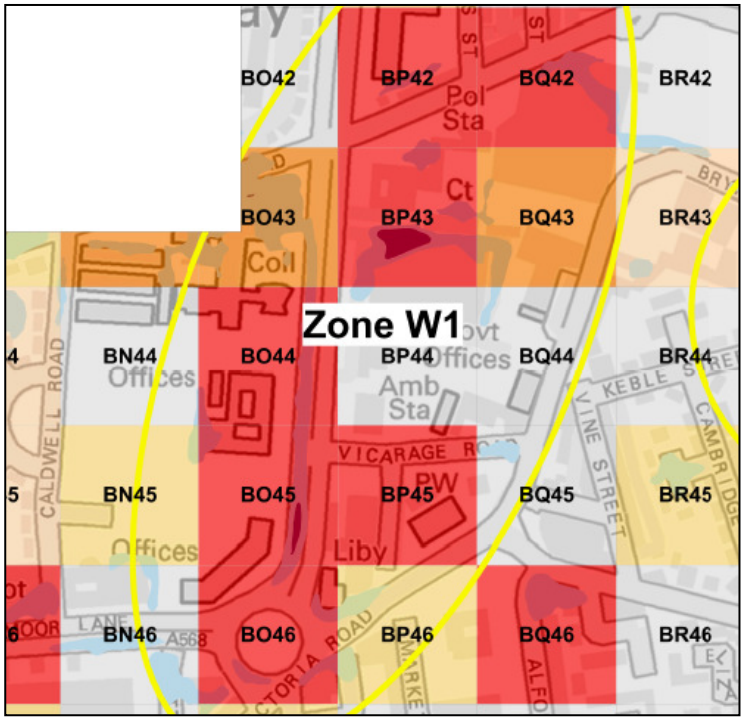


Figure D.2: Widnes Area 2 (Brynn Street/Quinn Street)

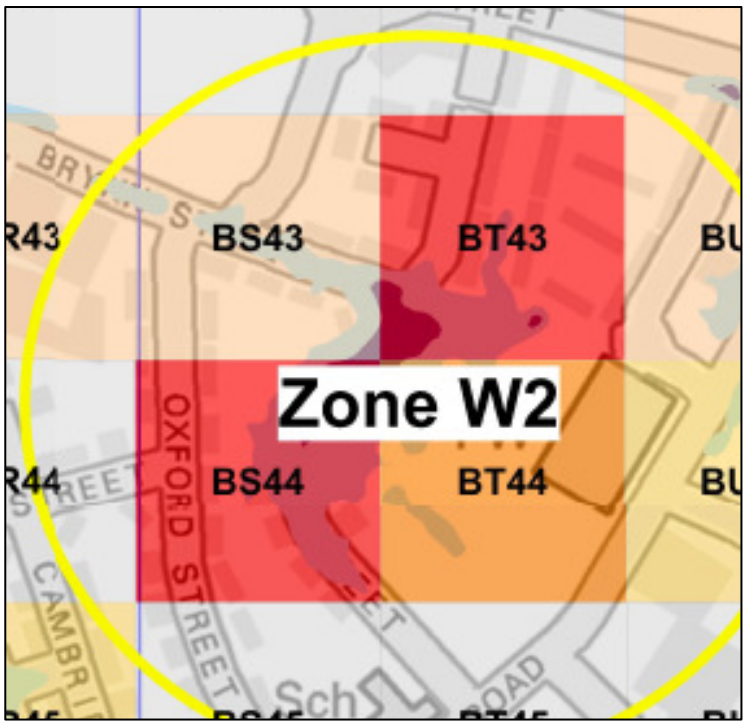


Figure D.3: Widnes Area 3 (Bradley Way)

