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# Hurlston Brook Flood Risk Study

Lancashire County Council

## Flood Risk Management Viability Report

B2237306-JAC-HB-RP-C-0001 | P02

30th January 2018

LCC Order No.678

## Hurlston Brook Flood Risk Study

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| Project No: | B2237603 |
| Document Title: | Flood Risk Management Viability Report |
| Document No.: | B2237306-JAC-HB-RP-C-0001 |
| Revision: | P02 |
| Date: | 30th January 2018 |
| Client Name: | Lancashire County Council |
| Client No: | LCC Order No.678 |
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| File Name: | B2237306_JAC_RP_C_001 - Viability Report P02.docx |

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### Document history and status

| Revision | Date | Description | By | Review | Approved |
|---|---|---|---|---|---|
| P01 | 07/04/2017 | | G Price / S Loughrey | M Shepard | M Shepard |
| P02 | 30/01/2018 | Revised following comments from LCC | S Loughrey | M Shepard | M Shepard |
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# 1. Introduction

## 1.1 Background

Ormskirk is a historic market town in West Lancashire, its location within the county is indicated in Figure 1.1. The town is composed principally of residential properties, with a number of commercial and light-industrial developments around the town centre.

The land surrounding Ormskirk town centre generally falls from south to north with higher ground also located to the east and west. In comparison, the town centre has a comparatively flat as illustrated by Figure 1.2, which also indicates the extents and location of Hurlston Brook.

Hurlston Brook is designated a Main River and acts as a 'trunk drain' into which large networks of surface water and land drains discharge. This includes several Ordinary Watercourses, which are culverted beneath the town.

The river has an extensive floodplain and has the potential to flood large numbers of residential properties. In addition, the culverted watercourses represent a potential risk of flooding as a result of blockage or limited capacity, resulting in surcharging.

Drainage of the highways and impermeable surface areas is collected by either the surface water or combined drainage systems, with the purely surface water system discharging directly into Hurlston Brook.

The area has suffered from flooding on numerous occasions over the last 20 years, with the most significant flood events occurring in 2012 and 2015.

**Figure 1.1 : Ormskirk Study Area Location Plan**

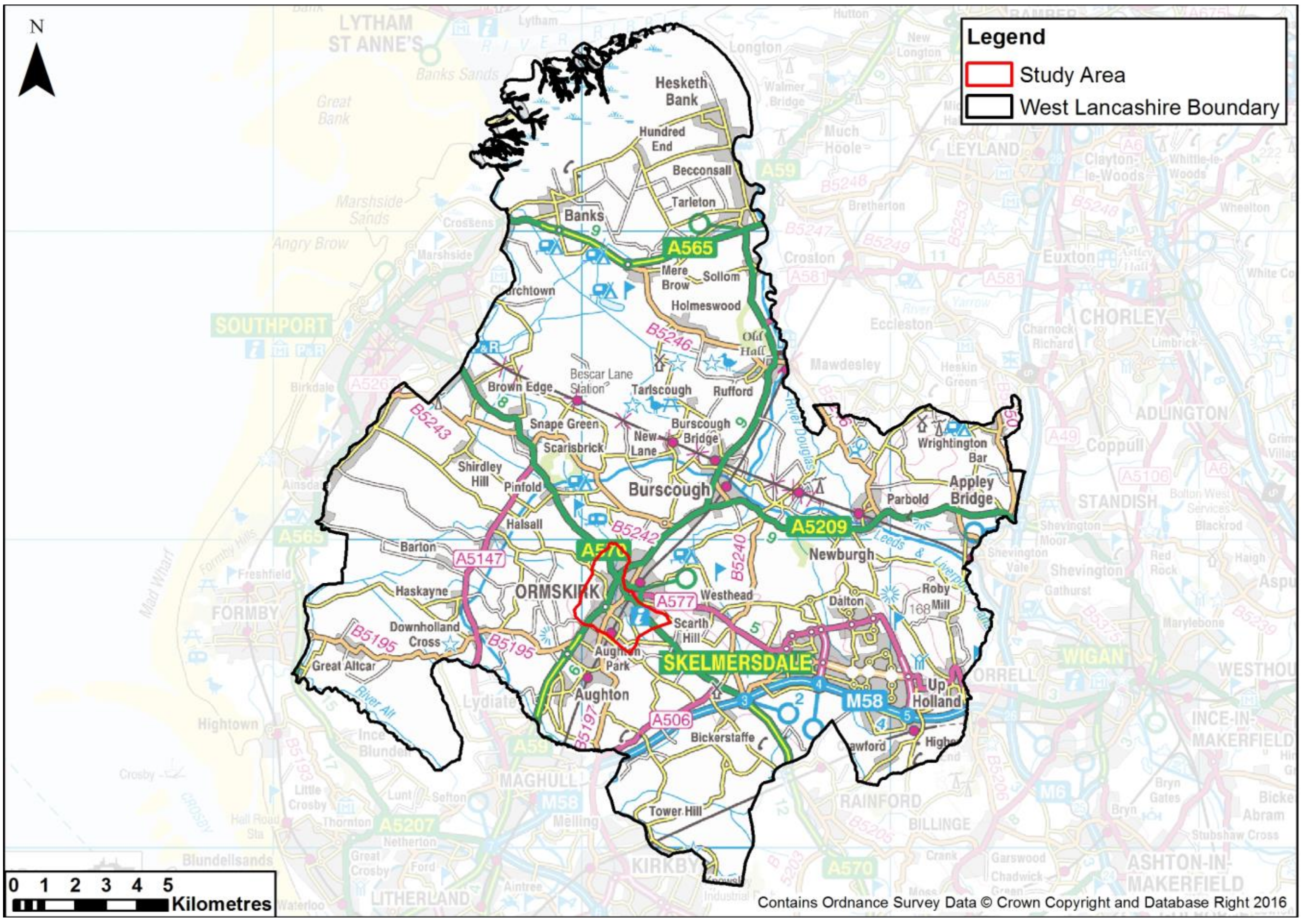
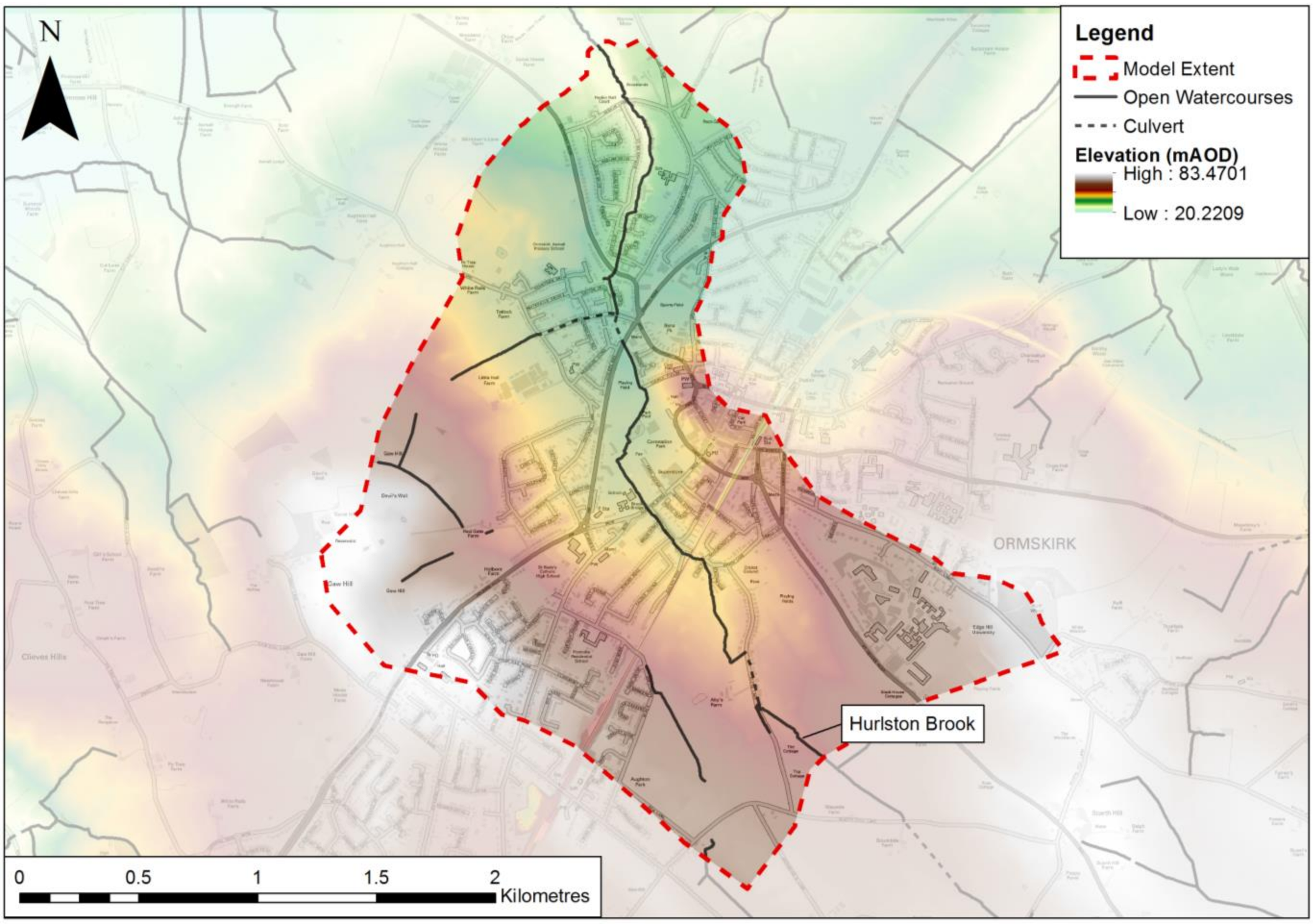


**Figure 1.2 : Study Area showing Topography and Hurlston Brook**




Lancashire County Council (LCC) is the Lead Local Flood Authority (LLFA) for the Ormskirk area and consequently has a responsibility to lead investigations into and the management of local flood risk under the Flood and Water Management Act 2010 (FWMA).

While LCC have a key regulatory role, they are not solely responsible for the management of all water assets in Ormskirk. This responsibility is shared between the main Risk Management Authorities (RMAs) as follows;

**Table 1.1 : Risk Management Authorities**

| Risk Management Authority | Role | Asset Responsibility in Ormskirk |
|---|---|---|
| Lancashire County Council (LCC) | Lead Local Flood Authority (LLFA) | Local sources of flooding (surface runoff, groundwater and ordinary watercourses) |
| Environment Agency (EA) | National responsibility for Flooding | Flooding from designated Main Rivers |
| Lancashire County Council | Highways Authority | Flooding from highways drainage |
| United Utilities | Statutory Undertaker | Sewer flooding |

As well as the RMAs, there are also resident-led flood actions groups for two of the areas, which have been most frequently and significantly affected by the recent flood events, namely;

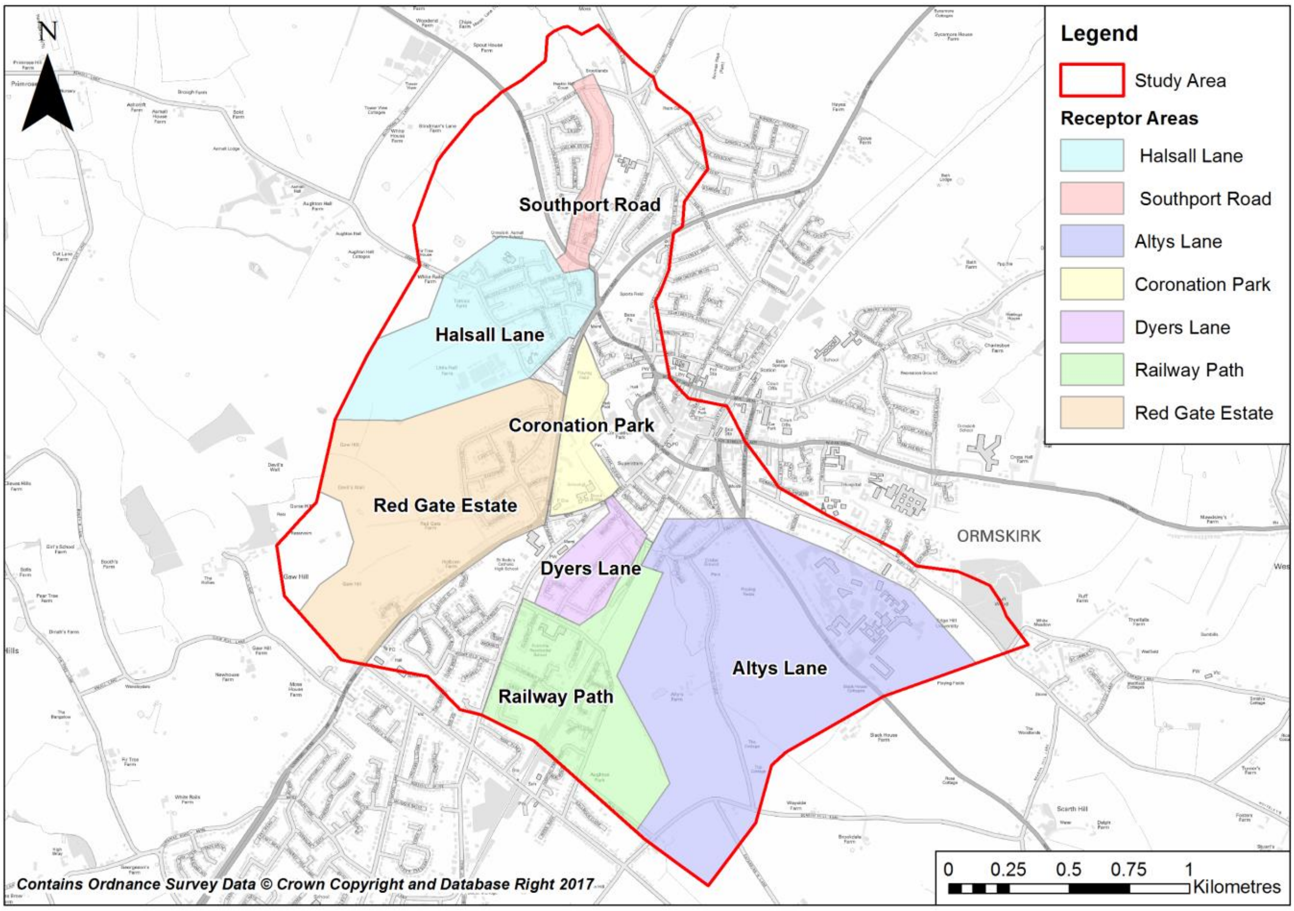
- Dyers Lane Flood Group
- Halsall Lane Flood Group

Following a number of flood events in recent years, LCC commissioned Jacobs in 2015 to undertake an investigation of the flood risk across Ormskirk.

## 1.2 Study Approach

Following a multi-agency meeting between LCC's Flood Risk Management team, LCC Highways, West Lancashire Borough Council and the Environment Agency, seven key flooding receptor areas, on which the study should focus, were identified and are indicated on Figure 1.3.

**Figure 1.3 : Key Receptor Areas**




The aim of this study is to investigate the flood risk across Ormskirk. In order to achieve this aim, the council have scoped this study which would aim to;

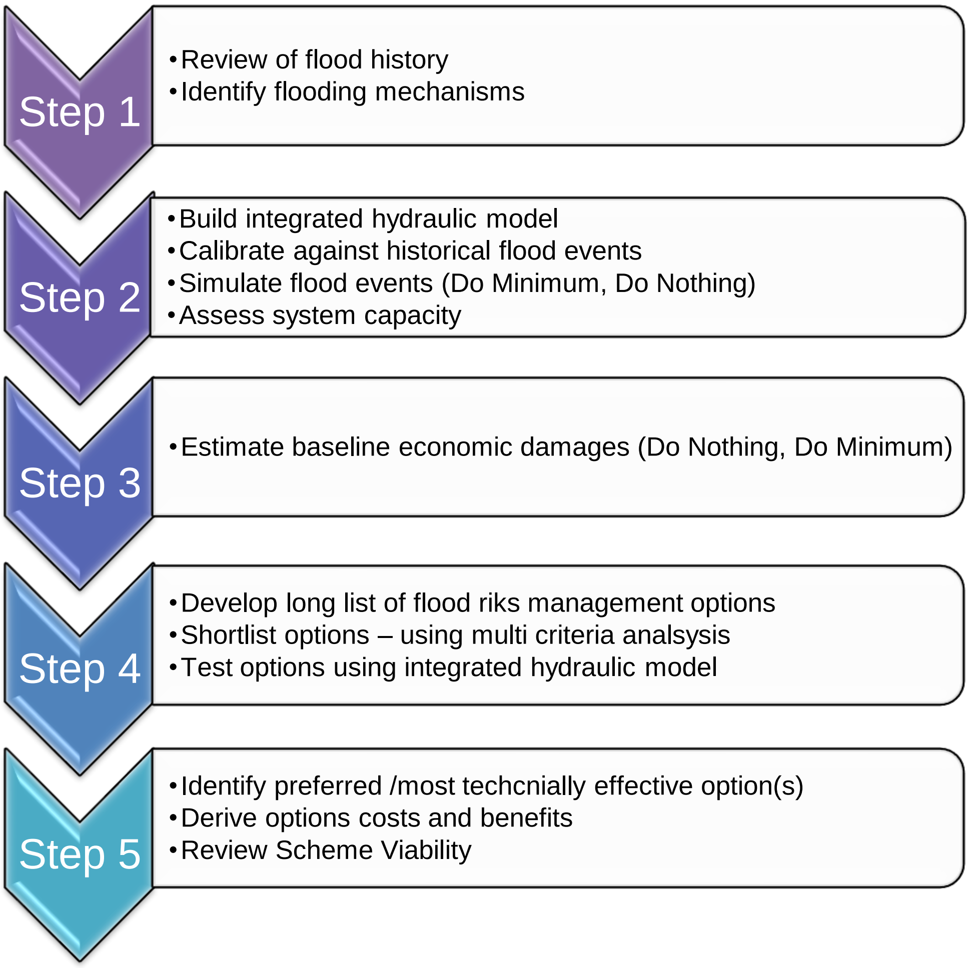
- Identify the primary sources of flooding within each of the seven key risk areas;
- Identify potential options to manage the risk of flooding from these sources; and
- Provide commentary on potential next steps to develop a scheme further.

The method adopted to satisfy these aims is discussed in detail in Section 1.3. Once complete, the findings of this study would be used to submit further funding applications, identify partnership funding contributions and develop a Strategic Outline Case should a preferable solution be identified.

## 1.3 Methodology

To achieve the stated aims of the study, a five-step approach was developed - starting with a review of historical flooding incidents and the construction of an integrated hydraulic model, and concluding with an assessment of options to reduce flood risk. Figure 1.4 illustrates the five-steps of the analysis, with a detailed description provide underneath.

**Figure 1.4 : Study Methodology**




**Step 1** involved a review of historical flooding information collected from resident flood response questionnaires provided by LCC and the Environment Agency. Additional information has been gathered from internet searches, feedback sessions with local stakeholders and from discussions with property owners during site visits. This information was then used to gain an initial understanding of potential flooding mechanisms and areas of focus.

To develop a detail understanding of flooding mechanism, **Step 2** involved the development of an integrated hydraulic model, which incorporates the existing drainage and sewer network data provided by United Utilities, and a two-dimensional hydrodynamic model of Hurlston Brook received from the Environment Agency. Details of the model build, calibration and simulation process are contained in Appendix B.

Since the hydraulic model contains a representation of the both the drainage and Ordinary Watercourse networks and thus represents overland flow routes and interactions with the main river whilst also being able to interrogate the drainage component, to establish which parts of the system become surcharged (and may result in above ground flooding) under certain storm events. To do this, two baseline scenarios were simulated including the:

- **Do Minimum -** assumes present operating conditions and the continuation of current maintenance regimes
- **Do Nothing** - assumes cessation of active maintenance, repair and operation of the system, resulting in the asset system deteriorating, increasing the blockage risk and reducing the conveyance capacity for the drainage system and watercourses

Both scenarios were simulated for a range of flood return periods, as listed in Table 1.2, and modelled flood extents and depths extracted.

**Table 1.2 : Flood Event Frequencies**

| Annual Chance | 1 in 5 | 1 in 10 | 1 in 20 | 1 in 30 | 1 in 50 | 1 in 75 | 1 in 100 |
|---|---|---|---|---|---|---|---|
| Annual Exceedance Probability (AEP) | 20% | 10% | 5% | 3.33% | 2% | 1.33% | 1% |

One of the key outputs from the Do Minimum and Do Nothing simulations is a suite of flood depth grids, which when applied to a geographically referenced property dataset, are used to generate an estimate of the economic flood damages incurred over a 50-year appraisal period. This process is completed in **Step 3**.

The hydraulic model is also further interrogated to identify flood flow routes and flooding volumes, which, when reviewed with the evidence of historical flooding and economic damages, help provide a detailed understanding of flood probability, mechanisms and consequences. Based on this detail understanding, **Step 4** involves the development of a comprehensive list of potential FRM options, which can be assessed at each of the flood risk areas. The long list of options is screened using a multi-criteria analysis, including, technical effectiveness, health and safety and environmental criteria, to generate a shortlist of options. These options are then tested for their technical effectiveness in reducing flooding using the hydraulic model. The option identification and assessment process is detailed in Appendix D.

**Step 5** involves the development of outline **cost estimates** for the shortlisted options, including provision for design development, capital and maintenance costs over the 50-year appraisal period. The detailed cost estimates are contained in Appendix E and summarised in Section 5. The residual flooding with the options in place are then processed through the economic evaluation tool to estimate the damages avoided (known as the **benefits**) of each option so that a Benefit Cost Ratio (BCR) is generated. This is a key indicator of financial viability and is used in the final economic appraisal calculations to determine the financially preferred options. The economic assessment is summarised in Section 4.2 and detailed calculations are contained in Appendix EF.

# 2. Historical Flooding

Over the last 20 years, there have been a number of significant flood events of note, with the most severe of these events occurring in 2012 and 2015. These significant events are discussed in more detail in Sections 2.1 and 2.2. Appendix A contains information on the flooding records obtained during both the 2012 and 2015 events.

