URS

Southend-on-Sea Flooding 24th August 2013

Flood Investigation Report

Final

October 2014

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UNITED KINGDOM & IRELAND

Prepared for:

southend onsea BOROUGH COUNCIL

REVISION SCHEDULE					
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EXECUTIVE SUMMARY

This report constitutes the findings of the Flood Investigation completed for the flooding event of the 24th August 2013 within Southend-on-Sea. This has been completed under Section 19 of the Flood and Water Management Act 2010.

Flooding on the 24thAugust 2013 was primarily a result of intense rainfall coinciding with a high spring tide. A total of 54.8mm of rainfall was recorded to fall within 4 hours; this is above the average total rainfall for the month of August. It is believed that flooding across the borough resulted from a number of sources occurring simultaneously, including, surface water, fluvial and sewer flooding.

A total of 255 incidents of flooding were recorded, however it was considered that many incidents were not recorded. Of the recorded incidents, 151 properties were flooded internally. The greatest concern was for three properties (two of which provide sheltered accommodation) which were evacuated due to significant flooding.

Widespread flooding was observed across Southend-on-Sea. Three main clusters of flooding incidents occurred in the localities of Eastwood, Chalkwell and Marine Parade & Eastern Esplanade.

Flooding within the Eastwood area was concentrated around the course of the Eastwood Brook. Flooding resulted from high fluvial flows in the Eastwood Brook coinciding with overland surface water runoff. The Eastwood Brook catchment is heavily urbanised and the channel greatly modified; as a result, water levels rise rapidly following rainfall. In addition, the presence of multiple culverts and service crossings within the channel increases the tendency for blockages, causing water to back up. On the 24th August 2013, water levels within the river channel rose quickly and overtopped the banks of the channel. Details of flooding suggest that surface water had been pumped into the Eastwood Brook from Rayleigh Weir, upstream of Southend-on-Sea, which may have also had an influence on the water levels.

To the south of the borough, there are two clusters of flooding incidents around Chalkwell and Marine Parade & Eastern Esplanade. Flooding within these areas is primarily a result of overland surface water runoff and surcharging sewers. The surface water sewers that discharge to the Thames Estuary were tide locked soon after the peak of the rainfall event, thus preventing the discharge of surface water from the surface water sewer network. The sewer network reached its capacity rapidly and surcharged as surface water from much of the Southend urban area drained towards the outlets in the south.

In addition to the flooding mechanisms described above, there were a number of localised flooding incidents which are considered to have occurred as a result of blocked road gullies, structures impeding flow or areas of localised low elevation.

Southend-on-Sea Borough Council (SBC), the Environment Agency (EA) and Anglian Water (AW) are working together to identify and alleviate sources of flood risk within the borough. Following the flooding incident in 2013 several meetings have been held to clarify asset ownership and to outline the next steps going forward.

During the flooding event, SBC, AW and the EA responded as required to take calls from the public and provide advice and support where needed. Operatives from the EA cleared trash screens along the Eastwood Brook for the duration of the event.

The EA has permissive powers to maintain the banks and channels of Main Rivers, including the Eastwood Brook, within the borough. The EA proposes to commence an investigation into the existing fluvial flood risk along sections of Eastwood Brook and Prittle Brook in 2015.

However this is dependent upon securing the necessary funding in February 2015. Following the 2013 event, actions have also been taken to install a flood warning system on Eastwood Brook, upstream of Southend-on-Sea.

Following the flooding event, SBC identified a number of actions to be undertaken including public engagement, communication of riparian ownership responsibilities, and prioritisation of areas for road gully cleansing. In addition, the SBC Emergency Response Procedure has been updated to include information from this flooding incident and to highlight areas at greatest risk of flooding.

SBC is in the process of coordinating the investigation into the alleged pumping of surface water into Eastwood Brook, upstream of Southend-on-Sea. This will predominantly involve Essex County Council (ECC) and the EA.

AW have since repaired and made more resilient the Eastern Esplanade Pumping Station which failed as a result of the rainfall event. AW have also identified areas of open ditch that fall under their responsibility.

SBC will continue to work with AW and the EA to ensure that flood risk is managed appropriately within the borough and that potential mitigation options are investigated.