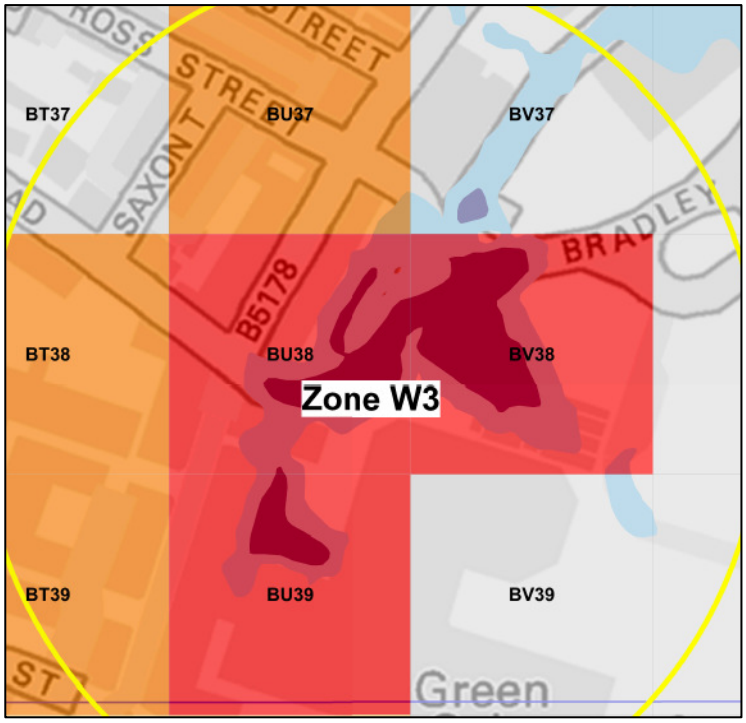


Figure D.4: Widnes Area 4 (Peel House Lane/St. Anne's Road/Fairhaven Road)

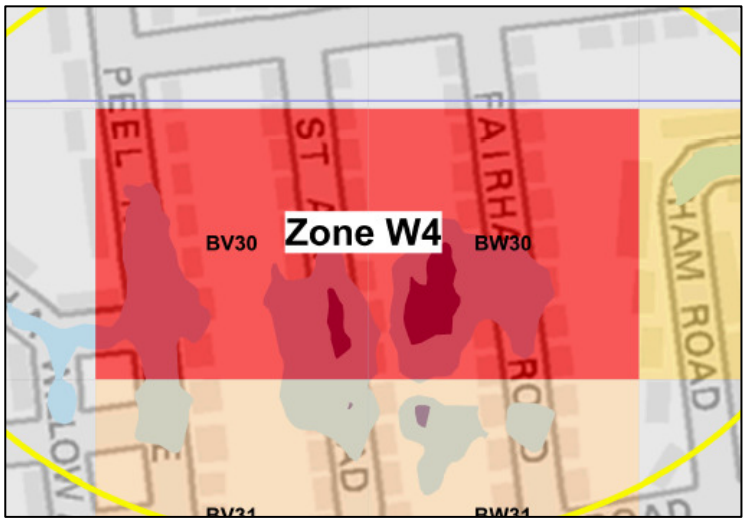


Figure D.5: Widnes Area 5 (Moorfield Road)