## 2.1 History of Flooding – Events up to and including September 2012

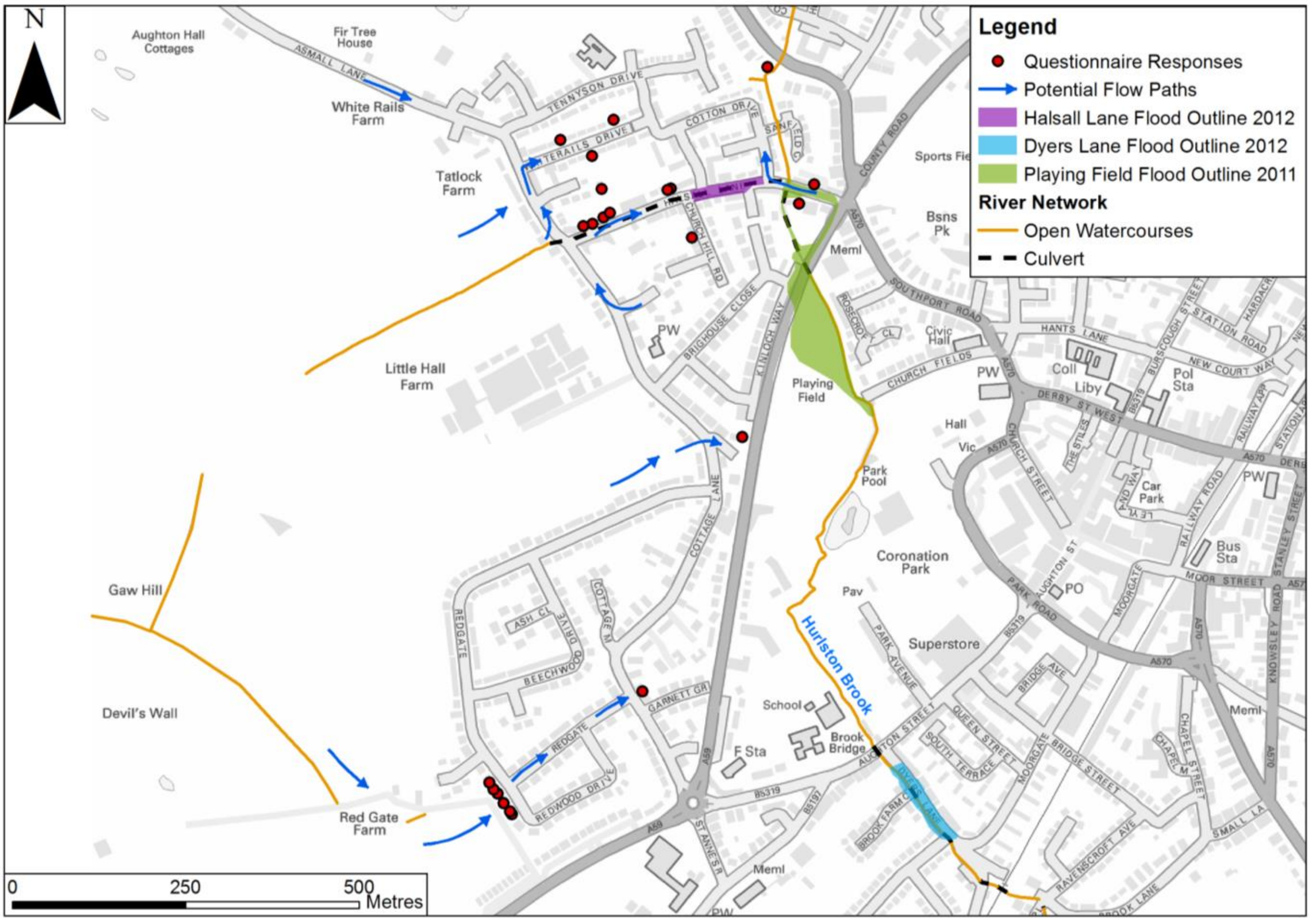
Between January 2008 and September 2012 there are a number of formal records of internal flooding to residential properties on Redwood Drive, Tennyson Drive, Whiterails Drive, Halsall Lane, Dyers Lane, Railway Path, Altys Lane and Southport Road. While helpful in developing an understanding of the mechanisms and extents of recent flooding, it is important to recognise that these records do not provide a comprehensive account of all flooding incidents during this period as data is not held for every property within each area.

From a review of these records the most severe event was that of September 2012, when the occupants of at least ten properties were forced out of their homes due to flood damage, including properties on Altys Lane, Halsall Lane and Southport Road. Due to the severity of flood damage, the residents of two were unable to return to their homes for six months.

During the same event, LCC received three further reports of floodwater being within 2 metres of residential properties and 12 reports of flooding to the local highways. The September 2012 was a large rainfall event and was estimated to have been between a 5% AEP and 3.33% AEP flood event.

Figure 2.1, below, shows the flood incident records up to and including the 2012 flood event. The data presented in the figure includes flood incident records (which have been collated from the Environment Agency records and LCC Questionnaire responses) together with recorded outlines of flooding on Dyers Lane, Coronation Park and Halsall Lane.

**Figure 2.1 : Flooding Records up to September 2012**




During the September 2012 event, properties in each of the seven key receptor areas were affected. The following sub-sections describe the impact on each area and collated commentary on any flooding mechanisms.

### 2.1.1 Altys Lane

In September 2012, local ditches were overtopped as a result of flood flows. This resulted in overland flow flooding several properties, the extents of which are evident in the photographs provided below. Records indicate that the trash screen at the upstream end of the culvert through which Hurlston Brook flows, along with the road drainage gullies were blocked with debris. While the rate of natural percolation (water soaking into the ground) was reduced due to combination of near surface sandstone and heavily compacted farmland, both of which would have exacerbated the flooding.

**Photograph 1 : Altys Lane Flooding, September 2012**

View looking south along Altys Lane

Floodwater outside No. 69 Alty's Lane

### 2.1.2 Railway Path

Records identify that overland flow down Railway Path contributed to out of bank flows at Dyers Lane. The private residence at No. 19 Railway Path was flooded.

### 2.1.3 Dyers Lane

Hurlston Brook overtopped it's banks. This in combination with the overland flow down Railway Path resulted in the flooding of six properties on the right bank of Hurlston Brook.

### 2.1.4 Coronation Park

Wide spread flooding occurred in Coronation Park. It has been suggested that the trash screen to the culvert through which Hurlston Brook flows beneath County Road became temporarily blocked, causing floodwater in Hurlston Brook to back up, resulting in the river spilling over its left bank, increasing the depth of floodwater in the park.

Post event surveys indicated that the culvert at the end of Church Fields had been affected by debris build up, which may have contributed to the volume of water overtopping the river banks and flooding the park.

### 2.1.5 Halsall Lane

Flood records suggest that flooding of properties on Halsall Lane occurred in 2001, 2002, 2008, 2011 and 2012. To the western end of Halsall Lane, including Whiterails Road and Tennyson Drive, several residential properties recorded internal and external (garden) flooding up to 150mm in depth.

On these occasions, it was believed that the flooding experienced was caused by a combination of pluvial runoff from the fields to the west (Little Hall Farm and Tatlock Farm), raised groundwater levels, surcharged drains and sewers, and blocked gullies.

Floodwater was reported as flowing down Halsall Lane and Whiterails road, contributing to the volume of water collecting in a low spot at the bottom of Halsall Lane under which Hurlston Brook is culverted.

### 2.1.6 Southport Road

In September 2012, the increased flows in Hurlston Brook and persistent heavy rainfall resulted in flooding to three properties on Southport road, the residents of which reported a 600mm depth of floodwater affecting their garden and inside the ground floor of the property.

### 2.1.7 Red Gate Estate & Redwood Drive

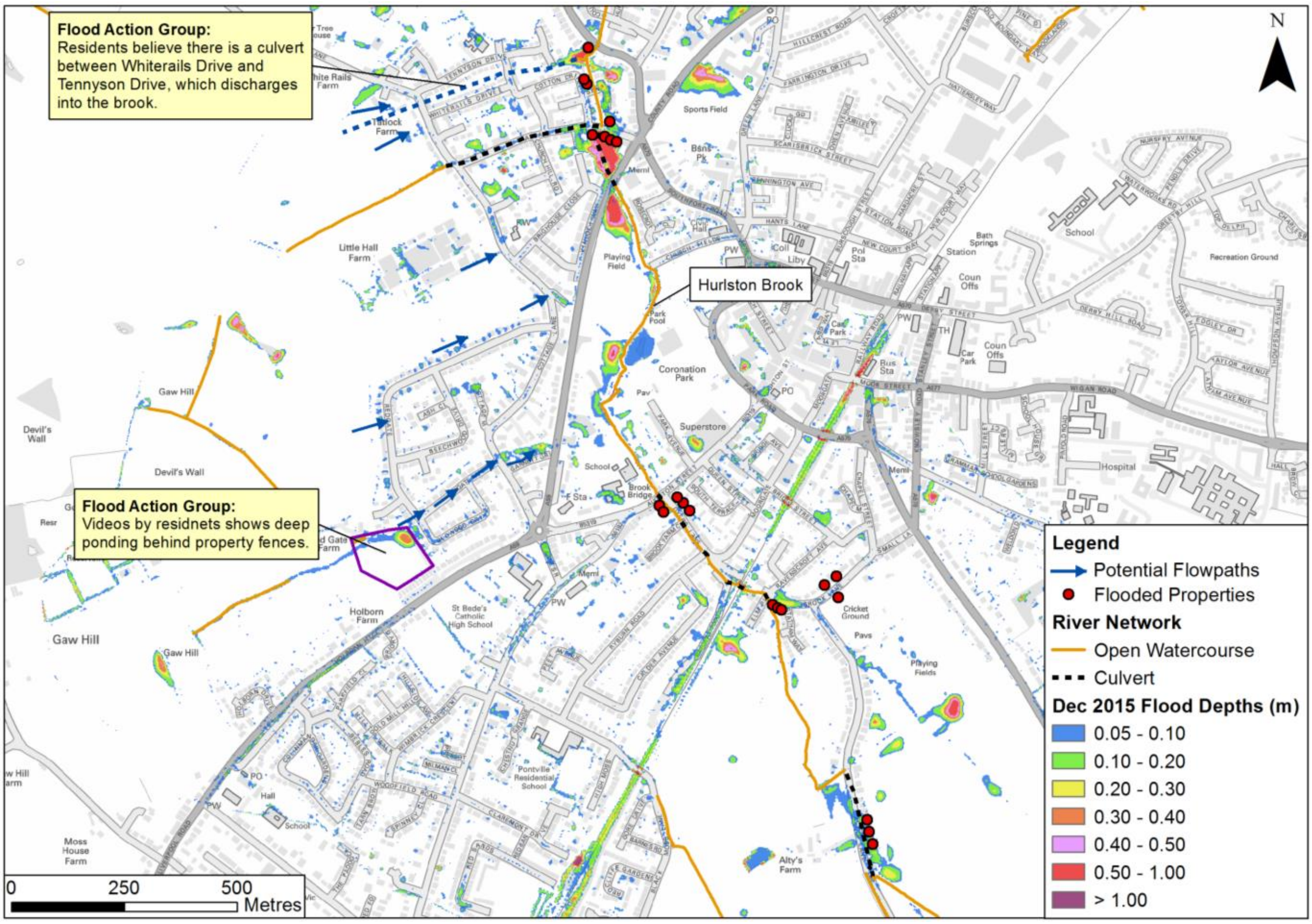
Evidence suggests that flooding has occurred in the Red Gate area in 2002, 2010 and 2012. To the western end of Redgate, several properties were affected by a combination of pluvial runoff from the fields and ditches to the rear of the properties, blocked gullies and elevated groundwater levels. The floodwater then flowed down Redgate and onto Cottage Lane, where further properties were affected.

## 2.2 History of flooding - December 2015 Event

On the 26th December 2015, widespread flooding occurred across Ormskirk. The event resulted in flooding in each of the seven key risk areas, including residential properties on Altys Lane, Brook Lane, Dyers lane, Halsall Lane, Cotton Lane, Garnett Green and areas in and around Coronation Park including Ormskirk Tennis Club.

The hydraulic model has been used to simulate the flood extents observed during the event, with local observations during the event and data collected post event used to assist with the calibration of the model. Figure 2.2, below, shows the modelled extent and depth of flooding accompanied by flood incident records collected post event.

**Figure 2.2 : December 2015 Flood Extents**




The impact of the flooding within each of the key areas is summarised as follows;

### 2.2.1 Altys Lane

Residential properties were affected by floodwater flowing along the road. Records show that gullies and the trash screens before which Hurlston Brook becomes culverted became blocked and as a result, there were signs of overland flow from the Brook and the adjacent local ditches and fields.

Overland flow was also seen running off the playing fields and cricket pitch to the north eastern end of Altys Lane. This contributed to the ponded water on Brook Street where residential properties suffered internal flooding. Anecdotal evidence suggests that there is a near surface permeable sand stratum below the cricket pitch, which conveys groundwater towards Brook Lane during wet conditions. Properties on Brook Lane reported internal flooding of approximately 200mm.

### 2.2.2 Railway Path

Water was seen flowing down Railway Path and this contributed to the depth of floodwater along Dyers Lane, where the right bank of Hurlston Brook had overtopped.

An eye witness recalls that the floodwater appeared to come both from the vehicle access pathway to the west of the Railway Path terraced properties and down the pedestrian footpath that runs parallel to the railway line. It is believed that this water was the result of a combination of surcharged drains and pluvial runoff.

### 2.2.3 Dyers Lane

The right bank of Hurlston Brook overtopped resulting in flooding of the properties on the eastern side of Dyers Lane. Properties on the left bank of the brook were also affected, near to Brook Bridge at the junction with Aughton Street, where overland flow sought to re-enter the surcharged channel at a topographical low-spot.

**Photograph 2 : Dyers Lane Flooding, December 2015**

View looking West from junction with Brook Farm Close

View facing East from Brook Farm Close

### 2.2.4 Coronation Park

Hurlston Brook is culverted beneath Aughton Street, after which it returns to an open channel and passes between St Anne’s Primary School on the left bank and a new mixed use development on the right bank. Following which it enters Coronation Park. During the December 2015 event, the brook overtopped its banks, flooding the tennis club and courts to the left bank, and overwhelming the existing ornamental pond to the right.

Within Coronation Park, floodwater was observed ponding in the park behind the culvert at the County Road crossing before passing, in culvert, downstream to Halsall Lane.

**Photograph 3 : Coronation Park Flooding, December 2015**

Flood water at Ormskirk Tennis Club

Surcharged brook inundating a footbridge within the park

### 2.2.5 Halsall Lane & Asmall Lane

Flood records show a variety of potential sources contributed to the flooding experienced, including run-off from the fields to the west of Cottage Lane, blocked surface water drains and a blockage of the trash screen at County Road.

During the event, floodwater was seen to flow down Halsall Lane (eastwards) towards the topographical low point where Hurlston Brook emerges from its culvert beneath Halsall Lane. The photographs below provide an indication of the depth of floodwater that was experienced.

**Photograph 4 : Flooding along Halsall Lane, December 2015**


View looking west along Halsall Lane

View looking west along Halsall Lane

During an interview with a resident of Asmall Lane, the owner described how run-off from the fields behind Asmall Lane was directed towards a small watercourse which runs alongside the property before passing into a culvert and into the main surface water drainage system at the western end of Halsall Lane. During the flood event, the culvert became surcharged and water backed up the watercourse spilling out behind the properties on Asmall Lane, finding its way through the gardens and gaps between the properties before running down Asmall lane and into Halsall Lane. There was evidence of properties on the adjacent Cotton Lane using sand bags during the event, although there were no confirmed reports of flooding at these locations.

**Photograph 5 : Overland flow at Asmall Lane, December 2015**

Overland flow from surcharged drain at No.1 Asmall Lane

Flooding at a property on Asmall Lane

### 2.2.6 Southport Road

A residential property on Southport Road, adjacent to Hurlston Brook experienced inundation with floodwater up to a depth of 600mm during the event. The resident noted that repairs from damage sustained during the February 2012 event, during which a similar depth of flooding was recorded, had only recently been completed at the time of the December 2015 event.

### 2.2.7 Red Gate Estate & Redwood Drive

Four residential properties were affected on Garnett Green, when overland flows from Redgate and Cottage Lane flowed through the front of the properties, ponding in the back gardens. Internal flood depths of 150mm were recorded and residents were only just returning to their property some 6 months after the event.

**Photograph 6 : Flooding along Redgate, December 2015**

Flooding at the Junction of Redgate and Cottage Lane

Floodwater was seen to pond in the fields to the west of the Redgate estate. This water then overtopped the access track, which separates the fields from the housing estate, before flowing onto the highway via the gardens of the properties that back onto it. From this point, water followed the topography of the area, flowing down the road towards Cottage Lane and onto Garnett Green.

Formal flood reports from properties on Garnett Green were not recorded at the time of the event, however discussions with residents and evidence of repair works being undertaken to properties along Garnett Green confirmed that numerous properties suffered from differing levels of flooding during the event.

# 3. Hydraulic Model

Flood records indicate that the causes of flooding across Ormskirk are complex and are due to a combination of factors including surface water run-off from adjacent fields and the urban catchment area, Main River flooding, unmaintained Ordinary Watercourses, exceedance of the existing surface water drainage systems and blocked surface water gulleys.

Due to the intricacies of the flooding mechanisms, an integrated hydraulic model was designed and built to represent the different sources of flooding and the interactions between them. This section of the report contains a brief summary of the hydraulic modelling that were undertaken in support of the flood risk review works. A detailed description of the modelling work is provided in the hydraulic modelling report in Appendix B.

To construct the hydraulic model, data was gathered from a number of sources. These sources included:

- LiDAR data to inform the hydraulic model of ground elevation information
- Ordnance Survey data
- Hydrology for a range of Annual Exceedance Probabilities (AEP)
- Environment Agency (EA) fluvial model of Hurlston Brook
- Drainage network model from United Utilities

The model was built using TUFLOW software and it is a pluvial-fluvial integrated One-Dimensional (1D) – Two-Dimensional (2D) model. The storm and combined pipes of the drainage system and Hurlston Brook were modelled as ESTRY (1D engine of TUFLOW). The Hurlston Brook open channel includes representation of all the structures across the watercourse. The ground surface is represented in 2D in TUFLOW and the rainfall falling on this 2D surface is converted to volume that generates runoff.

The fluvial component of the model was imported from an existing Environment Agency model that was developed for Hurlston Brook as part of the Strategic Flood Risk Management (SFRM) framework by Capita. This model included a representation of Hurlston Brook in Ormskirk and further downstream, but for this study it has been truncated to cover Ormskirk only. The Hurlston Brook representation has not been updated from the SFRM model (except the weir crest representing a sluice in Coronation Park). The cross sections are generally less than 100m apart with quite a large number of footbridges in the urban area.

Following the construction of the hydraulic model, the model was validated against available flood records and extents from the recent flooding events. Given that the sources of flooding included both fluvial and pluvial flooding, this was a complicated task. Jacobs worked closely with Environment Agency to verify the model using the known flood extents for the December 2015 event and a comparison of routed flows at the downstream end of the catchment. Following a number of iterations the model variations between the compared data were considered to be within an acceptable tolerance. This process gave confidence that the model provided a fair representation of the baseline flooding conditions and complex flooding mechanisms.

The model was then run for a range of flood events with 20%, 10%, 5%, 2%, 1.33% and 1% AEP and the outputs reviewed in conjunction with factual and anecdotal data from recent flood events and information gathered from site visits to establish the key flooding mechanisms. A detailed description of the flooding mechanisms is described in Section 4.

# 4. Flood Risk

## 4.1 Flood Mechanisms

The causes of flooding in each area are complex and are due to a range of factors, including:

1) Pluvial runoff from agricultural land;
2) Main river flooding from Hurlston Brook;
3) The capacity of the existing drainage infrastructure;
4) Influence of topography and existing land-use; and
5) The interaction between the each of the above factors.

However, by using the outputs of the integrated hydraulic model, supplemented by historical flood data and site observations, it is possible to establish key flooding mechanisms through Ormskirk. The sections below provide an overview of flooding mechanisms geographically across each of the seven receptor areas.

To provide consistency, the figures provided to accompany the discussion of the flood mechanisms have been generated for the same magnitude of flood event, specifically the 1.33% AEP (1 in 75 year) event for the Do Minimum scenario.

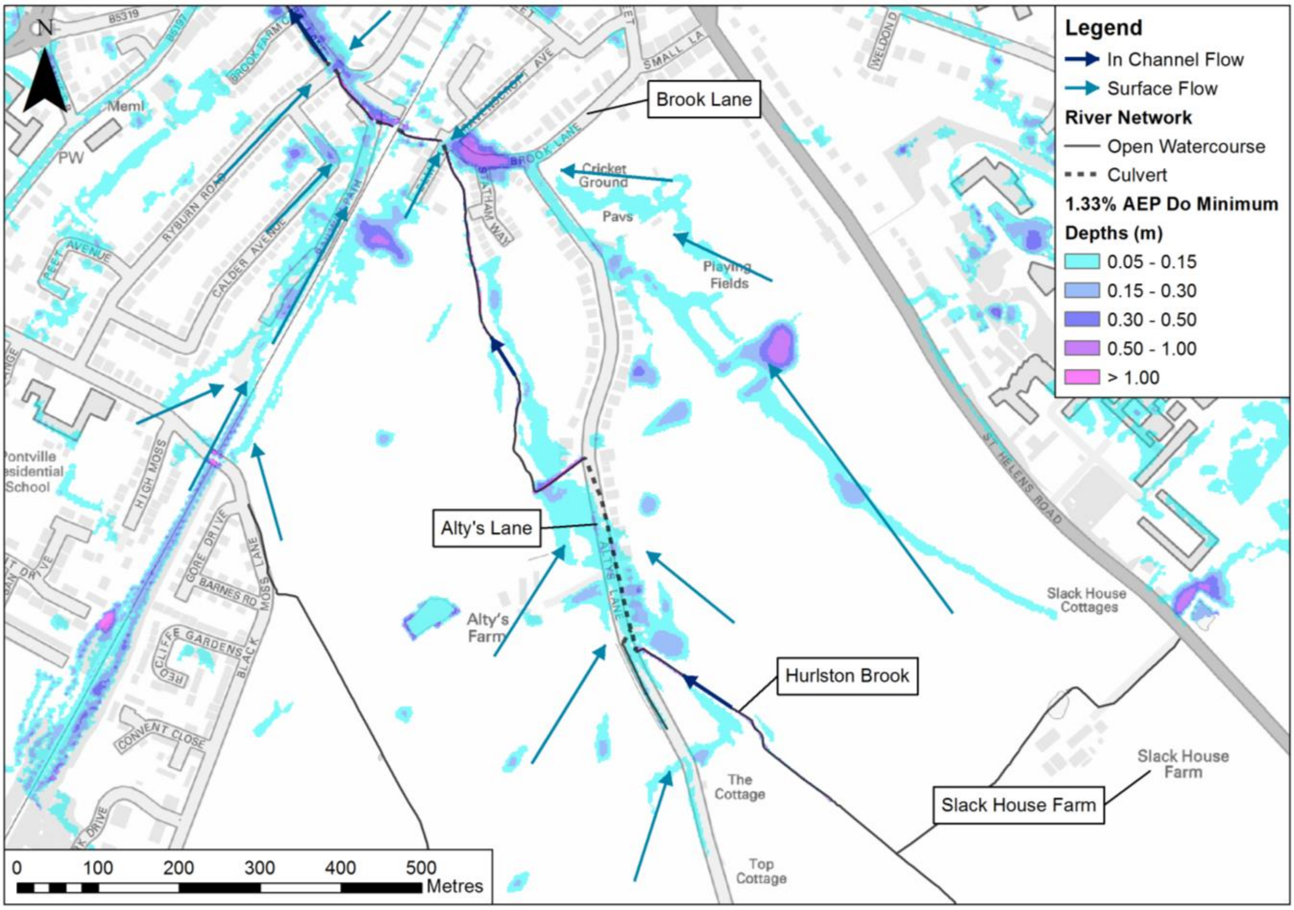
### 4.1.1 Altys Lane

The flood mechanisms for Altys Lane can be divided into two separate sources. To the southern end of Altys Lane, upstream of Alty's farm, the flooding appears to emanate from a combination of insufficient capacity of the culvert through which Hurlston Brook flows combined with conveyance restrictions resulting from trash screen blockage. This results in water backing up along Hurlston Brook and overtopping the banks, causing overland flow down Altys Lane and into properties.