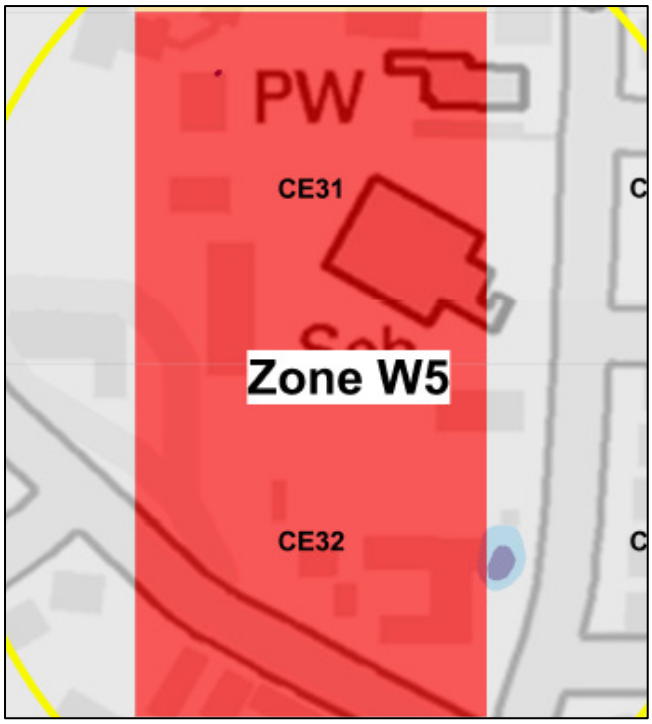
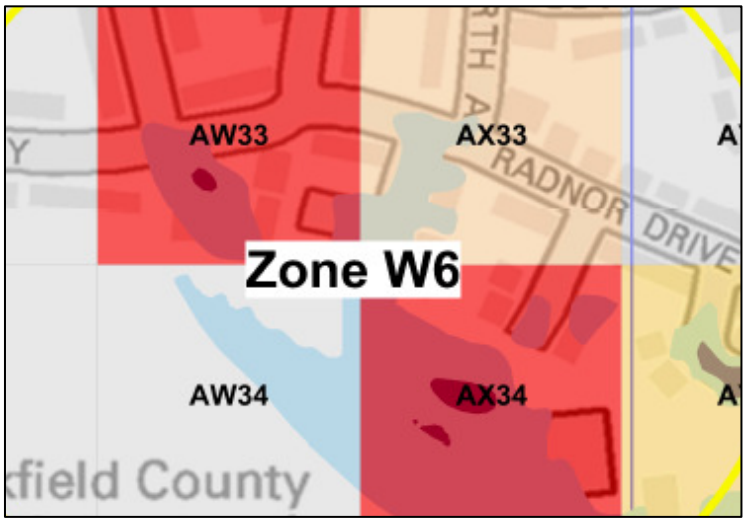


Figure D.6: Widnes Area 6 (Radnor Drive/Cradley)



D.2.2. Runcorn

Figure D.7: Runcorn Area 1 (Cow Hey Lane)

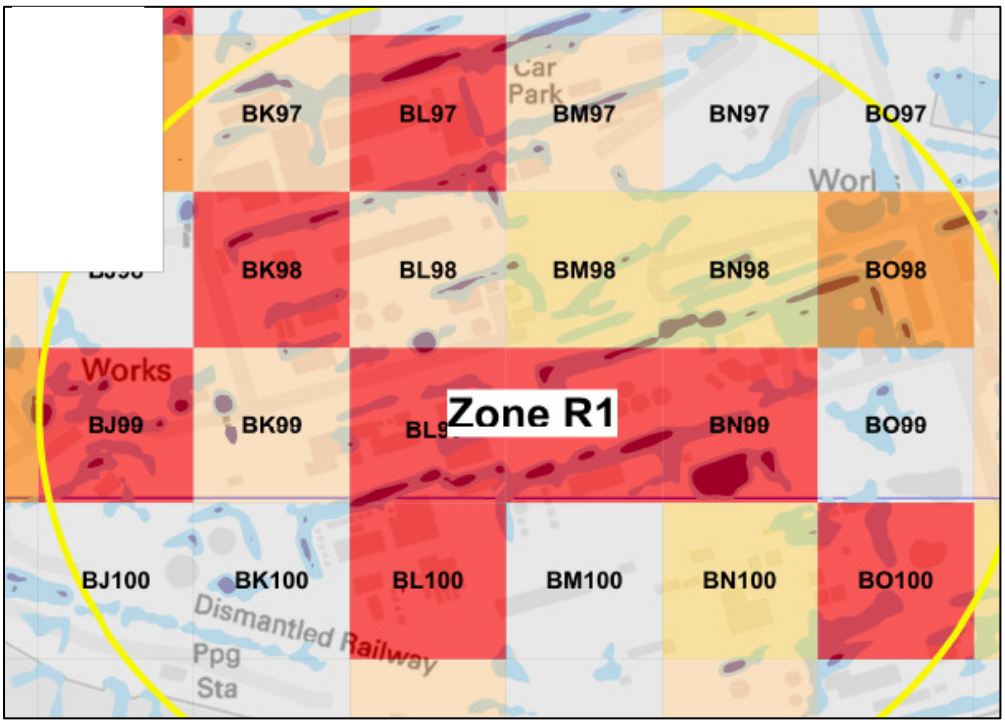


Figure D.8: Runcorn Area 2 (The Heath)