This is exacerbated by overland flows from the adjacent fields and local ditches. The road gullies along Altys Lane are vulnerable to blockage and the adjacent farmland appears to be heavily compacted, meaning that greater volumes of runoff were experienced as the flow could not enter the drainage system or percolate naturally into the ground. The culvert running along Altys lane, through which Hurlston Brook flows reaches capacity during a 20% AEP storm event and begins to surcharge in events in excess of this storm frequency.

At the northern end of Altys Lane, an overland flow path originating near Slack House Farm, runs through the adjacent playing fields and cricket pitch before spilling onto the road and making its way to the open brook at the interface between Altys Lane and Brook Lane. Surface water runs off the hillside (east to west), directed towards the cricket pitch and ultimately finds its way onto Brook Lane. The existing drainage system in the Brook Lane area is also surcharged during a 20% AEP event.

**Figure 4.1 : Altys Lane Flood Mechanisms**

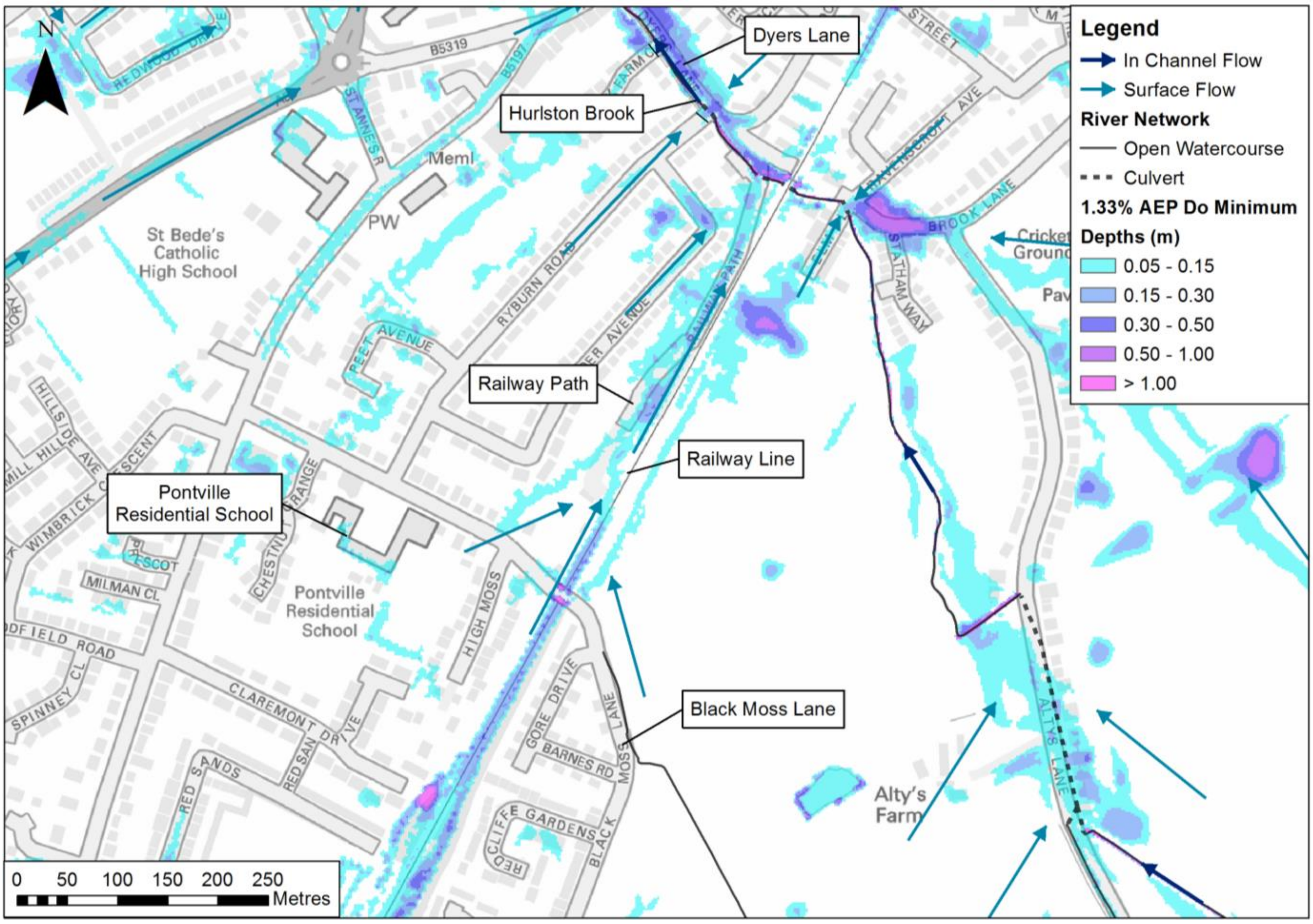



### 4.1.2 Railway Path

The hydraulic modelling shows the source of flooding along Railway Path is from a combination of flooding from Black Moss Lane Ordinary Watercourse and overland flows from Pontville Residential School. The surface water drain along Railway Path has been shown to reach capacity during a 20% AEP event, resulting in surface water flows running north east along Railway Path before entering Hurlston Brook upstream of Dyers Lane.

Towards the southern end of Railway Path, just downstream of Moss Lane, the elevation of the railway line is below the level of the adjacent ground, leaving a potential flow path from the east of the railway line, across the track and onto Railway Path. Ground levels adjacent to the railway embankment fall heading north, with surface water on the track able to spill onto Railway Path where the level of the path falls below the track ballast. This contributes to the overland flows that are channelled down Railway Path towards Dyers Lane.

**Figure 4.2 : Railway Path Flood Mechanisms**

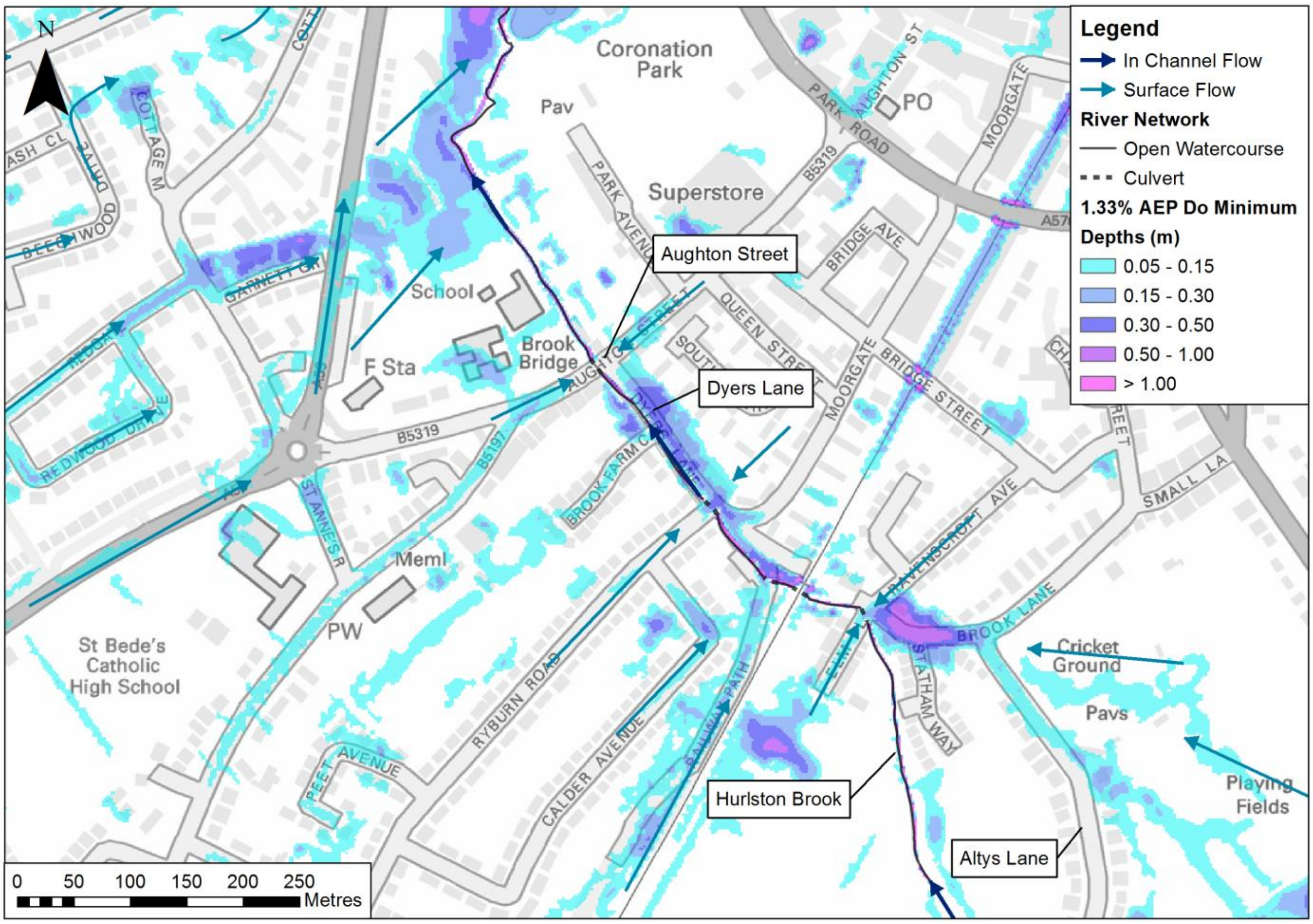


### 4.1.3 Dyers Lane

Hurlston Brook flows in an open channel parallel to Dyers Lane. The watercourse is crossed at regular intervals by access bridges and culverts leading to properties and side roads on the left bank of the brook. When the flow in the channel reaches the capacity of the culverts, it spills over the right bank resulting in flooding to the properties along the right hand side of Dyers Lane. The floodwater then flows back into Hurlston Brook further downstream, which then flows under Brook Bridge beneath Aughton Street.

The drainage system, which runs south-east to north-west along Dyers Lane reaches capacity during a 20% AEP event. The drainage system is fed by contributions from the Altys Lane and Railway Path areas before joining the network at Aughton Street.

**Figure 4.3 : Dyers Lane Flood Mechanisms**

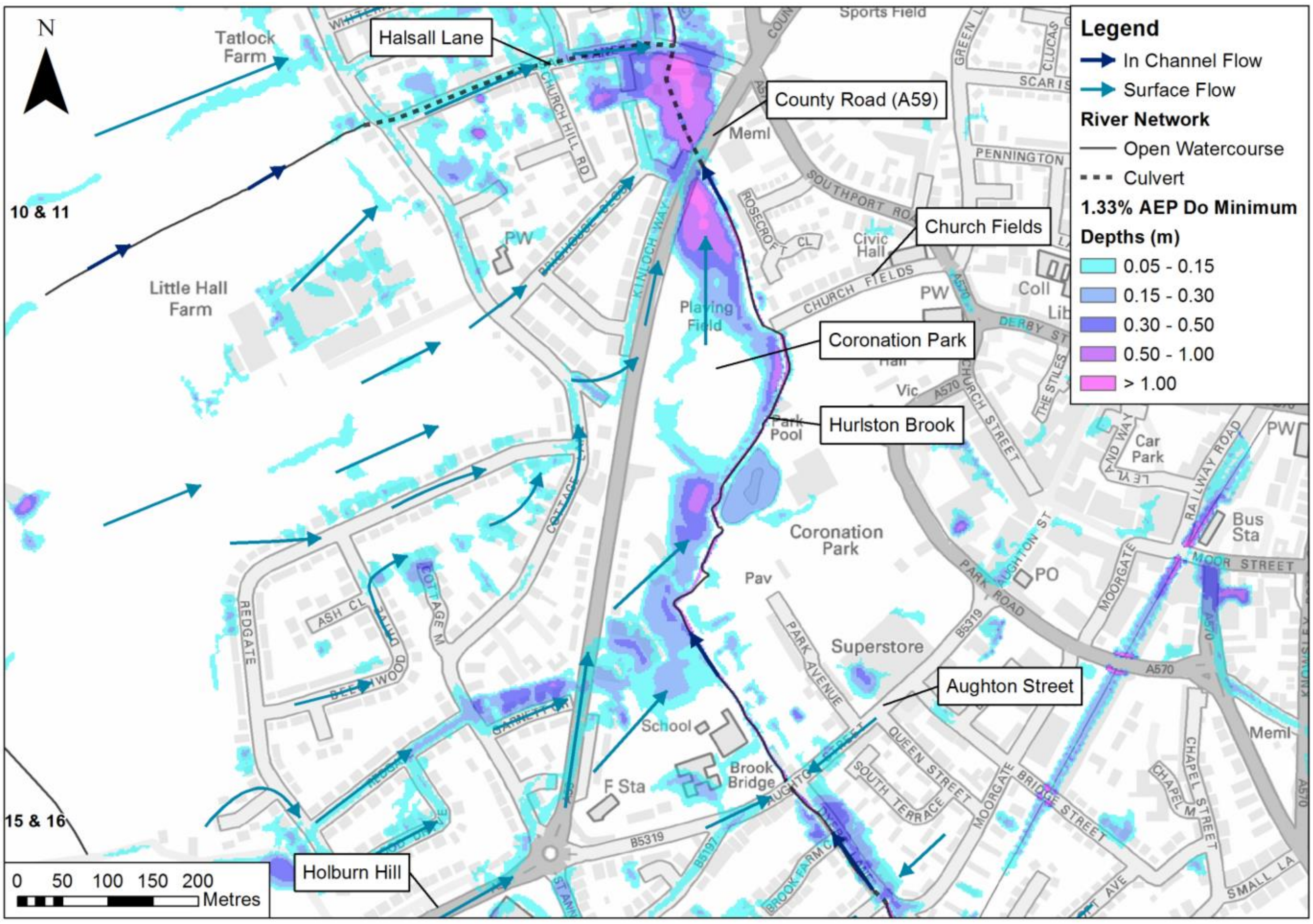


#### 4.1.4 Coronation Park

Downstream of Aughton Street (at Brook Bridge), the brook flows in open channel passing between a primary school on the left bank, and a residential development on the right. As the river flows towards the entrance to the park, the brooks floods the left hand floodplain, which includes the tennis courts and club house. This area was known to have flooded during the December 2015 event.

Hurlston Brook then flows through Coronation Park , passing through a section of open channel which has been reinforced by gabion baskets and under a pedestrian access route which leads to the ornamental pond on the right bank. A new sluice gate has been installed at this crossing point although the purpose of this feature is unknown. Further downstream, the brook passes through a small section of culvert at the western end of Church Fields. This culvert is known to suffer from blockage and is thought to have been partially blocked in the Dec 2015 event exacerbating out of bank flows.

**Figure 4.4 : Coronation Park Flood Mechanisms**




The culvert under County Road (A59) surcharges during a 20% AEP event, which also causes water to back up and pond in the natural floodplain at the northern corner of the park. In more severe storm events, this ponded water can exceed the level of the road, leading to flood water crossing the road and draining towards Halsall Lane. The trash screen on the upstream face of the culvert was installed following the 2012 flood event. Modelling shows that when blocked, the brook backs up and floods areas within the park. .

The floodwater overtops the road is exacerbated by surface water flowing along County Road. The A59 (Liverpool Road, Holborn Hill and Country Road) drainage system, reaches capacity during a 20% AEP event. Once the capacity is exceeded, surface water flows down the A59 towards the northern end of Coronation Park and drains towards Halsall Lane.

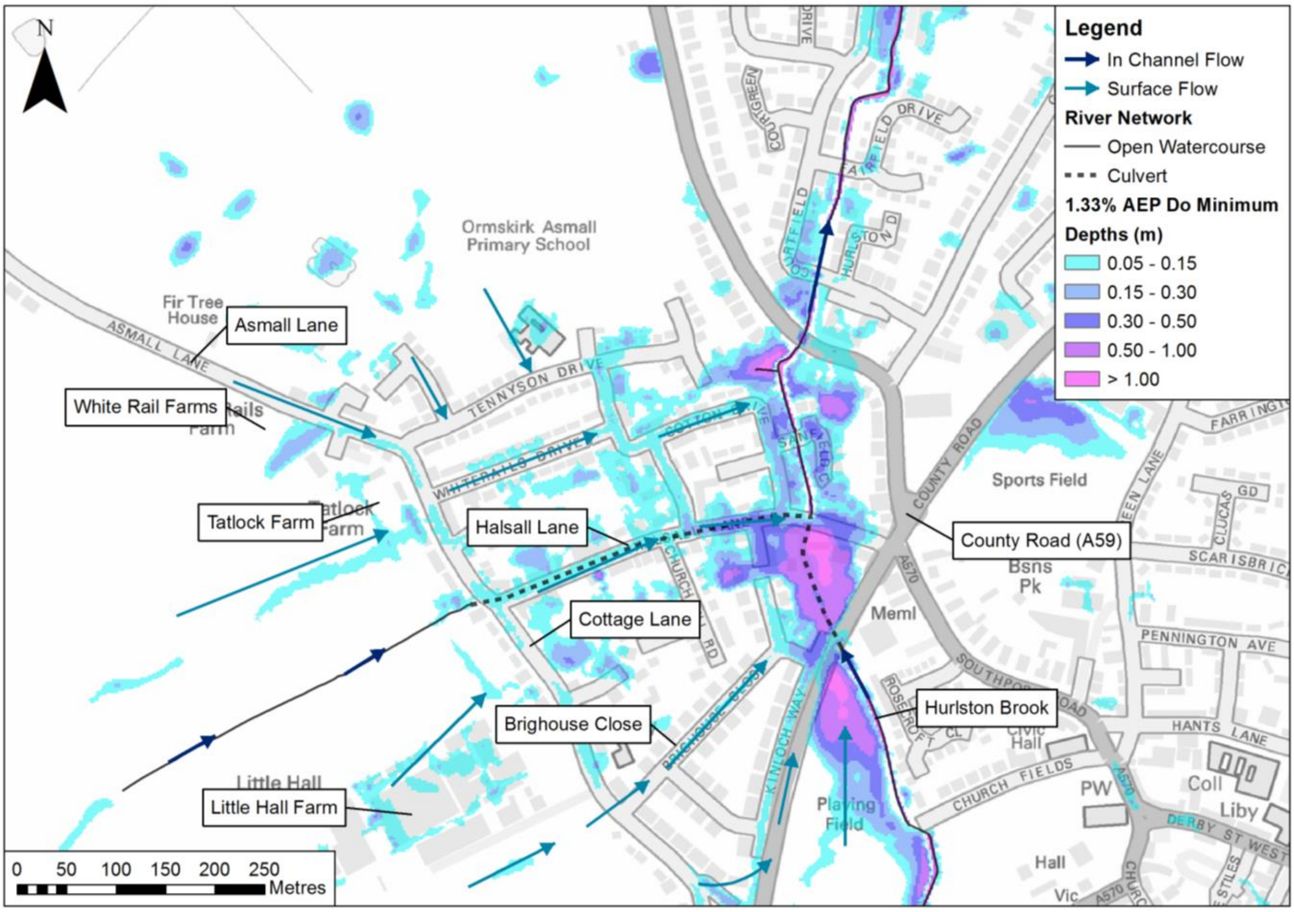
#### 4.1.5 Halsall Lane

Similarly to Redgate Estate, flooding to Halsall Road, Asmall Lane and Cottage Lane is in part as a result of pluvial runoff from the adjacent farmland at Little Hall Farm, Tatlock Farm and Whiterails Farm, combined with pluvial runoff from the urban areas, which overwhelm the capacity of the existing drainage system.

The hydraulic modelling shows surface water to flow down a small open watercourse along the field boundary between Little Hall Farm and Tatlock Farm. The watercourse then continues between the properties before entering a culvert, which runs along Halsall Lane. A trash screen is located at the opening to the culvert. When the trash screen is blocked or the culvert is at capacity, water overtops the trash screen and flows down Halsall lane before entering Hurlston Brook. Additional floodwater flows over the farmland and through the rear of the properties on Asmall Lane. The floodwaters from the farmland to the south of Little Hall Farm flow onto Cottage Lane. This then makes its way along Brighouse Close and contributes to the flooding at the bottom of Halsall Lane.

Halsall Lane is also affected by overland flow travelling north along County road (A59) as discussed in Section 4.4.

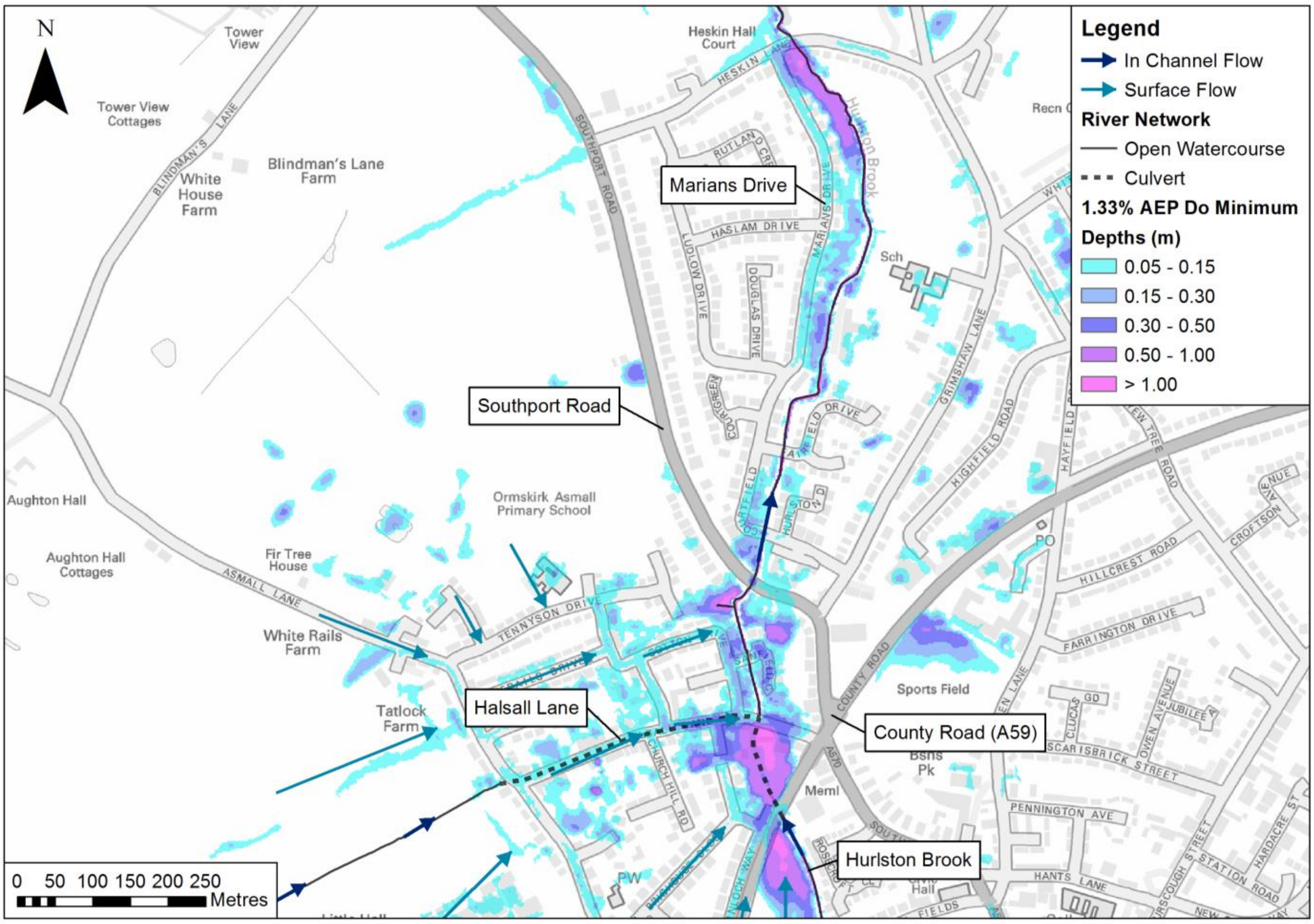
**Figure 4.5 : Halsall Lane Flood Mechanisms**




#### 4.1.6 Southport Road

Downstream of the culvert that ends at Halsall Lane, Hurlston Brook runs in open channel until it reaches the bridge beneath Southport Road. The bridge deck has recently been upgraded, but the upstream entrance remains as a stone arch, and the downstream end as a box culvert with training walls. The ground levels on the left bank upstream of the entrance are relatively low, providing a preferential spill route for flows exceeding channel capacity. Downstream of Southport Road, Hurlston Brook runs along the property boundaries. When the flow exceeds the channel capacity, it overtops the banks resulting in flooding to properties along Marians Drive.

**Figure 4.6 : Southport Road Flood Mechanisms**

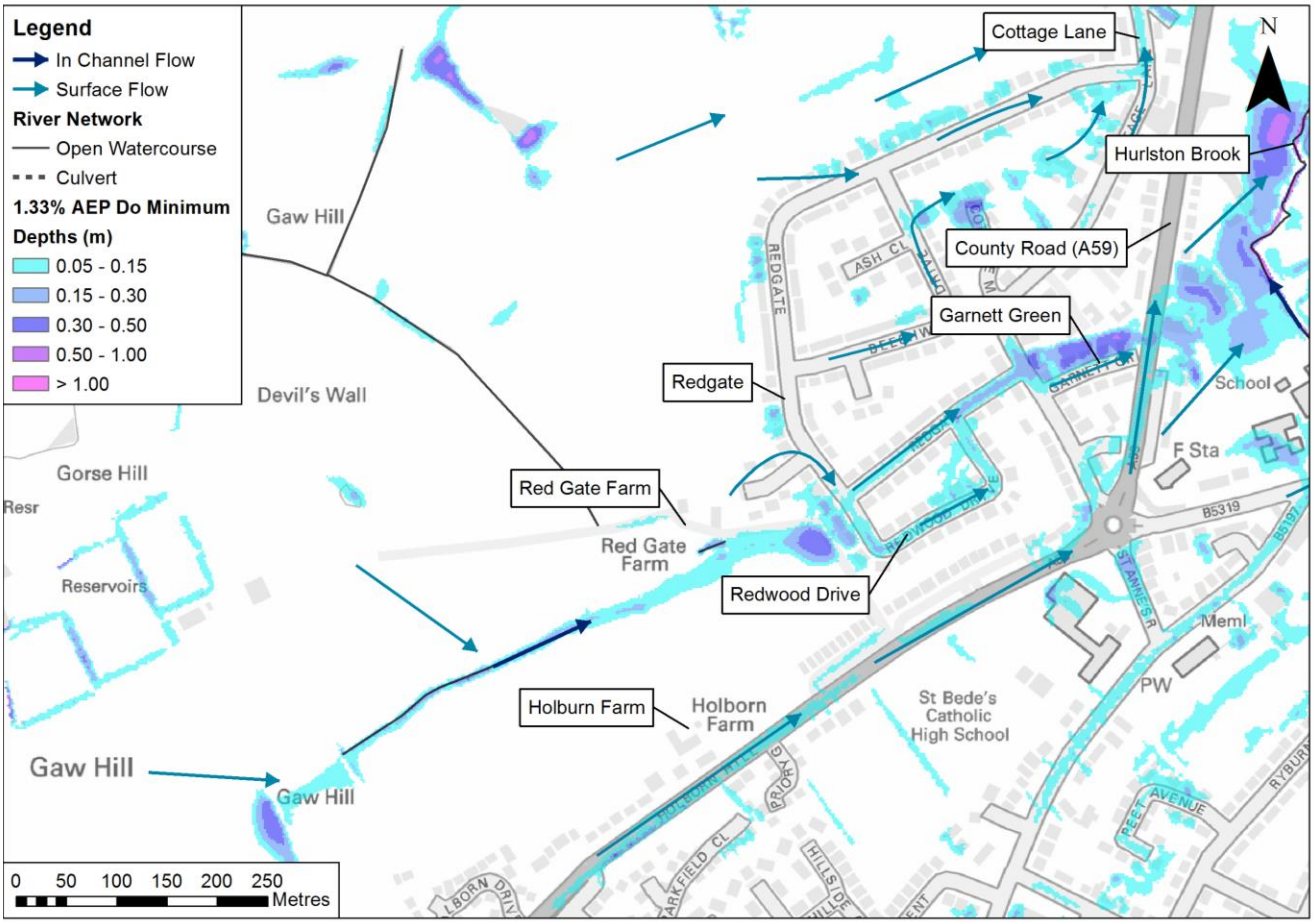


### 4.1.7 Red Gate Estate

Flooding to the Red Gate Estate, including Redwood Drive, Redgate Drive, Cottage Lane and Garnett Green is as a result of pluvial runoff from the land surrounding Red Gate Farm and from direct rainfall onto the urban development area. A small watercourse also runs in an open channel between the field boundaries of Redgate Farm and Holdborn Fam, before entering a culvert for a short length and then opening back out into an open channel. The channel then enters a culvert, which either runs underneath the houses on Redwood Drive or does a 90 degree turn and connects to the drainage system on Holborn Hill. A trash screen is located at the entrance to the culvert.

When the trash screen is blocked, or the culvert reaches capacity, floodwater is shown to flow overland following the path of the culvert and through the residences on Redwood Drive. This flow path then continues down Garnett Green and across the A59 before entering Hurlston Brook.

**Figure 4.7 : Red Gate Estate Flood Mechanisms**

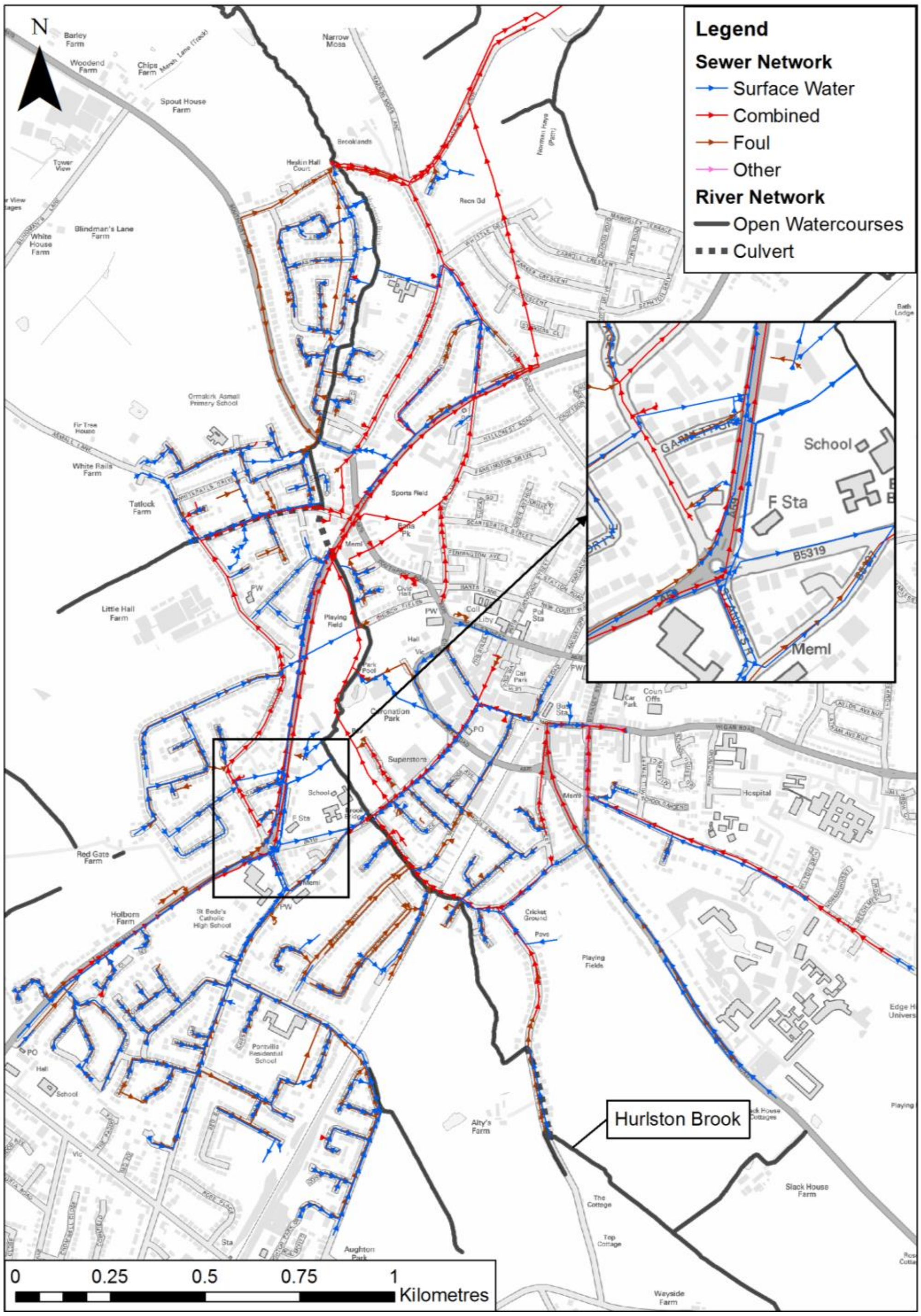



## 4.2 Surface Water Drainage Network

The drainage network in Ormskirk consists of a surface water system draining elements of the catchment towards Hurlston Brook, and a much larger combined system draining both surface and foul water to Burscough WwTW, which is operated by United Utilities.

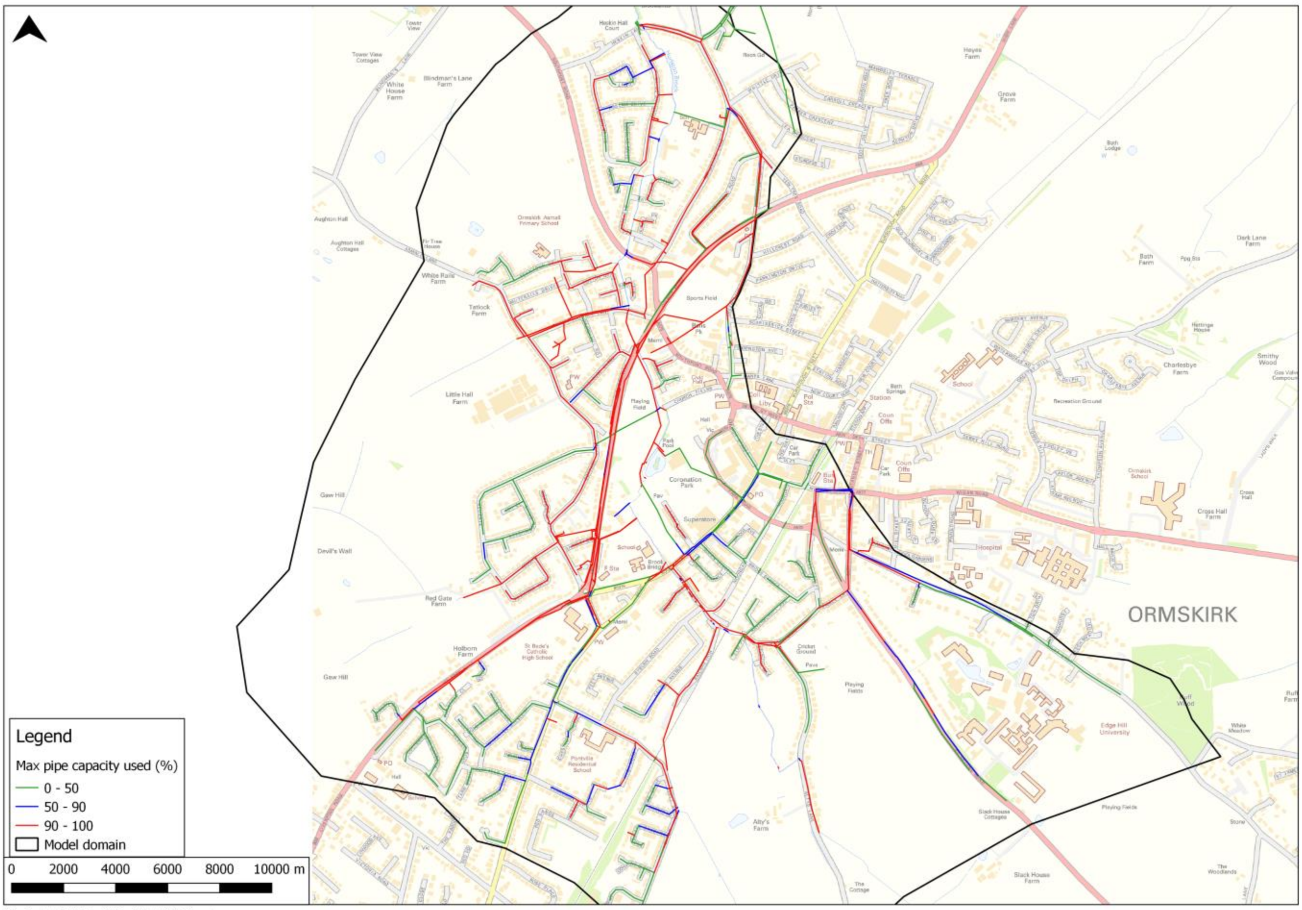
Figure 4.8, below, provides an indication of the distribution of these distinct elements of the system within the catchment. The figure also indicates key locations where the main river, Hurlston Brook, enters into culvert.

**Figure 4.8 : Ormskirk Drainage and Sewer Network**




The hydraulic model has been used to identify the key capacity constraints within the existing surface water drainage system. For a range of events between a 20% AEP (1 in 5 year) to a 1% AEP (1 in 100 year), the percentage of pipe capacity utilised has been assessed. Figure 4.9 illustrates the percentage pipe utilisation during the lowest order, 20% AEP event. The parts of the network coloured red are estimated to be between 90 and 100% full during the 20% AEP storm event.

**Figure 4.9 : Drainage Network Capacity during 20% AEP event**




Results: Hurl DoMin 005vr 3.3hr 003 1d ccA

From this analysis, it is clear that much of the drainage network reaches its conveyance capacity during a 20% AEP event, which may result in the surcharging of manholes and drainage gullies. A key observation from this is that the system has little capacity to accept flood flows, which limits the potential options for directing further floodwater into the system without exacerbating existing issues.

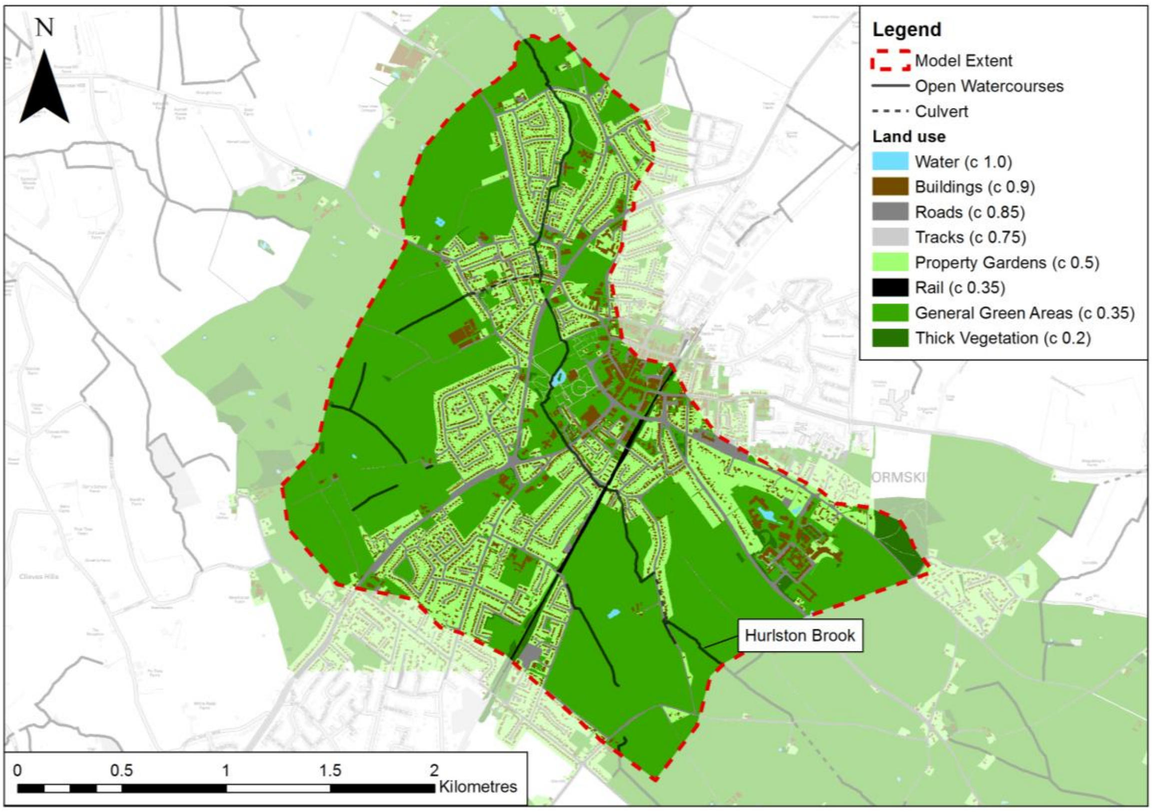
Due to the age of the urban development in this area much of the sewerage infrastructure is combined, with both surface water and foul sewage mixed within one combined network. During an extreme rainfall event, surcharging or blockage of combined sewerage systems has the potential to result in contaminated foul sewage flooding areas of residential property.

Surface water flooding often happens rapidly and the severity and consequences are influenced by the antecedent weather conditions (i.e. surface water run-off is generally worse when the ground is saturated by long periods of wet weather). Conversely, the speed of run-off can be accelerated when land, which is normally permeable, has been hard baked following prolonged periods of dry weather. The ability for the local drainage network to receive and convey large volumes of water depends on the condition of the system at the time of the flood event. Blocked road gullies, siltation and vegetation deposits, channel and pipe blockages all reduce the ability of the drainage network to convey water and can contribute to localised flooding.

## 4.3 Land Use

As was noted in Section 2, the topography of Ormskirk and its surrounding area is a key factor in the scale and distribution of the flood risk. Figures 4.10 illustrates the model's representation of existing land use.

**Figure 4.10 : Land-use with the Study Area**




The Figure 4.10 legend includes details of the runoff coefficient (c) for each land use. These coefficients are used in developing the hydrology, which is included in the hydraulic model to estimate the amount of pluvial runoff that would be generated during a rainfall event.

Buildings and roads are represented as largely impermeable surfaces and therefore have much higher runoff coefficients than undeveloped areas. As can been seen from the figure, the largest proportion of the land use is 'general green areas' (predominately agricultural land), followed by property gardens, roads and then buildings. The areas classed as 'thick vegetation' are generally tree-populous areas such as forests. It is notable that the key receptor areas, which are worst-affected by flooding, typically have a run-off coefficient of 0.5 or above.

Comparing the land use to the topography, helps to explain why so much pressure is exerted on the surface water drainage system during prolonged and intensive rainfall events. The topography of the study area generally falls towards the areas with the least permeable terrain, which leaves the drainage network and roadways as the primary means of flood water flow conveyance. This, combined with the prior discussion about the capacity limitations of the drainage network illustrates the challenge in managing water in Ormskirk town centre.

Changes inthe land use will influence the scale of flood risk. Reduced rates of run-off can be achieved by increasing the potential absorbtion in the soil strata through measures such as decompaction, tree planting, alternative ploughing configurations and by slowing the flow down naturaly occurring flow paths. Conversely, if areas of agricultural land were to be developed increasing the area of impermeable surface the risk of flooding may increase.

## 4.4 Flood Consequences

### 4.4.1 Properties at Risk

The hydraulic model has been used to simulate a range of flood events, with flood extents and depths produced. Figures B1 and B2, provided in Appendix C, show the flood extents for Do Nothing and Do Minimum scenarios. Figures B3 to B8, show the maximum flood depths for the Do Minimum Scenario for various flood events.

- Do Minimum scenario assumes the present day operating conditions and that the current maintenance regimes continue.
- Do Nothing scenario assumes that no future maintenance is undertaken, resulting in the asset system deteriorating, increasing the blockage risk and reducing the conveyance capacity for the drainage system and watercourses. The output of this scenario is used in the baseline economic analysis.