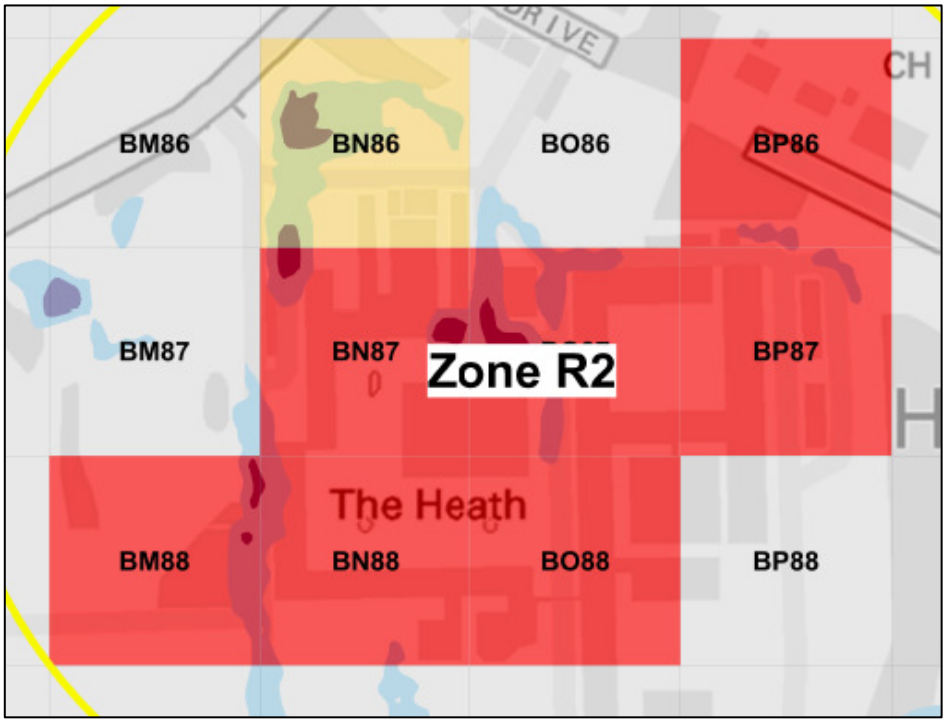


Figure D.9: Runcorn Area 3 (Picow Farm Road/Shaw Street)

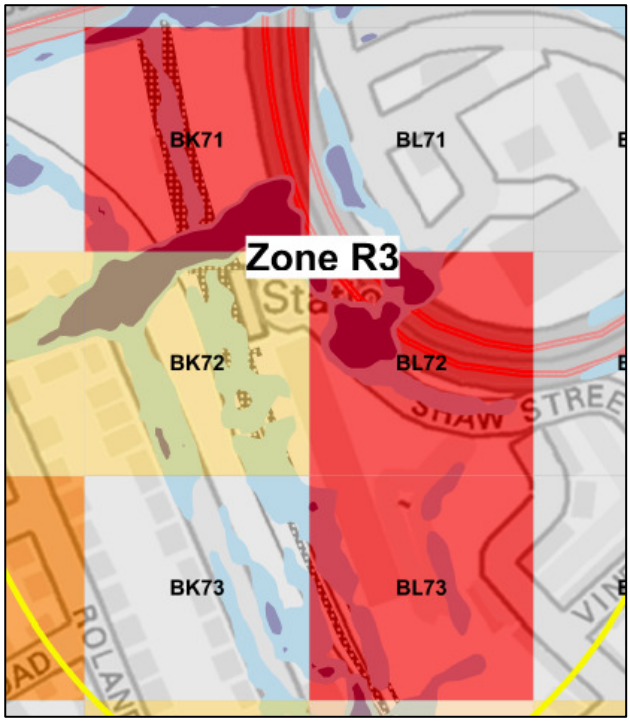


Figure D.10: Runcorn Area 4 (Halton Lea)