Table 4.1 and During the Do Nothing scenario, the majority of the properties, both residential and non-residential, are at risk in the 20% AEP flood event. This reflects the significant impact that could occur if no maintenance was undertaken within the study area.

Table 4.2 contain the number of properties predicted to be at risk of flooding throughout the whole of study area in both the Do Nothing and Do Minimum scenarios respectively.

**Table 4.1 : Properties at risk in the Do Nothing Scenario**

| Rainfall event AEP | Properties at Risk (Do Nothing) | | |
|---|---|---|---|
| | Residential | Non-residential | Total |
| **20%** | 114 | 65 | **179** |
| **10%** | 20 | 10 | **30** |
| **5%** | 18 | 9 | **27** |
| **2%** | 46 | 18 | **64** |
| **1.33%** | 25 | 5 | **30** |
| **1%** | 21 | 4 | **25** |
| **Total** | **244** | **111** | **355** |

During the Do Nothing scenario, the majority of the properties, both residential and non-residential, are at risk in the 20% AEP flood event. This reflects the significant impact that could occur if no maintenance was undertaken within the study area.

**Table 4.2 : Properties at risk in the Do Minimum Scenario**

| Rainfall event AEP | Properties at Risk (Do Minimum) | | |
|---|---|---|---|
| | Residential | Non-residential | Total |
| **20%** | 52 | 49 | **101** |
| **10%** | 22 | 6 | **28** |
| **5%** | 14 | 12 | **26** |
| **2%** | 46 | 18 | **64** |
| **1.33%** | 21 | 9 | **30** |
| **1%** | 32 | 5 | **37** |
| **Total** | **187** | **99** | **256** |

With the current maintenance regime undertaken, there is a smaller number of properties at risk in the 20% AEP flood event. The Do Minimum scenario predicts that there would be fewer properties at risk of flooding when compared to the Do Nothing scenario, highlighting the importance of the maintenance regime.

### 4.4.2 Economic Damages

The consequence of flooding in monetary terms is estimated through the calculation of Present Value (PV) Damages. PV Damages include direct damages resulting from floodwater inundation into properties as well as 'indirect' or 'intangible' damages that occur as a result of a flooding event, such as the cost of emergency response, providing temporary accommodation, and the loss of personal items.

The calculation of PV Damages has been undertaken for a 50-year appraisal period using standardised guidelines and figures, provided in the Environment Agency's Flood and Coastal Erosion Risk Management Appraisal Guidance (FCERM-AG), and Middlesex University's Flood Hazard Research Centre's Multi-Coloured Manual (MCM).

A methodology known as the 'property footprint' approach was adopted to count properties where the building footprint intersects with the modelled flood extents. The average depth of flooding to the property was extracted for a range of modelled flood events for both the Do Nothing and Do Minimum scenarios.

Only residential properties flooding to a depth greater than 150mm were identified as being at risk of internal flooding. This is the industry standard level adopted when property specific threshold levels are not available. For non-residential properties, an industry standard 0mm threshold level was used.

Table 4.3 contains the total PV Damages for both residential and non-residential properties across the whole of the study area for the 50-year appraisal period.

**Table 4.3 : Total Present Value Damages**

| Property Type | Do Nothing - PV Damages | Do Minimum - PV Damages |
|---|---|---|
| Residential | £14,142k | £7,489k |
| Non-residential | £26,065k | £23,314k |
| **Total** | **£40,207k** | **£30,803k** |

As indicated in Table 4.2, there are more residential properties than non-residential properties at risk of flooding. However, the proportion of non-residential property damages is greater. The key non-residential properties at risk are Edge Hill University, St Bede's Catholic High School, Little Hall Farm, Aldi on Park Road, Morrisons on Aughton Street and two car dealers on County Road (A59).

Figures 4.11 and Figure 4.12 illustrate the distribution of PV Damages across the study area for both the Do Nothing and Do Minimum scenarios. PV Damages for each property flooded within a 50m grid cell have been totalled to help identify clusters of high risk areas. In both instances, the damages are shown relative to the flood outline for a 1% AEP event.

From these figures, the high risk areas in terms of damages are Halsall Lane, Dyers Lane, Edge Hill University, Little Hall Farm and Ormskirk Town Centre, due to the high number of non-residential properties.

Figure 4.11 : Do Nothing PV Damages Heat Map

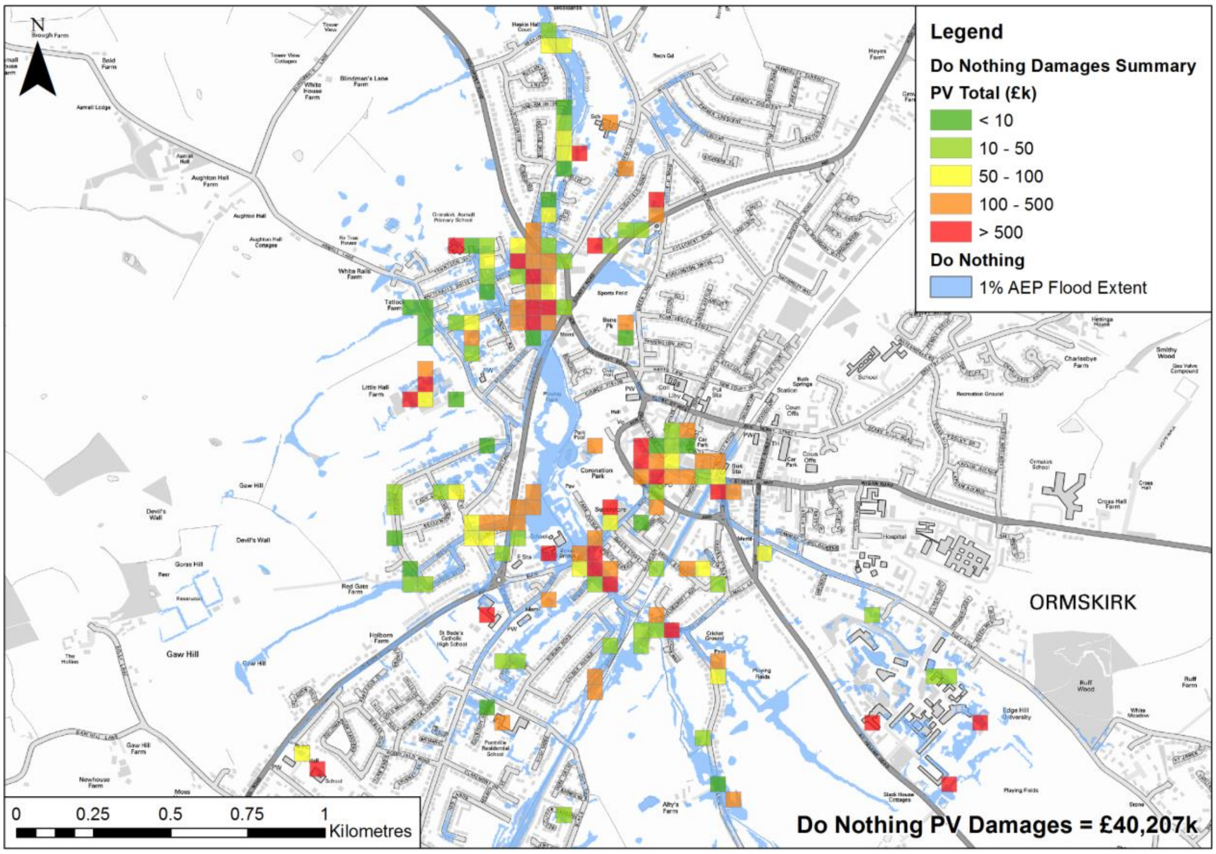
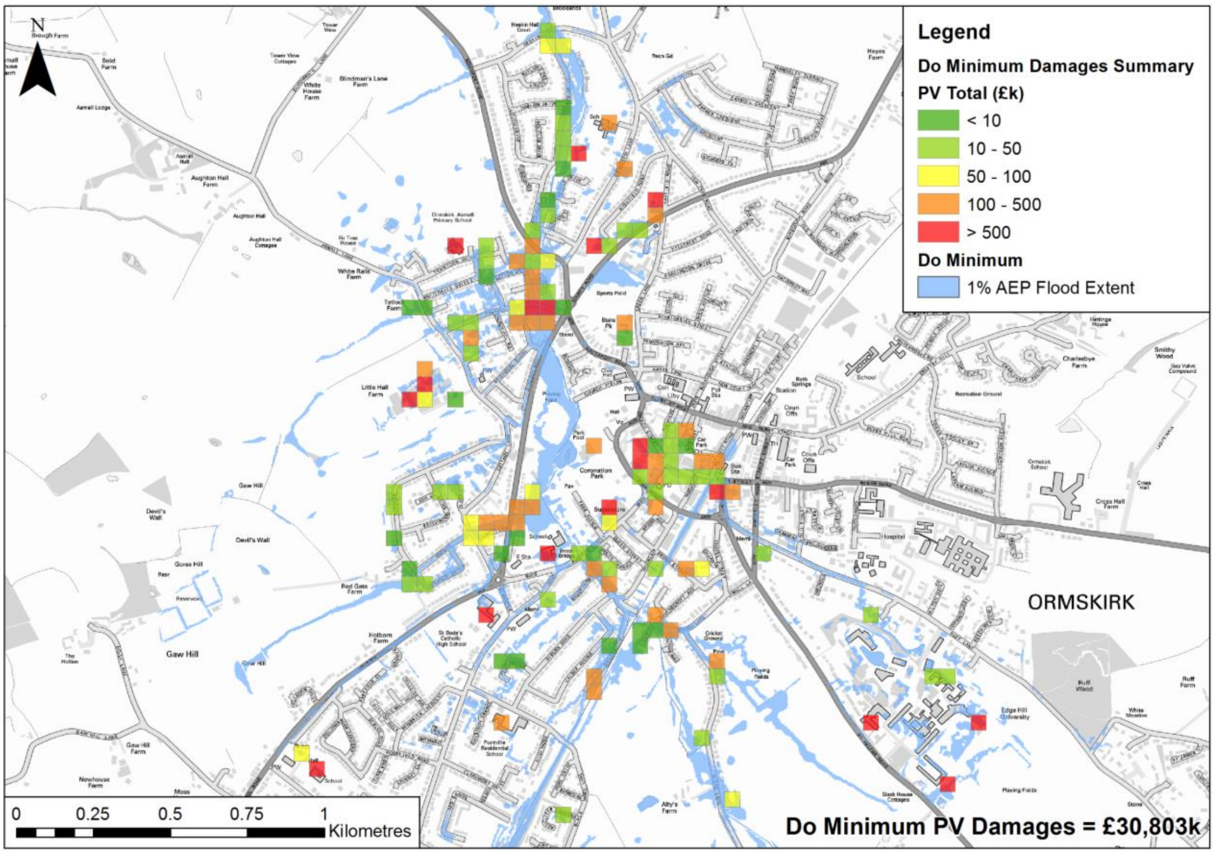


**Figure 4.12 : Do Minimum PV Damages Heat Map**




The significance of the value of these damages, and their influence in assessing the viability of a scheme of flood risk management options will be discussed further in Section 7 of this report.

# 5. Optioneering

The objective of the optioneering exercise is to identify possible flood risk management (FRM) options that could reduce the flood risk and those which would be most effective for inclusion in a preferred package of works. The review of appropriate options has been carried out in three stages as shown in Table 5.1 below. A detailed account of the optioneering process is provided in the Optioneering Report in Appendix D.

**Table 5.1 : Optioneering Process**

| Stage | Process | Description |
|---|---|---|
| 1 | Long list Identification | Develop a long-list of practical FRM options. |
| 2 | Rationalisation and shortlisting | Rationalise the long-list to identify those options which are more likely to be technically effective. |
| 3 | Testing | Model a number of options and rank them based on their effectiveness. |

Based on the understanding of flood risk developed from the historical flood records and hydraulic modelling results, it is clear that there is no single FRM option would be able to fully mange the risk of flooding within Ormskirk. As such, it is likely that a 'combination option' would be required, involving several FRM options.

## 5.1 Stage 1 – Identification

A wide range of FRM options is available for any given site. Table 5.2 provides a list of typically available options for an inland flooding issue with a brief description of what each option would likely involve.

**Table 5.2 : Matrix of Flood Risk Management Options**

| Option | Description |
|---|---|
| Enhanced Maintenance | Increase the current maintenance regime to reduce the likelihood of blockages on the existing surface water drainage network. |
| Permanent Raised Defences | Provide permanent raised defences along the banks of a watercourse in the form of walls or compacted earth embankments. Alternatively, provide elements of raised infrastructure to direct water away from properties or into existing channels. |
| Active Defences | Provide temporary raised flood defences (e.g. floodgates, demountable barriers etc.), which can be deployed in advance of flood events. |
| Channel Bypass / Diversion | Construction of a new channel to bypass problem areas or a permanent diversion of the river channel. |
| Flood Storage | Construct new storage areas, with associated flow control, to impound water during a flood event, or formalise and increase the capacity of areas known to store water (e.g. existing floodplain). |
| Channel Widening | Increase the width or depth of existing sections of the river channel to increase storage capacity and improve conveyance. |
| Culvert or Drainage Network Upgrades | Enhance the piped drainage network, by upsizing culverts, increasing pipe diameters, removing blockages, or improving network connectivity and conveyance. |
| Natural Flood Management (NFM) | Soft engineered solutions using natural features to manage the flow of water from one location to another. |
| Property Level Protection (PLP) | Protection at property thresholds including but not limited to flood doors, stoplogs and other home resilience measures. Each element would require deployment by individual residents / property owners. |
| Flood Warning Improvements | Improve the existing flood warning system to provide an improved response time. |

The objective of this stage of the process is to identify which of the aforementioned options have the potential to provide an effective reduction in flood risk and are appropriate for each receptor area. The suitability of the options has been reviewed by undertaking an initial assessment of several key criteria, including technical effectiveness, stakeholder acceptability and safety.

Priority has been given to options that LCC can seek to develop and implement independently (minimising the need for approval from other stakeholders).

The option appraisal process is detailed in Section 2 of the Optioneering Report in Appendix D. Table 5.3 provides an overview of the outcome of this initial long list screening assessment. 28 successful option-location combinations progressed to the shortlist rationalisation stage, which is described in Section 5.2.

**Table 5.3 - Stage 1 Option Suitability Matrix**

| Option | Receptor Area | | | | | | |
|---|---|---|---|---|---|---|---|
| | Altys Lane | Railway Path | Dyers Lane | Coronation Park | Halsall Lane | Southport Road | Redgate Estate |
| Permanent Raised Defences | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ |
| Active Defences | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ |
| Channel Bypass / Diversion | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ | ✗ |
| Flood Storage | ✓ | ✓ | ✗ | ✓ | ✓ | ✗ | ✓ |
| Channel Widening | ✗ | ✗ | ✗ | ✓ | ✗ | ✗ | ✗ |
| Culvert or Drainage Network Upgrades | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✓ |
| Natural Flood Management (NFM) | ✓ | ✓ | ✗ | ✗ | ✓ | ✗ | ✓ |
| Property Level Protection (PLP) | ✓ | ✓ | ✓ | ✗ | ✓ | ✓ | ✓ |

## 5.2 Stage 2 – Rationalisation of Options

The 28 successful option-location combinations, as indicated by ticks in Table 5.3, have been rationalised to produce a short-list of options to be taken forward for testing using a hydraulic model. The objective of the hydraulic model testing is to assess the effectiveness of these options in reducing flood risks.

Of the 28 option-location combinations some can be eliminated or streamlined from the modelling process as by their nature they;

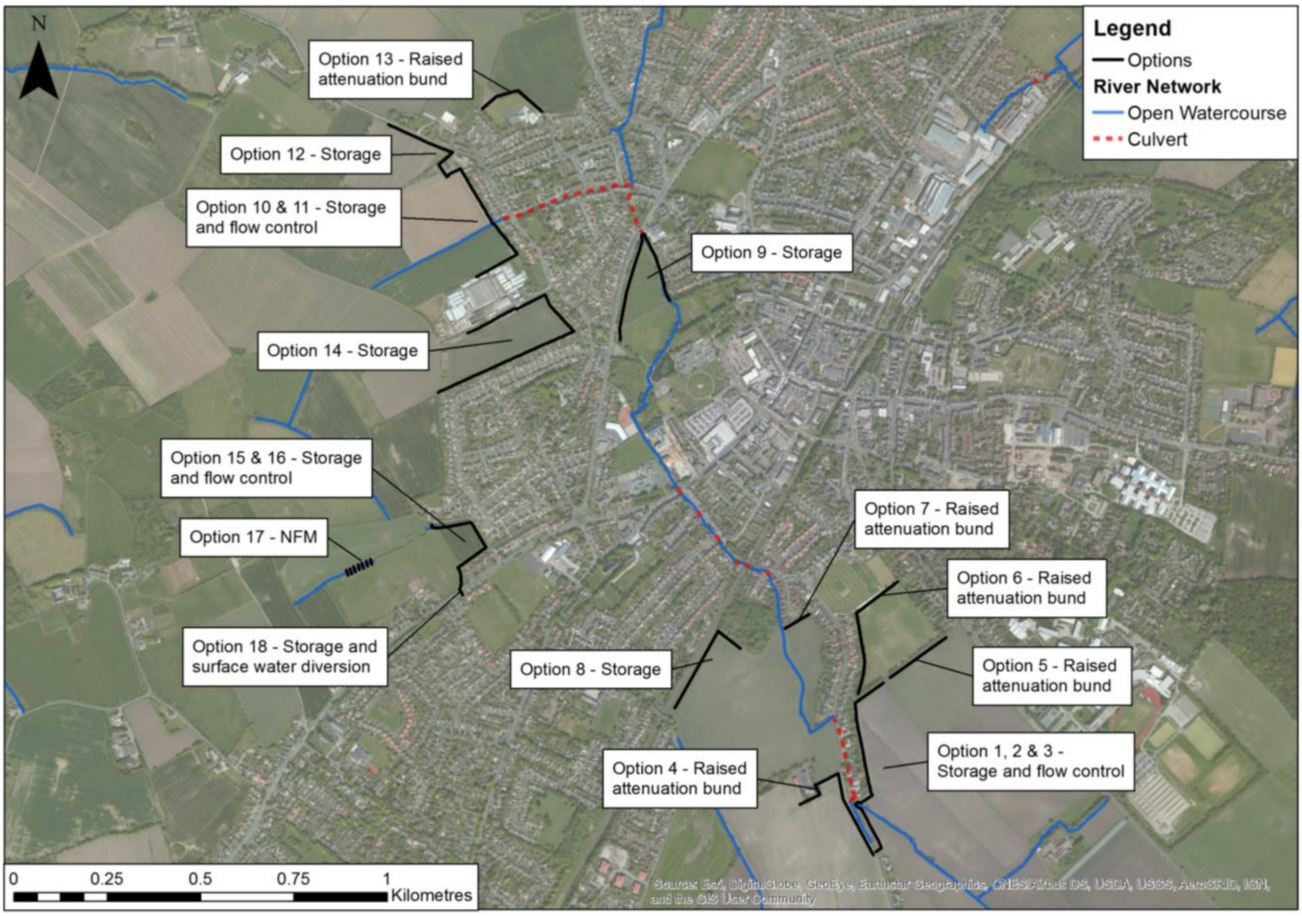
- May not provide clear results of their effectiveness if modelled; or
- May be ineffective if modelled in isolation for each receptor site and would benefit from being treated as a single catchment-wide option.

By applying past project experience and professional judgement this long list has been cut down to 18 options that have been taken forward to hydraulic model testing. These are summarised in Table 5.4 and a detailed explanation can be found in Appendix D. Figure 5.1 illustrates the location of the 18 options.

**Table 5.4 : FRM Options Short-listed for Testing**

| Receptor Site | Ref | Description |
|---|---|---|
| Altys Lane | 1 | Flood storage immediately upstream of the residential properties on Altys Lane. Pass forward flow in channel is limited by the size of the existing culvert. |
| | 2 | As Option 1, but existing culvert size is increased to 750mm diameter. |
| | 3 | As Option 1, but existing culvert size is reduced to 300mm diameter. |
| | 4 | Bund along field boundary to impound overland flow from Altys Farm, and prevent flooding onto the highway. |
| | 5 | Bund along boundary between playing fields and farmland. |
| | 6 | Bund along boundary between cricket club and playing fields. |
| | 7 | Bund behind Statham Way/Elm Place. |
| Railway Path | 8 | Flood storage on eastern side of railway line, to restrict passage of water onto the railway. |
| Coronation Park | 9 | Formalise flood storage at the downstream end of the park. Pass forward flow limited to the capacity of the existing culvert. |
| Halsall Lane | 10 | Formalise flood storage behind No.1 Asmall Lane. Pass forward flow limited to the capacity of the existing culvert. |
| | 11 | As option 10, with size of existing outlet culvert reduced by 33%. |
| | 12 | Formalise flood storage at Whiterails Farm. Pass forward flow limited to the capacity of the existing culvert. |
| | 13 | Permanent flood defence embankment to block flow path of overland flow from fields behind Asmall Primary School. |
| | 14 | Storage area behind Little Hall Farm. |
| Redgate | 15 | Storage area with pass forward flow restricted by the size of the existing culvert. |
| | 16 | As option 15, with size of existing outlet culvert reduced by 33%. |
| | 17 | Natural Flood Management – wooded debris dams. |
| | 18 | As Option 15, with addition of surface water diversion from Holborn Hill. |

**Figure 5.1 : Location Plan of Tested Options**




## 5.3 Stage 3 - Testing

The final stage of the optioneering process involves testing each option listed in Table 5.4 using the hydraulic model. By testing each of the options, the technical effectiveness in reducing flood extents and depths, and the economic effectiveness in reducing PV Damages is be determined.

### 5.3.1 Technical Effectiveness

To provide a fair and structured comparison of the technical effectiveness of the respective options a standard means of comparison was established. This was done by identifying a number of fixed monitoring points throughout the study area, at which the flood depths generated by the hydraulic model for each option were recorded. This process allowed the impact of each of the options on both local flood depths as well as those further downstream to be assessed. The greater the reduction in flood depth, the higher the score achieved.

To enable comparison full comparison, flood depths at each monitoring point were recorded for the Do Nothing flood model for both 3.33% AEP and 1.33% AEP rainfall events.

### 5.3.2 Economic Effectiveness

To assess the economic effectiveness of the respective options, the difference in economic damages between the baseline and option scenarios has been scored.

To ensure that depth reduction is being targeted in the areas that would benefit most (i.e. areas with highest baseline damages), the technical effectiveness scores have been given a weighting. The weighting factor is based on the value of economic damages within a 250m radius of each monitoring point, and the proportion of the overall damages that this monitoring point captures.