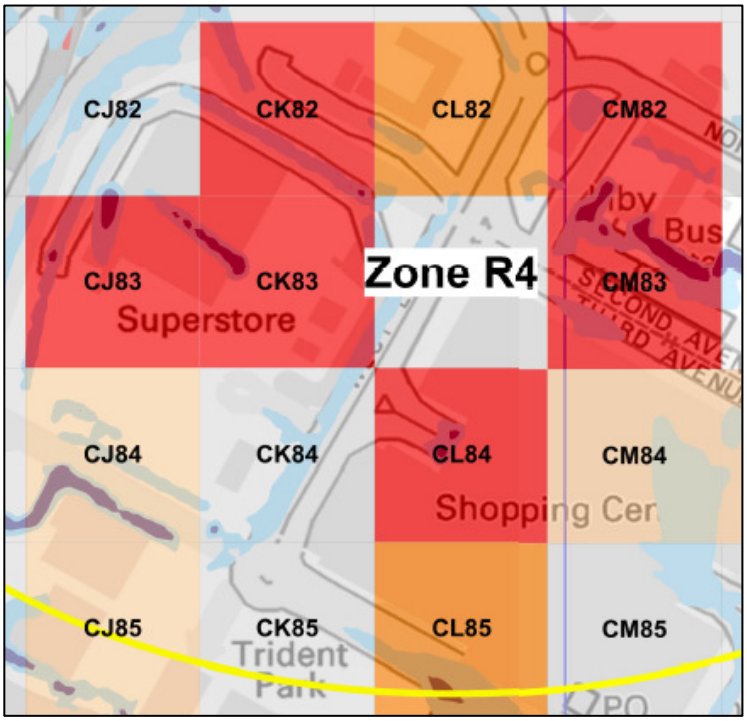


Figure D.11: Runcorn Area 5 (Castlefields Avenue South)

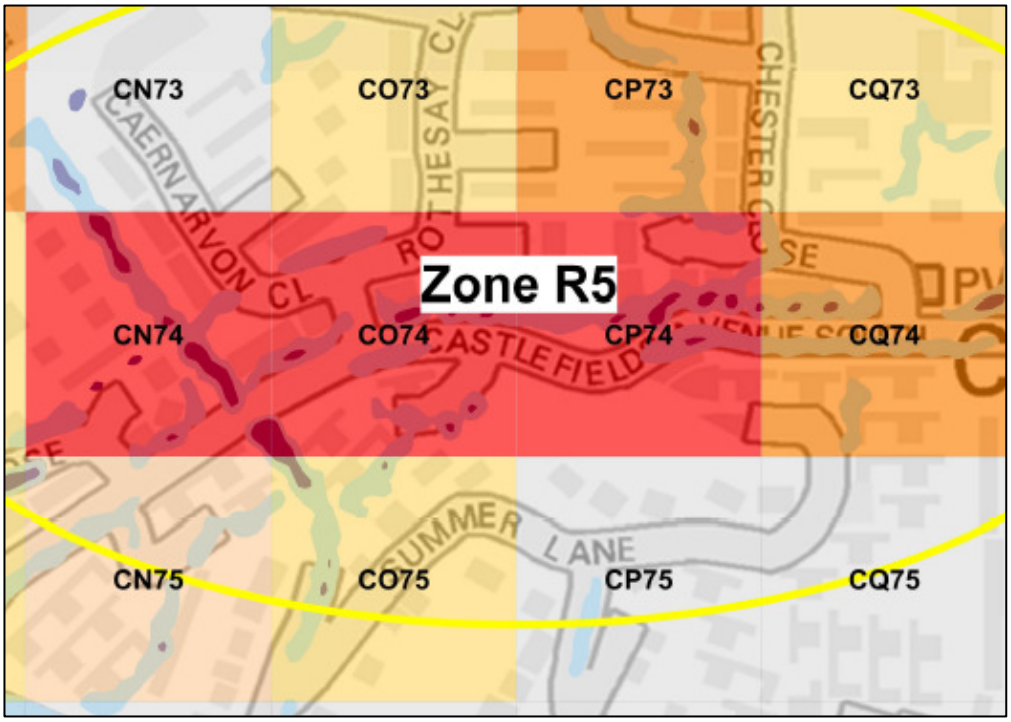


Figure D.12: Runcorn Area 6 (Castlefields Avenue South)