Using this method of measuring surrogate damages (further details are provided in Appendix D), the 18 options have been ranked, with the results of this process recorded in Table 5.5, below.

**Table 5.5 : Option Effectiveness Results**

| Option | Rank | Taken Forward to Economic Appraisal |
|---|---|---|
| Option 9 – Flood Storage within Coronation Park | 1 | **Yes** |
| Option 18 – Option 15 plus road diversion | 2 | **Yes** |
| Option 15 – Flood Storage with existing culvert capacity | 3 | **No** |
| Option 16 – Flood Storage with reduced culvert capacity | 3 | **No** |
| Option 6 – Bund between playing fields and cricket pitch | 5 | **Yes** |
| Option 1 – Flood Storage with existing culvert capacity | 6 | **Yes** |
| Option 3 – Flood Storage with reduced culvert capacity | 6 | **No** |
| Option 10 – Flood Storage with existing culvert capacity | 8 | **Yes** |
| Option 11 – Flood Storage with reduced culvert capacity | 8 | **No** |
| Option 12 – Flood Storage at Whiterails Farm | 10 | **Yes** |
| Option 14 – Flood Storage | 11 | **Yes** |
| Option 2 – Flood Storage with increased culvert capacity | 12 | **No** |
| Option 5 – Bund between playing fields and farmland | 13 | **No** |
| Option 8 – Flood Storage along Railway Line | 14 | **No** |
| Option 4 – Bund around Altys Farm | 15 | **No** |
| Option 7 – Bund behind Statham Way / Elm Place | 15 | **No** |
| Option 13 – Bund being Asmall Primary School | 15 | **No** |
| Option 17 – Wooded Debris Dams | 15 | **No** |

Each of the options that have progressed helps to manage a different mechanism or mechanisms relative to its location within the study area. Where options are similar, or involve variations on a theme (such as Options 15, 16 and 18), the most effective of the group has been taken forward.

As noted previously, due to the nature of the flooding to Ormskirk no single option is effective at reducing the risk of surface water flooding for the entire catchment. Instead, a combination of options, including Options 1, 6, 9, 10, 12, 14 and 18 would be combined as a single scheme and taken forward to the economic appraisal process.

# 6. Combined Scheme

## 6.1 Description

The combined scheme features the six options, which were found to be most effective at reducing flood risk within the study area. Each element has sought to intercept flow contributions from a difference flooding mechanism. Figure 6.1 shows the location and approximate extents of these elements and Figures 6.2 – 6.8 show the general arrangements for each of the sites.

**Figure 6.1 : Combined Scheme Location Plan**

Each of these options involves measures to retain and control the release of water. The following sub-sections provide a more detailed account of the composition of each element. Reference to each options number reference, from Tables 5.4 and 5.5 are retained for clarity.

The general arrangement details of each option show the length and height of required FRM measures and the resulting flood outline for the attenuated flood water for the 3.33% AEP and 1.33% AEP events. The defence heights stated incorporate a freeboard allowance of 250mm at all sites other than Coronation Park to which 500mm has been incorporated due to the greater volume of stored water and it's proximity to sensitive receptors. It should be noted that these options would not protect Ormskirk entirely during these event and that there would still be a residual risk of flooding which would need to be managed. The lengths and height of the measures is defined by the volume and extent of ponded water attenuated by the defence structure. This has been derived in each location for the 3.33% and 1.33% AEP rainfalll events. It is to be noted that this does not define a Standard of Protection (SoP) offered by the defence structure, as the SoP will be a function of the cumulative effects of multiple flloding sources.

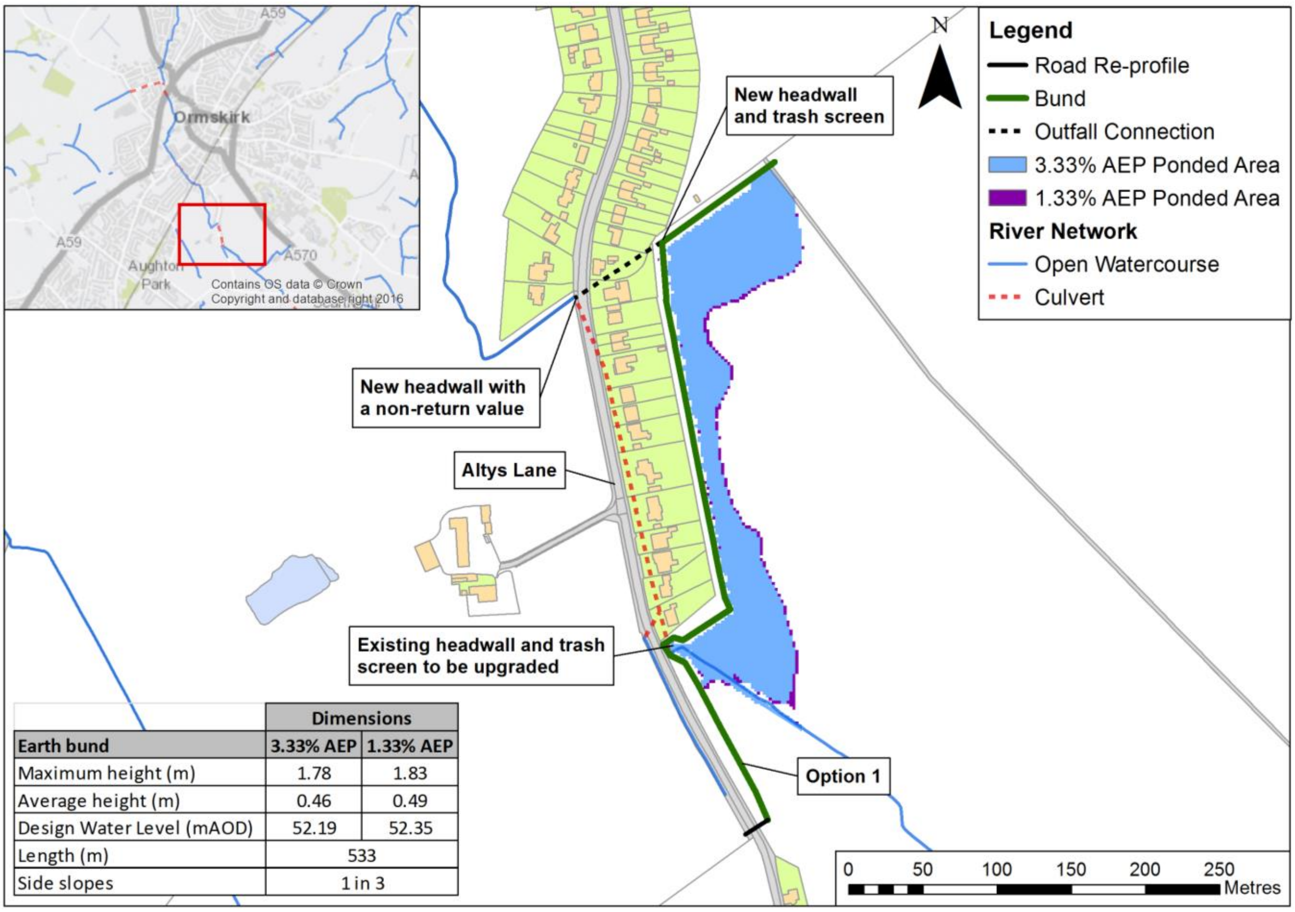
## 6.2 Option Arrangement

### 6.2.1 Option 1 – Flood storage along Altys Lane

Flows exceeding the capacity of Hurlston Brook and surface water runoff from the fields surrounding Altys Lane were identified as two of the key flooding mechanisms in the Altys Lane area. This option consists of a formal storage area upstream of the Altys Lane culvert, in combination with permanent raised defences to divert overland flows into the storage area. When the culvert becomes surcharged, floodwater would be stored within the storage area rather than spilling out onto the highway, as it does currently.

As is shown on Figure 6.2, the works would involve the construction of approximately 540m of raised embankment, upgrades to the existing upstream headwall, a new culverted connection to the watercourse with non-return valve and a new headwall and associated ancillaries.

**Figure 6.2 : Altys Lane Option Component General Arrangement**



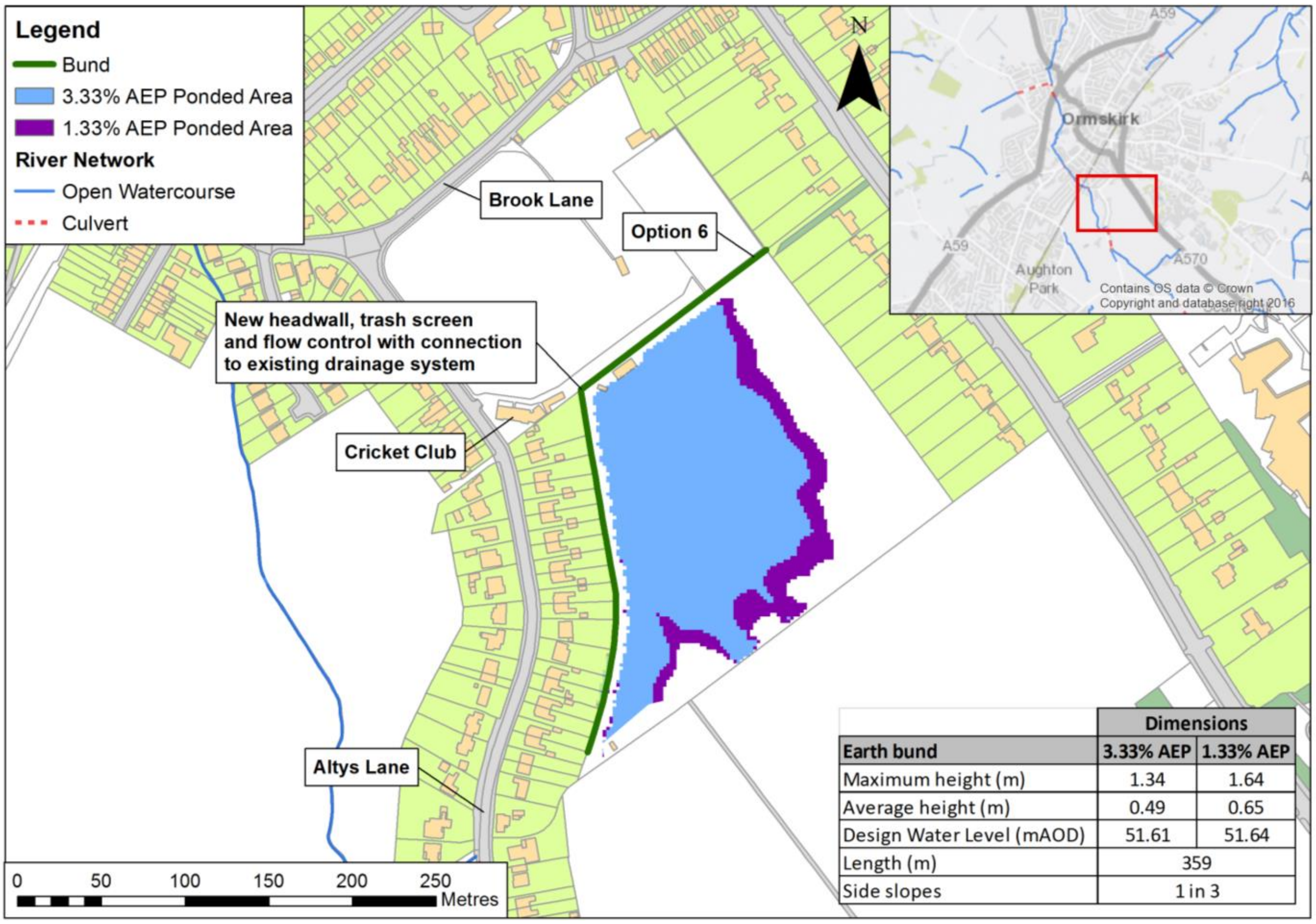

| | Dimensions | |
|---|---|---|
| Earth bund | 3.33% AEP | 1.33% AEP |
| Maximum height (m) | 1.78 | 1.83 |
| Average height (m) | 0.46 | 0.49 |
| Design Water Level (mAOD) | 52.19 | 52.35 |
| Length (m) | 533 | |
| Side slopes | 1 in 3 | |

### 6.2.2 Option 6 – Flood storage on Altys Lane Playing Fields

This option consists of a formal storage area within the playing fields at the bottom of Altys Lane. The purpose of which is to intercept overland flows and to store floodwater temporarily until the peak of the flood has passed before allowed to discharge back into the drainage network.

As is shown on Figure 6.3, the works would involve the construction of approximately 360m of raised embankment and a new piped connection to the surface water drainage system, with a headwall and associated ancillaries.

**Figure 6.3 : Altys Lane Playing Fields Option Component General Arrangement**




| | Dimensions | |
|---|---|---|
| **Earth bund** | **3.33% AEP** | **1.33% AEP** |
| Maximum height (m) | 1.34 | 1.64 |
| Average height (m) | 0.49 | 0.65 |
| Design Water Level (mAOD) | 51.61 | 51.64 |
| Length (m) | 359 | |
| Side slopes | 1 in 3 | |

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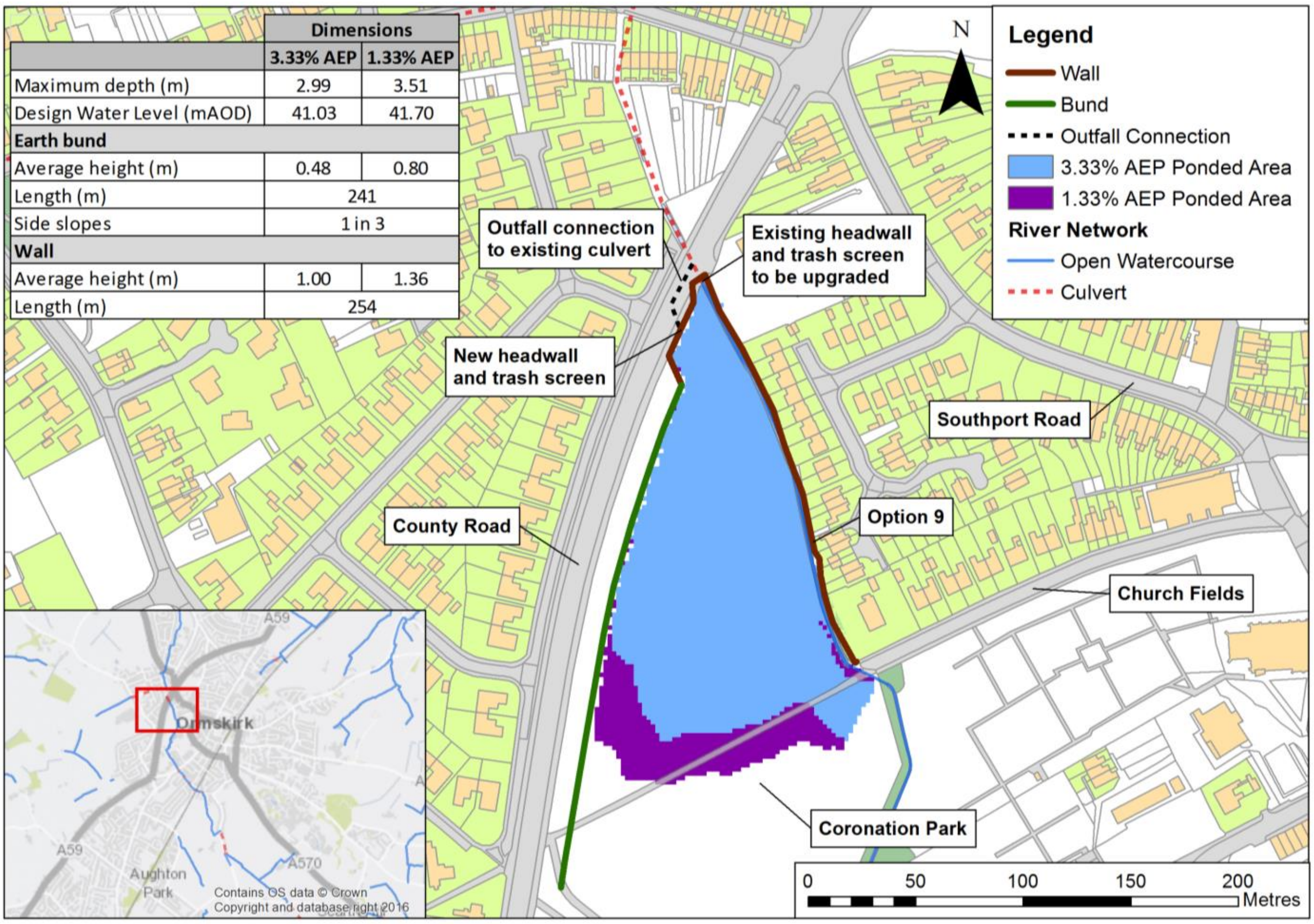
### 6.2.3 Option 9 – Flood storage within Coronation Park

Out of bank flow in the Coronation Park area was identified as one of the key flooding mechanisms. This option consists of a formal flood storage area to store flood flows once the County Road culvert becomes surcharged.

As is shown on Figure 6.4, the works would involve the construction of approximately 240m of raised embankment, 250m of reinforced concrete floodwall, a new headwall and connection to the main river, and a number of upgrades to the existing headwall and associated ancillaries.

**Figure 6.4 : Coronation Park Option Component General Arrangement**



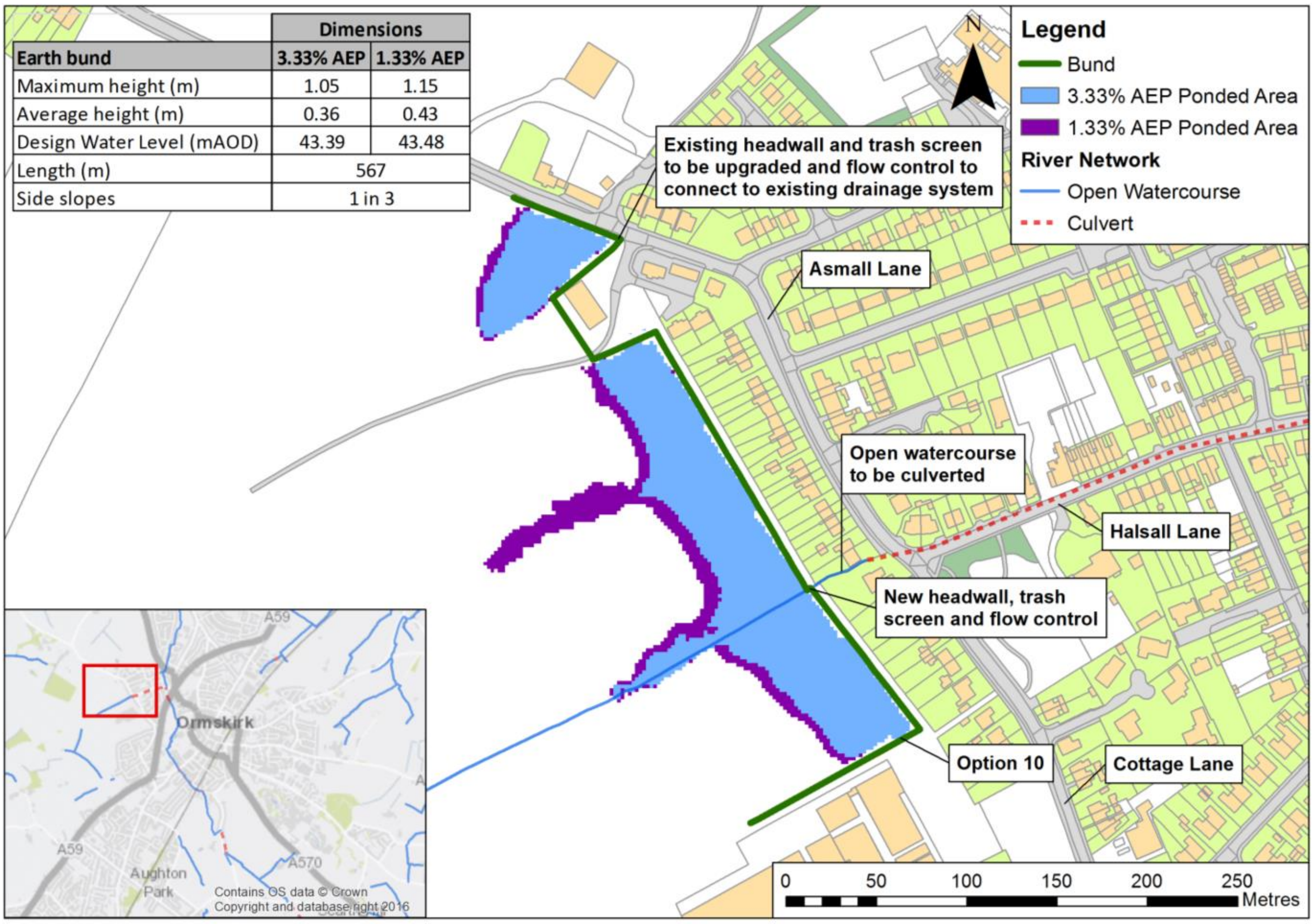
| | Dimensions | |
|---|---|---|
| | 3.33% AEP | 1.33% AEP |
| Maximum depth (m) | 2.99 | 3.51 |
| Design Water Level (mAOD) | 41.03 | 41.70 |
| **Earth bund** | | |
| Average height (m) | 0.48 | 0.80 |
| Length (m) | 241 | |
| Side slopes | 1 in 3 | |
| **Wall** | | |
| Average height (m) | 1.00 | 1.36 |
| Length (m) | 254 | |

### 6.2.4 Option 10 & Option 12 Combined – Flood storage behind Asmall Lane

Overland flow from the adjacent fields collects behind the properties on Asmall Lane before flowing down Halsall Lane. This option looks at creating a flood storage area behind the properties with the pass forward flow released into the drainage system in a controlled manner.

As is shown on Figure 6.5, the works would involve the construction of approximately 570m of raised embankment, a new headwall with trash screen and flow control, and an upgraded headwall and trash screen at the northern connection to the drainage system.

**Figure 6.5 : Asmall Lane Option Component General Arrangement**



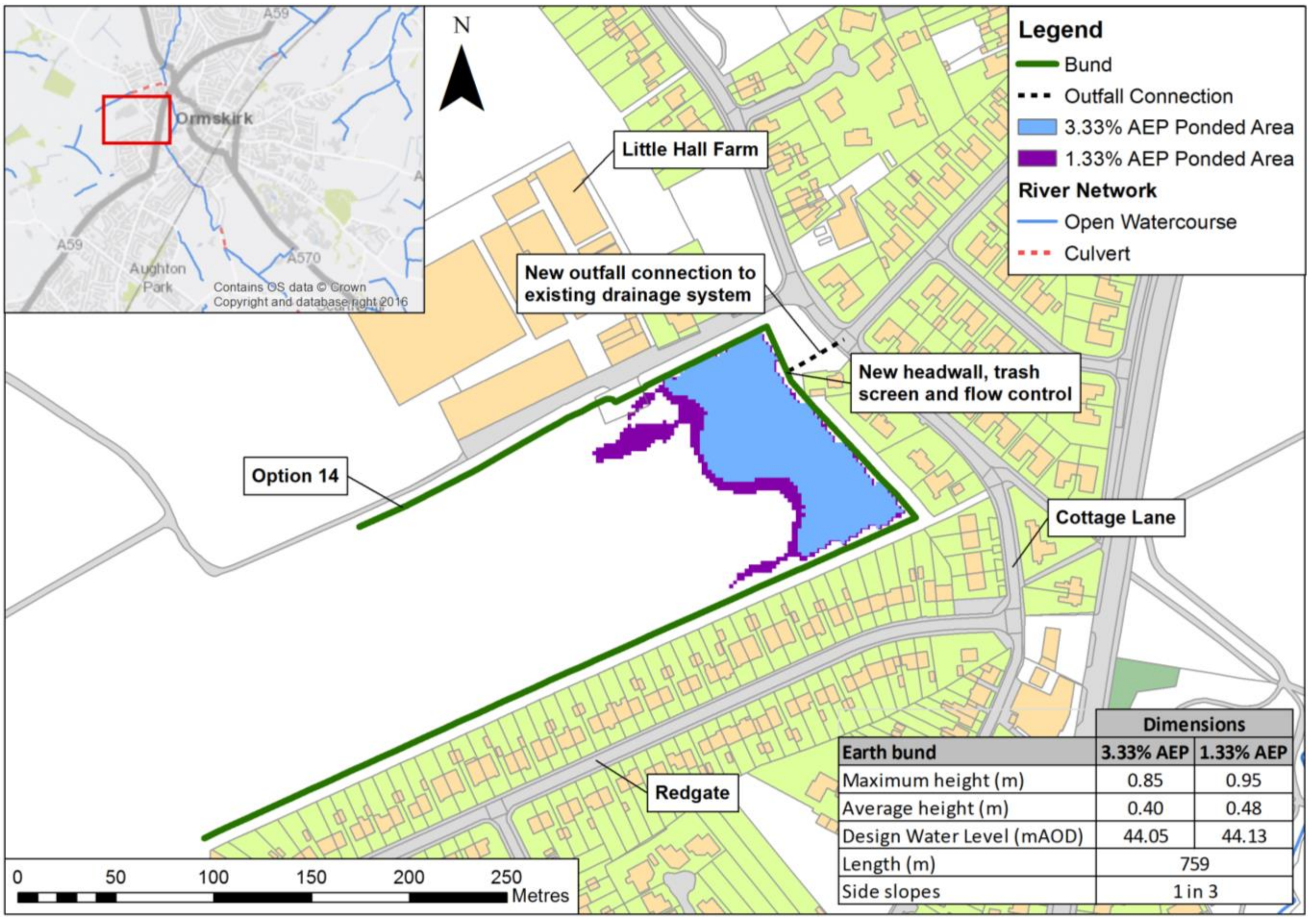

| Earth bund | Dimensions 3.33% AEP | 1.33% AEP |
|---|---|---|
| Maximum height (m) | 1.05 | 1.15 |
| Average height (m) | 0.36 | 0.43 |
| Design Water Level (mAOD) | 43.39 | 43.48 |
| Length (m) | 567 | |
| Side slopes | 1 in 3 | |

### 6.2.5 Option 14 – Flood Storage within Little Hall Farm

Similarly to Option 10, overland flow from the adjacent fields also collects and flow across the land immediately south of Little Hall Farm, spilling onto Cottage Lane and contributing to flooding that flows across Brighouse Close and Kinlcoh Way into the rear gardens of properties on Halsall Lane. This option attenuates these flows on the fields and provides a controlled release into the surface water drainage system.

As is shown on Figure 6.6, the works would involve the construction of approximately 760m of raised embankment and a new connection to the surface water drainage system, with a headwall and associated ancillaries.

**Figure 6.6 : Little Hall Farm Component General Arrangement**



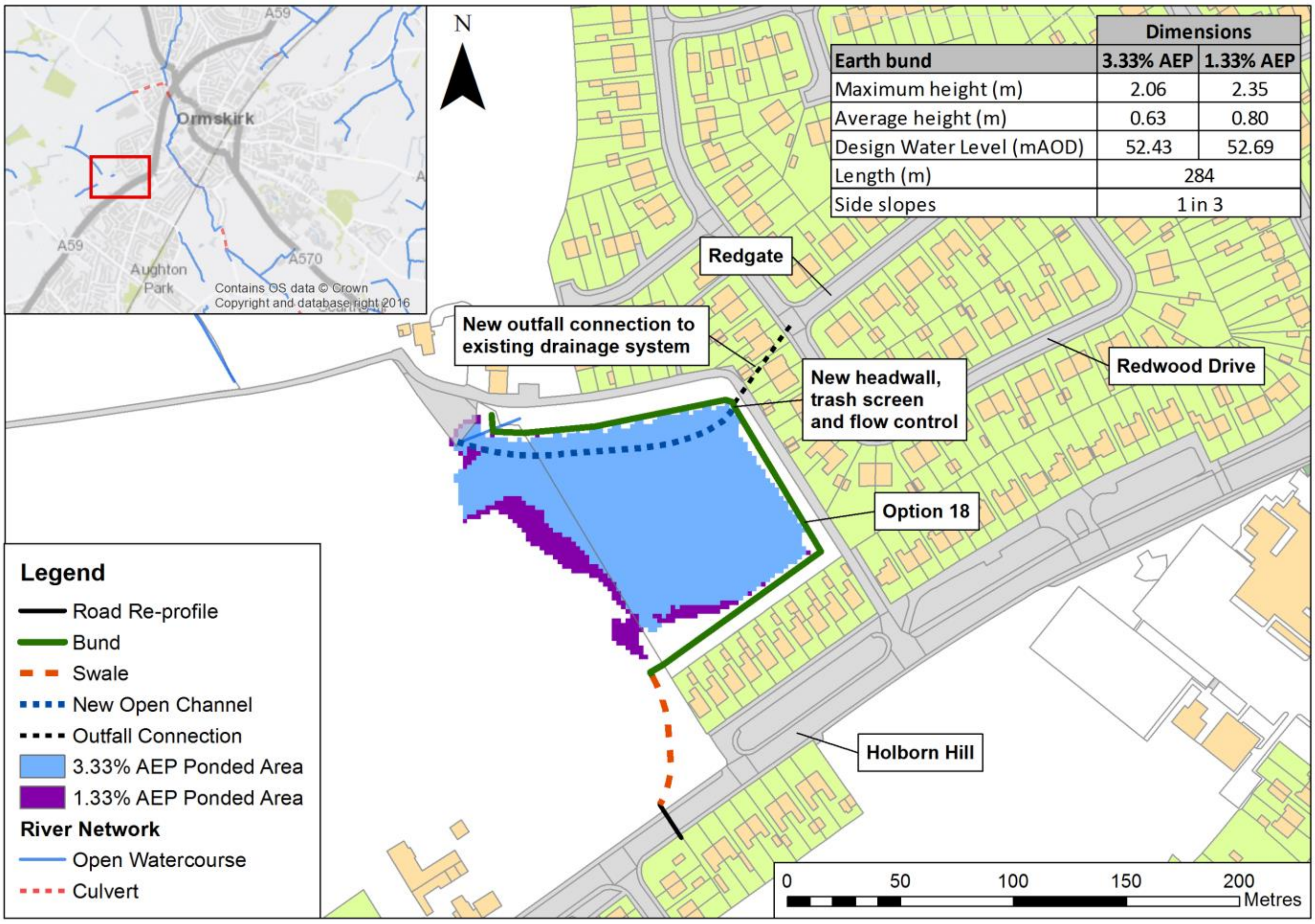

| | Dimensions | |
|---|---|---|
| Earth bund | 3.33% AEP | 1.33% AEP |
| Maximum height (m) | 0.85 | 0.95 |
| Average height (m) | 0.40 | 0.48 |
| Design Water Level (mAOD) | 44.05 | 44.13 |
| Length (m) | 759 | |
| Side slopes | 1 in 3 | |

### 6.2.6 Option 18 – Flood storage within Redgate Farm

Surface water flows from Redgate Farm and the surrounding area were identified as one of the key flooding mechanisms. Flood storage within Redgate Farm would allow this additional flow to be stored and released in a controlled manor once the peak of the flood had passed. Overland flow from the A59 (Liverpool Road / Holborn Hill) would also be intercepted, through either localised re-profiling of the road or the installation of combined drainage kerbs, which would be converyed to the storage area via a swale.

As is shown on Figure 6.7, the works would involve the construction of approximately 290m of raised embankment, a new connection to the surface water drainage system, with a headwall and associated ancillaries, a swale and an element of road re-profiling or drainage enhancements across the A59.

**Figure 6.7 : Redgate Farm Option Component General Arrangement**




| | Dimensions | |
|---|---|---|
| Earth bund | 3.33% AEP | 1.33% AEP |
| Maximum height (m) | 2.06 | 2.35 |
| Average height (m) | 0.63 | 0.80 |
| Design Water Level (mAOD) | 52.43 | 52.69 |
| Length (m) | 284 | |
| Side slopes | 1 in 3 | |

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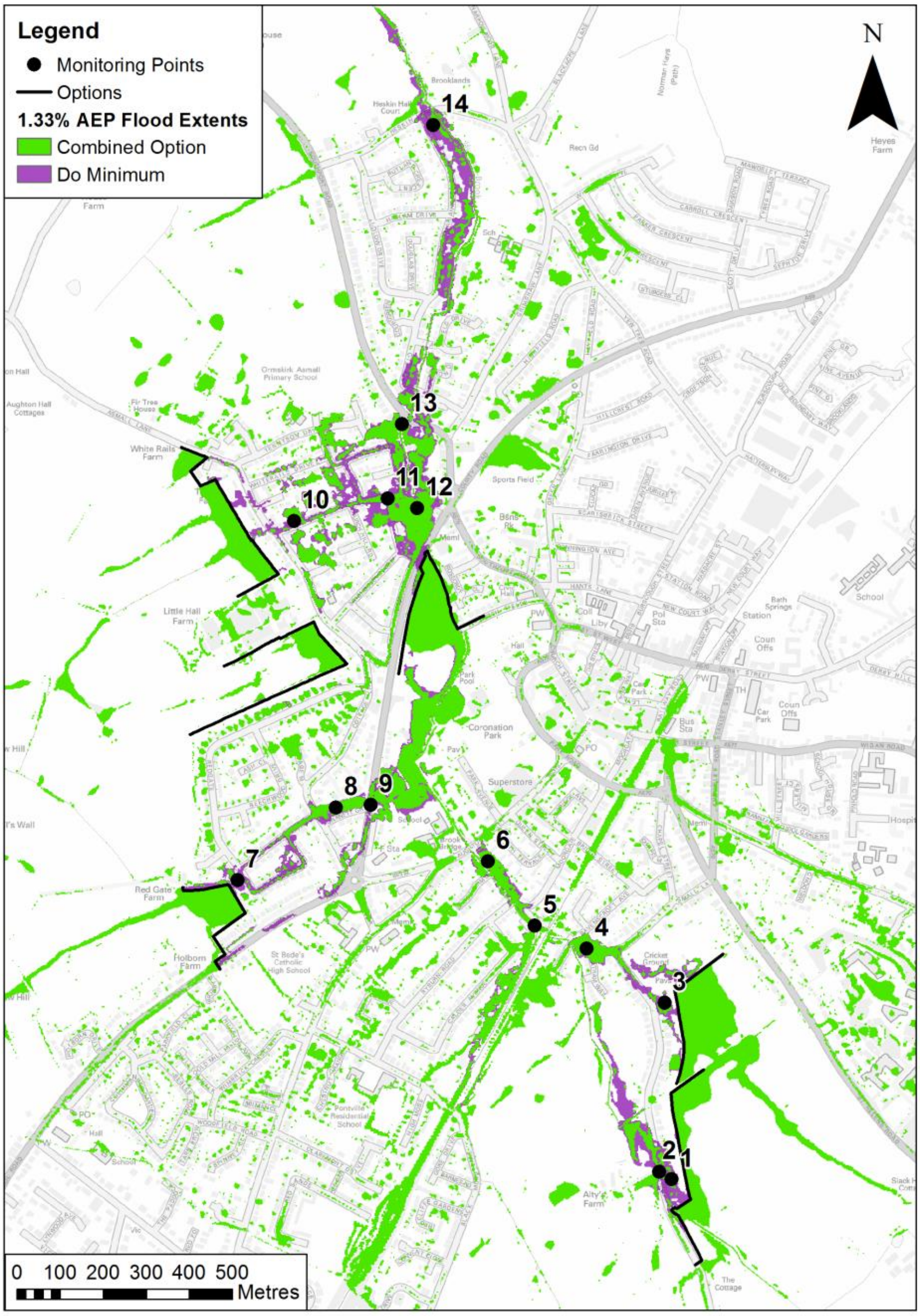
## 6.3 Residual Flood Risk

Whilst the options included within the combined scheme have been found to provide benefits in reducing the risk of flooding within the target receptor areas, a significant residual risk would remain. Figure 6.8 provides a comparison of the flood outlines from the Do Minimum and Combined Option model runs for a 1.33% AEP event.

**Figure 6.8 : Residual flood Outline (1.33% AEP)**




The comparison of flood outlines between the scenarios highlights a significant residual risk would remain even after the implementation of the Combined Option, however the frequency and depth of flooding is redued. To provide a better understanding of the reduction in risk offered by the Combined Option measures, the water level reductions at each of the 12 monitoring points is detailed in Table 6.1 for the Do Minimum and Combined Scheme model runs for 3.33% AEP and 1.33% AEP events.

**Table 6.1 : Baseline / With Scheme Flood Depths**

| Event | 3.33% AEP | | | 1.33% AEP | | |
|---|---|---|---|---|---|---|
| Monitoring Point | Flood Depth (m) | | Reduction (m) | Flood Depth (m) | | Reduction (m) |
| | Baseline | Scheme | | Baseline | Scheme | |
| 1 | 0.254 | 0.092 | 0.162 | 0.275 | 0.104 | 0.171 |
| 2 | 0.142 | 0.079 | 0.063 | 0.157 | 0.090 | 0.067 |
| 3 | 0.164 | 0.082 | 0.082 | 0.210 | 0.091 | 0.119 |
| 4 | 0.599 | 0.532 | 0.067 | 0.669 | 0.584 | 0.085 |
| 5 | 0.378 | 0.246 | 0.132 | 0.463 | 0.346 | 0.117 |
| 6 | 0.354 | 0.287 | 0.067 | 0.413 | 0.349 | 0.064 |
| 7 | 0.215 | 0.070 | 0.145 | 0.241 | 0.086 | 0.155 |
| 8 | 0.318 | 0.168 | 0.150 | 0.378 | 0.209 | 0.169 |
| 9 | 0.116 | 0.061 | 0.055 | 0.153 | 0.083 | 0.070 |
| 10 | 0.091 | 0.049 | 0.042 | 0.110 | 0.058 | 0.052 |
| 11 | 0.392 | 0.210 | 0.182 | 0.447 | 0.241 | 0.206 |
| 12 | 1.113 | 0.921 | 0.192 | 1.185 | 0.943 | 0.242 |
| 13 | 0.830 | 0.802 | 0.028 | 0.880 | 0.827 | 0.053 |
| 14 | 0.163 | 0.113 | 0.050 | 0.633 | 0.132 | 0.501 |

Cells that are coloured green show a residual flood depth of less than 150mm which would tend to be below property threshold levels. Amber cells show a residual depth is below 600mm, making the application of Property Level Protection (PLP) at affected properties a realistic prospect, whilst red cells exceed the maximum depths at which PLP is appropriate.

Inspecting these results, in combination with Figure 6.8, demonstrates that the scheme has been successful in reducing flood risk in several areas; however, there remains significant depths of water in the vicinity of monitoring points 12 and 13 – which are located towards the eastern end of Halsall Lane.

The measures that have been applied have been chosen to intercept all of the key overland flow paths, which have been proven to make significant contributions to flooding within the study area. However, even with these contributions intercepted and controlled, there remains significant residual flooding related to the multiple sources of overland flow, the capacity of the existing drainage system and Main River channel, and direct run-off within the urban areas.

# 7. Economic Appraisal

## 7.1 Properties at risk

Table 7.1 below provides a breakdown of the total number of properties predicted to be at risk of flooding within the study area across a range of flood events modelled for the Do Nothing, Do Minimum and the Combined Scheme scenarios. The Combined Scheme scenario includes both the 3.33% and 1.33% AEP crest level versions.

**Table 7.1 : Onset of property flooding**

| Property Type | Option | Annual Exceedance Probability (AEP) / Number of properties | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | | 20% | 10% | 5% | 2% | 1.33% | 1% | |
| Residential | Do Nothing | 114 | 20 | 18 | 46 | 25 | 21 | **244** |
| | Do Minimum | 52 | 22 | 14 | 46 | 21 | 32 | **187** |
| | Combined Scheme 3.33% AEP | 11 | 7 | 0 | 70 | 15 | 20 | **123** |
| | Combined Scheme 1.33% AEP | 11 | 7 | 0 | 8 | 7 | 63 | **96** |
| Non-Residential | Do Nothing | 65 | 10 | 9 | 18 | 5 | 4 | **111** |
| | Do Minimum | 49 | 6 | 12 | 18 | 9 | 5 | **99** |
| | Combined Scheme 3.33% AEP | 48 | 6 | 10 | 14 | 11 | 7 | **96** |
| | Combined Scheme 1.33% AEP | 48 | 6 | 10 | 14 | 10 | 7 | **95** |

## 7.2 Damages and Benefits

Jacobs' in-house economic damages assessment tool (EcMap) has been used to determine the economic damages within the study area. The tool estimates the direct economic damages resulting from flooding to properties as well as the value of indirect and intangible damages based on hydraulic modelling results.

Indirect and intangible damages represent loss of personal items and on-going costs such as temporary accommodation. Emergency services costs are also estimated based on a percentage of total damages.

Several conservative assumptions have been made regarding the calculation of economic damages. These are listed below:

- Residential and non-residential properties are valued based on regional average.
- Direct damage to vehicles has been applied to residential properties.
- Indirect damages associated with schools and substations have been applied to the relevant non-residential property type.
- No damages have been calculated associated with flooding to transport infrastructure.
- No allowance for climate change has been included in the economic assessment.

As a result, economic damages calculation need to be interpreted carefully and should not be taken as the 'final' damage values. However, they do provide a set of comparable Present Value (PV) damages, which can be used to identify high risk areas and potential benefits for future flood risk management actions.

PV Benefits have been calculated for each scenario by subtracting the residual damages from the do nothing damages. Table 7.2 summarises the residual PV Damages and PV Benefits for both residential and non-residential properties. Figure 7.1 and 7.2 also provide an overview of the location of the areas benefitting from implementation of each option.

**Table 7.2 : Total Present Value damages and benefits**

| Property Type | Do Nothing | Do Minimum | Combined Scheme (3.33% AEP) | Combined Scheme (1.33% AEP) |
|---|---|---|---|---|
| Residential Damages | £14,142k | £7,489k | £3,014k | £2,257k |
| Non-Residential Damages | £26,065k | £23,314k | £23,097k | £23,098k |
| **Total Damages** | **£40,207k** | **£30,803k** | **£26,111k** | **£25,355k** |
| Residential Benefits | - | £6,653k | £11,128k | £11,885k |
| Non-Residential Benefits | - | £2,751k | £2,968k | £2,967k |
| **Total Benefits** | **-** | **£9,404k** | **£14,096k** | **£14,852k** |

The Combined Scheme focuses on providing benefits to residential properties, and therefore there are very little benefits for non-residential properties, as seen in Table 7.2. With the scheme in place, residential properties are benefitting along Altys Lane, Redgate Estate, Garnett Green, Dyers Lane and Halsall Lane.

Figure 7.1 and 7.2 also provide an overview of the location of the areas benefitting from implementation of each option. It is to be noted that the Combined Option measures provide storage for a 3.33% and 1.33% AEP rainfall events, but do not provide a consistant minimum standard of protection to the properties.