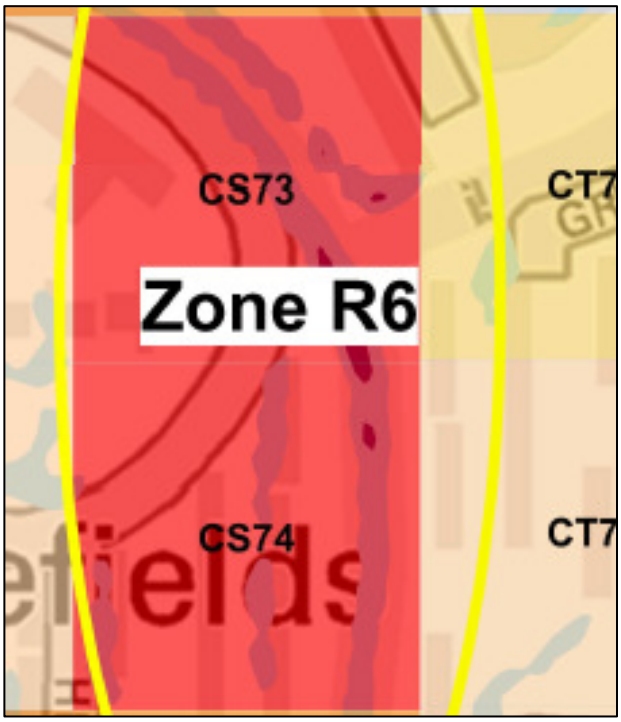


Figure D.13: Runcorn Area 7 (Bridgeway/Lockgate)

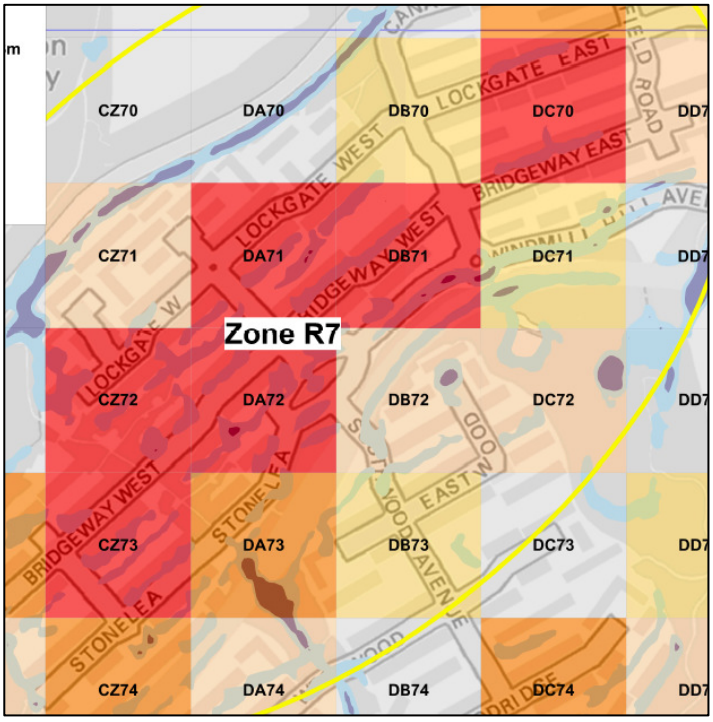


Figure D.14: Runcorn Area 8 (Compass Close)