**Figure 7.1 : Benefits for Combined Scheme 3.33% AEP**

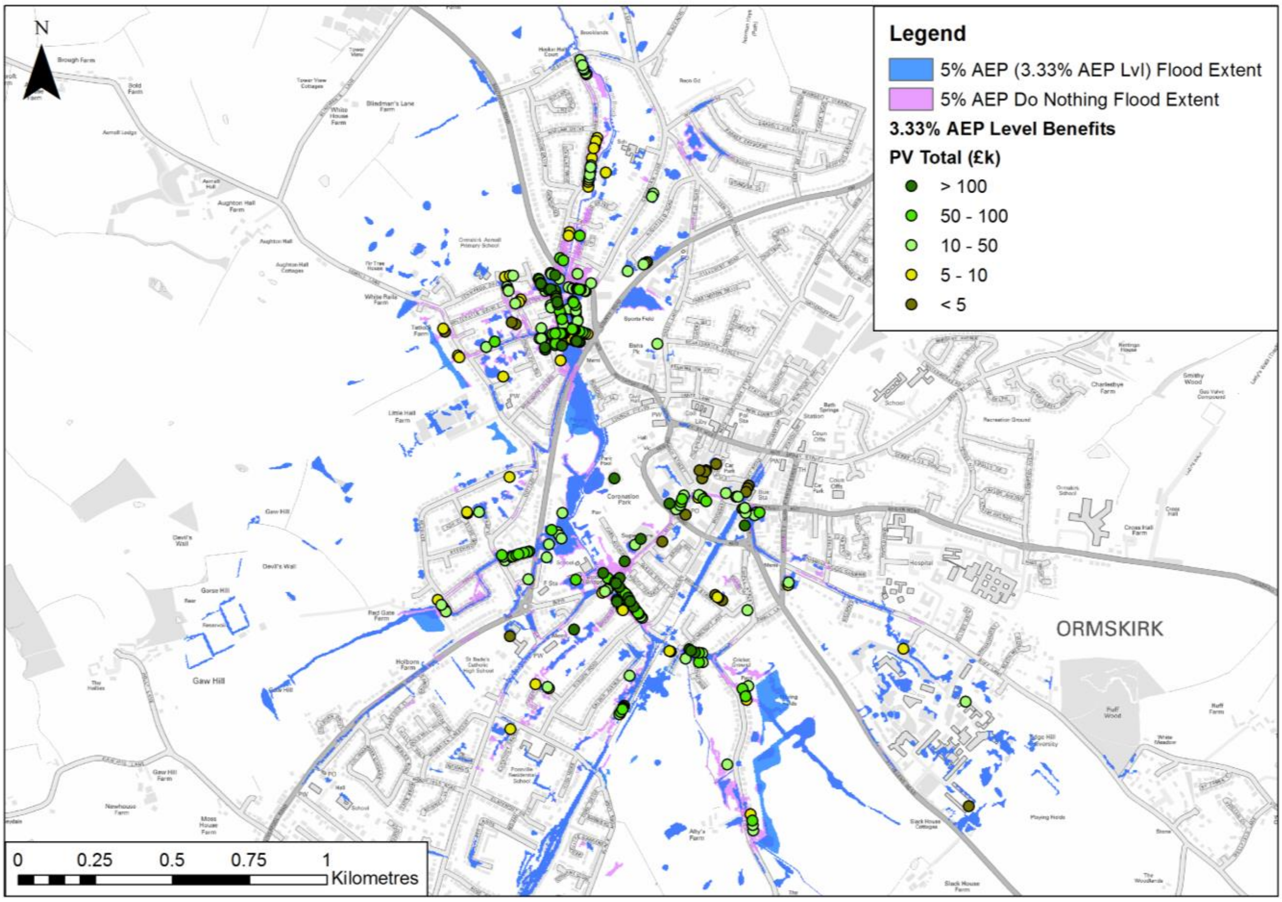
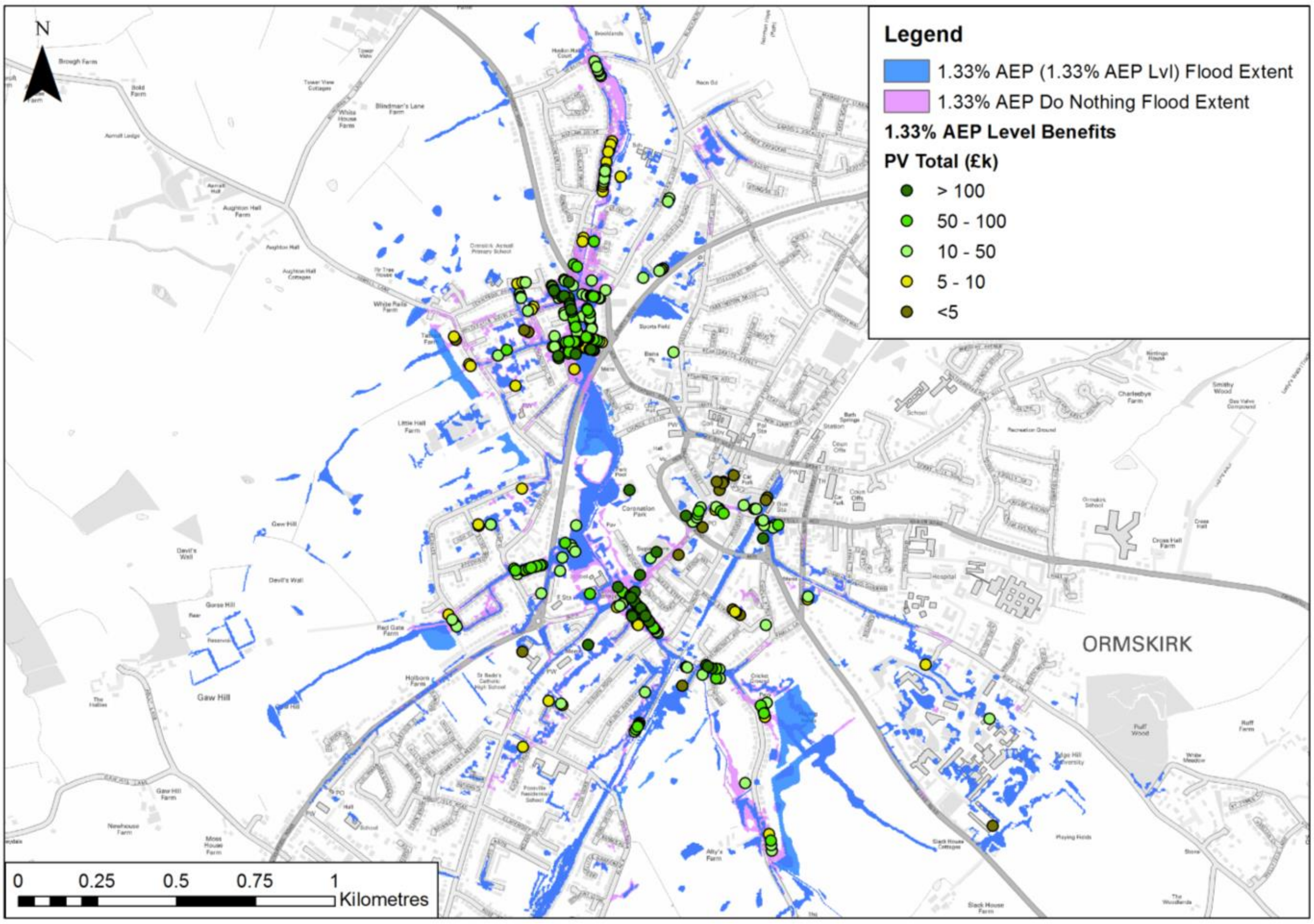


**Figure 7.2 : Benefits for Combined Scheme 1.33% AEP**




## 7.3 Scheme Costs

A high-level estimate of costs has been derived for the Combined Option using the Environment Agency's 'Long-term Costing Tool'. Details of the cost estimation process are contained in Appendix E. The costing exercise assumes a 50-year appraisal period, so includes long term maintenance costs discounted to reflect treasury discount rates. The whole life costs include:

- The initial capital costs of construction;
- Enabling costs (10% of capital costs);
- Annual maintenance costs; and
- Optimism bias (60% of total costs).

Table 7.3 and

Table 7.4 contain the total PV Costs for the combination of options for both the 3.33% AEP and 1.33% AEP levels, assuming a 50-year appraisal period.

Due to the high-level nature of this viability study, a 60% optimism bias has then been added to the PV Costs. If any of the options are taken forward, it is assumed that a detailed costing exercise would be carried out to refine the costing estimates and reduce the optimism bias presented in this assessment.

**Table 7.3 : Present Value Costs – Combined Scheme 3.33% AEP**

| | Do Nothing | Redgate | Little Hall Farm | Asmall Lane | Coronation Park | Altys Lane Playing Fields | Altys Lane | PLP | Total |
|---|---|---|---|---|---|---|---|---|---|
| Capital Costs | | £ 716k | £ 387k | £ 347k | £ 1,097k | £ 230k | £ 419k | £ 210k | **£3,406k** |
| Enabling Costs | | £ 72k | £ 39k | £ 35k | £ 110k | £ 23k | £ 42k | £ 21k | **£ 342k** |
| PV Maintenance Costs | | £ 86k | £131k | £ 114k | £ 103k | £ 78k | £ 137k | £ 0k | **£ 649k** |
| Total PV Costs | | £ 874k | £ 557k | £ 496k | £ 1,310k | £ 331k | £ 598k | £ 231k | **£ 4,397k** |
| **PV Costs + 60% Optimism Bias** | | £ 1,398k | £ 891k | £ 794k | £ 2,096k | £ 529k | £ 957k | £ 369k | **£ 7,035k** |

**Table 7.4 : Present Value Costs – Combined Scheme 1.33% AEP**

| | Do Nothing | Redgate | Little Hall Farm | Asmall Lane | Coronation Park | Altys Lane Playing Fields | Altys Lane | PLP | Total |
|---|---|---|---|---|---|---|---|---|---|
| Capital Costs | | £ 765k | £ 435k | £ 380k | £ 1,181k | £ 290k | £ 432k | £ 338k | **£ 3,820k** |
| Enabling Costs | | £ 76k | £ 43k | £ 38k | £ 118k | £ 29k | £ 43k | £ 34k | **£ 381k** |
| PV Maintenance Costs | | £ 89k | £ 126k | £ 111k | £ 117k | £ 84k | £ 125k | £ 0k | **£ 652k** |
| Total PV Costs | | £ 930k | £ 604k | £ 529k | £ 1,415k | £ 403k | £ 600k | £ 371k | **£ 4,853k** |
| **PV Costs + 60% Optimism Bias** | | £ 1,489k | £ 967k | £ 846k | £ 2,263k | £ 645k | £ 961k | £ 594k | **£ 7,765k** |

As discussed in Section 1.3, the Do Minimum option represents maintaining the present day conditions. For this option there would be no capital or enabling costs, only maintenance costs as the construction of a new asset is not required. The cost of the option has been assumed based on the cost of maintaining Hurlston Brook and the clearance and replacement of gullies located within the study area. The Environment Agency's maintenance estimate for Main Rivers was utilised to calculate the cost of maintaining the watercourse. The cost of maintaining the gullies has assumed that every gully in the catchment would be cleared and that 2% of all gullies in the system (80 gullies) would be replaced annually. A summary of the PV costs for each of the different options can be found in Table 7.5 below.

**Table 7.5 : Present Value Costs Summary**

| | Do Nothing | Do Minimum | Combined Scheme (3.33% AEP) | Combined Scheme (1.33% AEP) |
|---|---|---|---|---|
| Total PV Costs + Do Minimum Maintenance | | £ 2,624k | £ 9,659k | £ 10,389k |

The whole life estimated cost for maintaining the asset sytem in it's current condition for the next 50 years is £2.6m. This cost is included in the whole life estimate for both of the Combined Schemes.

## 7.4 Summary

Table 7.6 summarises the findings of the economic appraisal. The Benefit Cost Ratio (BCR) is a simple indicator, illustrating economically viable options (BCR above 1.0). The raw Partnership Funding Score shows how much FCERM GiA funding the option could be eligible for as a percentage of the total costs without any additional partnership contributions.

The raw Partnership Funding Score is intrinsically linked to the benefits the option provides, which includes the reduction in flood risk to households (residential properties). The Partnership Funding Score has been calculated assuming all but one of the properties is within the 60% least deprived areas according to the Index of Multiple Deprivation 2010[1]. Appendix F contains the full Partnership Funding Score results. The BCR, incremental BCR (iBCR) and the raw Partnership Funding Score can help identify the feasibility of the Combined Schemes in economic terms.

**Table 7.6 : Economic appraisal summary**

| | Do Nothing | Do Minimum | Combined Scheme (3.33% AEP) | Combined Scheme (1.33% AEP) |
|---|---|---|---|---|
| **OM1 – Economics** | | | | |
| Total PV Damages | £ 40,207k | £ 30,803k | £ 26,111k | £ 25,355k |
| Total PV Benefits | | £ 9,404k | £ 14,096k | £ 14,852k |
| Total PV Costs | | £ 2,624k | £ 9,659k | £ 10,389k |
| BCR | | 3.58 | 1.46 | 1.43 |
| iBCR | | - | 0.67 | 1.04 |
| **OM2a – Households at flood risk** | | | | |
| Total | 244 | 187 | 123 | 96 |
| **OM2b – Households better protected (total)** | | | | |
| Very Significant *(<20% AEP)* | | 88 | 70 | 70 |
| Significant *(>20% AEP & <1.33% AEP)* | | 67 | 18 | 52 |
| Moderate *(>1.33% AEP & <0.5% AEP)* | | 32 | 12 | 31 |
| **OM2c – Households better protected (20% most deprived areas)** | | | | |

[1] http://apps.opendatacommunities.org/showcase/deprivation

| | | | | |
|---|---|---|---|---|
| Very Significant | | | 0 | 0 |
| Significant | | | 0 | 0 |
| Moderate | | | 0 | 0 |
| **Prospect of FCRM GiA funding** | | | | |
| Raw Partnership Funding Score | | | 11% | 12% |

The iBCR shows that it is not economically feasible (<1) to implement the Combined Scheme 3.33% AEP over the Do Minimum situation. However, the iBCR shows that it is economically feasible (>1) to invest more money into the Combined Scheme 1.33% AEP over the Combined Scheme 3.33% AEP.

OM2b shows that 70 properties shift from the very significant risk band and into the significant and moderate risk bands for the Combined Scheme 3.33% AEP. The Combined Scheme 1.33% AEP shifts properties from the very significant and the significant risk bands into the moderate risk band. The green cells represent properties that are better protected, whilst the red cells represent an increase in the number of properties within that risk band.

Both options have a low raw Partnership Funding Score, due to the low BCRs and high scheme costs. These low scores also show that both Combined Schemes would require significant funding contributions from alternative sources outside of the Defra FCERM GiA process. Table 7.7 illustrate that the client would need to find additional funding of between £5,000k and £6,000k in order to gain a Partnership Funding Score of above 100%.

**Table 7.7 : Partnership funding score per contribution value**

| Combined Scheme | Partnership funding score per contribution | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | £0k | £100k | £250k | £500k | £1,000k | £2,500k | £5,000k | £6,000k |
| 3.33% AEP | 11% | 13% | 16% | 20% | 29% | 56% | 100% | 118% |
| 1.33% AEP | 12% | 14% | 16% | 20% | 28% | 51% | 91% | 106% |
| *As these options are likely to be delivered by Lancashire CC, the percentage of partnership funding contributions do not include future maintenance costs and these would still need to be found from elsewhere. | | | | | | | | |

## 7.5 Costs Sensitivity

A cost sensitivity analysis has been carried out to help understand the potential for increasing the Partnership Funding Score by refining capital and maintenance cost.

Due to the high-level nature of this viability study, a 60% optimism bias was added to the original PV Costs to cover any uncertainties within the source of capital costs, work duration and future operating costs. The first sensitivity check looked at reducing this from 60% to 30%.

As discussed in Section 7.3, the Do Minimum maintenance costs for the scheme were calculated by combining the cost of maintaining Hurlston Brook and the cost of maintaining the gullies within the catchment. Although Hurlston Brook is designated as a main river, due to its small size it is more comparable to an ordinary watercourse and so the maintenance costs would be much less. Similarly, the cost of maintaining the gullies has assumed that every gully in the catchment would be cleared and that 2% of all gullies in the system would be replaced annually. Given the size of the catchment and the different land uses across it, it is unlikely that this would be the case. The second sensitivity check looked at reducing the Do Minimum costs by 50%.

The third sensitivity check looked at combining the two combinations above.

Table 7.8 below illustrates the impacts these reduced costs have on the BCR and Partnership Funding Score of the Combined Scheme for the 1.33% AEP event.

**Table 7.8 : Cost sensitivity check for the Combined Scheme (1.33% AEP)**

| Combined Scheme (1.33% AEP) | Total PV Costs (including Do Minimum maintenance) | Benefit Cost Ratio | Partnership Funding Score (%) |
|---|---|---|---|
| Original Cost (Table 7.6) | £10,389k | 1.43 | 12% |
| Optimism bias reduced to 30% | £8,933k | 1.66 | 14% |
| Maintenance reduced by 50% | £9,077k | 1.64 | 14% |
| Optimism bias reduced to 30% and maintenance reduced by 50% | £7,621k | 1.95 | 16% |

The cost sensitivity check shows that even when the costs are refined the BCR and Partnership Funding Score are still low and the scheme would still require significant funding contributions from alternative funding sources.

## 7.6 Sub-Option Prioritisation

Recognising that the cost of implementing the Combined Scheme as a whole is unlikely to be feasible, it may be possible to proceed with a phased implementation of the individual components.

Table 7.9 below, uses the outcome of the technical effectiveness rating of the options that make up the combined scheme, as listed in Table 5.5, to rank the options against the cost of implementation.

The ranking shows that the two most technically effective options are also the most costly. Conversely, the least costly of the options is ranked the third most technically effective.

**Table 7.9: Sub-option prioritisation**

| Rank | Option | PV Costs | |
|---|---|---|---|
| | | 3.33% AEP | 1.33% AEP |
| 1 | Option 9 – Flood Storage within Coronation Park | £2,096k | £2,263k |
| 2 | Option 18 – Option 15 plus road diversion | £1,398k | £1,489k |
| 3 | Option 6 – Bund between playing fields and cricket pitch | £529k | £645k |
| 4 | Option 1 – Flood Storage with existing culvert capacity | £957k | £961k |
| 5 | Option 10 & 12 Combined – Flood Storage with existing culvert capacity | £794k | £846k |
| 7 | Option 14 – Flood Storage at Little Hall Farm | £891k | £967k |

# 8. Conclusions and Recommendations

## 8.1 Conclusion

LCC commissioned Jacobs to undertaken an investigation of the flood risk across Ormiskirk. To achieve this aim, this study was scoped the objective of which were to;

- Identify the primary sources of flooding within each of the seven key risk areas;
- Identify potential options to manage the risk of flooding from these sources; and
- Provide commentary on potential next steps to develop a scheme further.

In order to achieve this, a five-step approach was developed, starting with a review of historical flooding incidents and the construction of an integrated hydraulic model, and concluding with an assessment of options to reduce flood risk.

By using the outputs of the integrated hydraulic model, supplemented by historical flood data and site observations, the key flooding mechanisms through Ormskirk could be established. The study found that the flooding mechanisms are complex and that there is no single cause of flooding within Ormskirk town centre and the key receptor sites.

The main causes of flooding in each area are due to a range of factors, including:

- Pluvial runoff from agricultural land
- Main river flooding from Hurlston Brook
- The capacity of the existing drainage infrastructure
- Influence of topography and existing land-use
- The interaction between the above factors

Once the primary sources and the mechanisms of flooding had been established the next step was to identify potential flood risk management options for inclusion in a preferred package of works to help manage the risk of flooding. This was done through a multi-stage review process. The final stage of the optioneering process involves testing each option using the hydraulic model to determine their technical effectiveness. The option testing exercise demonstrated that no single solution would resolve these issues due the complex flooding mechanisms discussed above.

The options addressed the primary sources of flooding to each of the key areas; however, because the risk at some of the sites emanates from multiple sources, the measures were not effective at completely alleviating the risk to a prescribed standard of protection.

The residual flood risk being experienced within the town centre is a result of direct rainfall combined with the effect of there being insufficient capacity to store, and inadequate means of conveying the water downstream. The shortlisted options intercept significant overland flow contributions from around the study area. However, these measures have not proven to compensate for the deficiencies of certain key elements of infrastructure. The existing drainage infrastructure is of insufficient capacity to successfully capture and convey water away when faced with extreme rainfall events and increasing conveyance to Hurlston Brook may simply pass the problem downstream where there are other areas of acute risk.

The importance and potential influence of gulley and drainage system maintenance should not be underestimated as it helps to maximise the conveyance capacity of the existing system. However, maintenance alone would not provide benefits if the system is already full. Refurbishment of, and upgrades to, the system could improve the efficiency of this system and in turn provide benefits in risk reduction, but as much of the drainage connects into Hurlston Brook, any improvements in conveyance could lead to an increase in flood risk to properties in the key risk areas adjacent to the watercourse.

By implementing any individual or combination of options, a residual risk would remain, although these can be partially tackled by measures to reduce the impact of flooding such as Property Level Resilience.

There are also non-engineered options, which could reduce to alleviate the risk of flooding to the town. There are several strategic measures that if adopted and implemented by the relevant RMA can help to reduce the volume and speed of run-off, and reduce the resulting damage in extreme events, including but not limited to;

- Adopting rigorous strategic development planning and development control on all new development within the catchment to avoid innaproprotiate development but also identify opportunities to reduce the volume and speed of run-off and the contribution to flows into the surface water and combined sewer system.
- Adopting development control policy to make building more resilient to flood risk.
- Encouraging land-use measures that would help absorb more rainfall into the ground and reduce the speed of run-off. This may be in tandem with other more traditional FRM measures, which may be more effective in higher magnitude events.

Some of the measures discussed in this report would be a challenge to implement, as some would be reliant on the cooperation of landowners to accommodate flood defence measures on their land. If implemented, it would leave a legacy of assets that require adoption and maintenance commitment from the relevant RMA and would require legal agreements with the landowners.

Whilst the measures included within the combined scheme have been shown to provide some betterment, the likelihood of such a scheme achieving funding without significant external contributions is unlikely. The low BCR and Partnership Funding Score means that the prospect of attracting substantial FCERM GiA funding from the Environment Agency toward the cost of implementation is low. The majority of the funding would need to be found by alternative funding sources.

The analysis provides an indication of the relative effectiveness of each Combined Scheme, which shows implementing Combined Scheme 1.33% AEP is slightly more economically feasible than the Combined Scheme 3.33% AEP. However, the value of economic benefit has not been derived for each option in isolation. If the LLFA sought to proceed with individual options, and were to seek funding, then the options would need to be economically tested as standalone measures.

## 8.2 Recommendations

It is recommended that a wider, co-ordinated approach to managing the catchment be developed with emphasis on partnering with the other key stakeholder bodies, most notably United Utilities and developers known by LCC to be seeking opportunities in Ormskirk. The scope of this should extend to examining refurbishment and regeneration of the existing drainage network and consideration of future development needs.

The outcomes of this study can be used to understand the key risk areas and flooding mechanisms so that appropriate decisions on planning and future development can reduce the number of properties at risk.

# Appendix A. Flooding Records

| Figure Reference | Title |
|---|---|
| A1 | Flood Records – Up to September 2012 |
| A2 | Flood Records – December 2015 event |

# Appendix B. Hydraulic Modelling Report

# Appendix C. Flood Maps

| Figure Reference | Title |
|---|---|
| C1 | Flood Extent Map – Do Nothing Scenario |
| C2 | Flood Extent Map – Do Minimum Scenario |
| C3 | Flood Depth Map – Do Minimum Scenario 20% AEP |
| C4 | Flood Depth Map – Do Minimum Scenario 10% AEP |
| C5 | Flood Depth Map – Do Minimum Scenario 5% AEP |
| C6 | Flood Depth Map – Do Minimum Scenario 2% AEP |
| C7 | Flood Depth Map – Do Minimum Scenario 1.33% AEP |
| C8 | Flood Depth Map – Do Minimum Scenario 1% AEP |

# Appendix D. Optioneering Report

# Appendix E. Cost Estimates

The following documents are contained in this appendix;

| Document Number | Title |
|---|---|
| E1 | Do Minimum 50 year appraisal period Cost Estimate |
| E2 | Do Something 30 year level appraisal period Cost Estimate |
| E3 | Do Something 75 year level appraisal period Cost Estimate |

# Appendix F. Economics Assessment

The following documents are contained in this appendix;

| Document Number | Title |
|---|---|
| F1 | Partnership Funding 1 in 30 |
| F2 | Partnership Funding 1 in 75 |