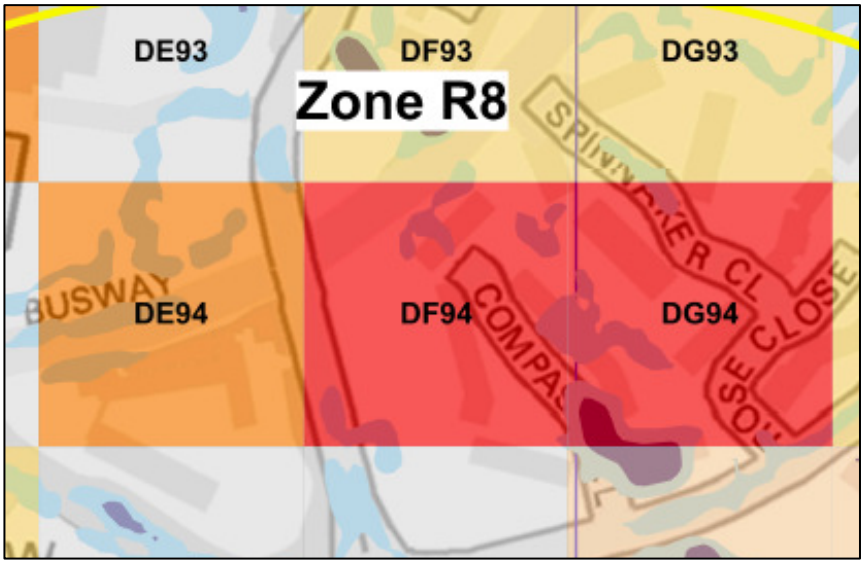
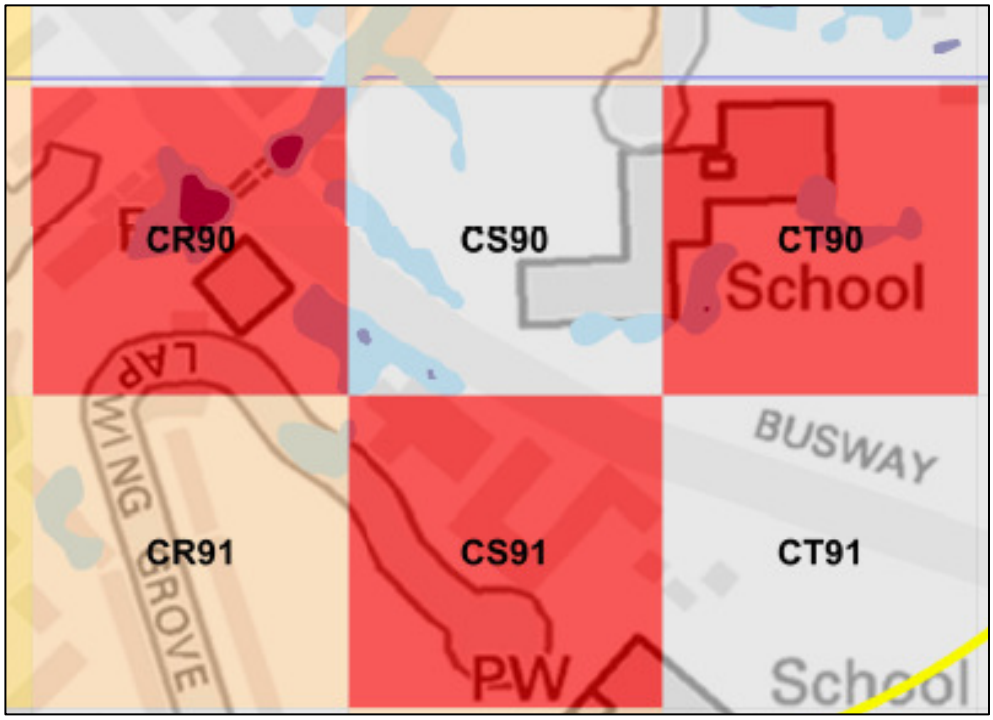


Figure D.15: Runcorn Area 9 (Lapwing Grove)



Appendix E. Document and Drawing Register and Transmittals

E.1. Incoming Document and Drawing Register

E.2. Outgoing Document Register

E.3. Outgoing Drawing Register