As part of this investigation, a range of options and actions have been identified for future consideration. These are intended to be implemented through joint working of the RMAs, residents, riparian owners and developers to assist in managing future flood risk.

1 INTRODUCTION

1.1 Background

Section 19(1) of the Flood and Water Management Act (FWMA, 2010)[i] places a duty on Lead Local Flood Authorities (LLFAs), such as Southend-on-Sea Borough Council (SBC), to investigate flood incidents from surface water, groundwater and ordinary watercourses[ii], where it considers it 'necessary and appropriate'.

Section 19 of the FWMA states that:

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

(a) which risk management authorities (RMAs) have relevant flood risk management functions, and

(b) whether each of those RMAs has exercised, or is proposing to exercise, those functions in response to the flood.

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

(a) publish the results of its investigation, and

(b) notify any relevant RMAs in accordance with Section 19(2) of the FWMA.

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

- LLFA (SBC) and neighbouring boroughs (Essex County Council, (ECC)),
- Environment Agency (EA),
- Internal Drainage Board (not applicable within SBC),
- Water Companies (Anglian Water (AW) and Essex & Suffolk Water),
- Highway Authorities (SBC).

1.2 Criteria for Investigating Flood Incidents

SBC has developed a set of criteria in order to determine if a flooding event requires investigation. This is based on the assessment of the consequences of flooding that are considered to be sufficiently serious.

Where any of these criteria are met, an investigation will be undertaken:

Is there, or have there been:

- more than four reports of the interior of a single residential property flooding?
- any reports of the interior of critical infrastructure flooding?

[i] Flood and Water Management Act 2010: http://www.legislation.gov.uk/ukpga/2010/29/contents
[ii] An ordinary watercourse includes every river, stream, ditch, drain, cut, dyke, sluice, sewer (other than public sewer) and passage through which water flows which does not form part of a Main River.

- flooding of a transport link such that it has been made impassable for a significant amount of time?
- more than 14 reports of flooding within 50m of the receptor in past three years?
- potential for accidents or health implications?
- effects on vulnerable people through service or amenity impacts?

Where the answer to any of the below is 'yes', the need for a flood investigation will be considered based on a risk based approach:

- Has there been more than one report of the interior of a commercial property flooding?
- and has this had an economic impact?
- Has the natural environment been affected?
- and is there a threat to a local ecosystem?
- Is the localised flooding known to occur according to historic records?
- Has a request for investigation been received?
- Is a single source of flooding evident?
- Are other flood risk management authorities investigating?

Following the above set of criteria, it was deemed necessary to complete an investigation into the flooding incidents across Southend-on-Sea on 24th August 2013 as major disruption occurred across the Borough and a considerable number of properties reported internal flooding. This report constitutes a record of this investigation.

1.3 Duties and Responsibilities

The legal framework for managing flooding lies with a number of different agencies, whose key responsibilities are outlined below. Reference should be made to the relevant legislation and the Local Flood Risk Management Strategy (LFRMS)[iii], when complete, for further information.

1.3.1 Southend-on-Sea Borough Council (LLFA)

SBC as the LLFA has a strategic overview role and a responsibility to investigate flood incidents from surface water, groundwater and ordinary watercourses where it is considered necessary and appropriate.

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

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

[iii] URS (2014) Draft Southend-on-Sea Borough Council Local Flood Risk Management Strategy

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

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

1.3.2 Environment Agency

The EA has permissive powers to carry out maintenance work on Main Rivers[vi] (see Figure 1.2) under Section 165 of the Water Resources Act (1991)[vii].

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

1.3.3 Anglian Water

Under the FWMA, AW is responsible for managing the risks of flooding from surface water, foul and/or combined sewer systems where the sewer flooding is wholly or partly caused by an increase in the volume of rainwater (including snow and other precipitations) entering or otherwise affecting the system. Within Southend-on-Sea there are sections of culverted watercourse that also fall under AW responsibility.

AW has a duty to provide and maintain a system of public sewers so that the areas for which they are responsible are effectually drained (Water Industry Act, 1991[viii]). Sewerage systems are not, however, designed to accommodate flows from severe weather events. AW's level of service is set by Ofwat, the industry regulator. In the context of drainage, severe weather is considered to be 'rainfall events having a storm return period that is less frequent than a rainfall event with an Annual Exceedance Probability (AEP) of 5% (1 in 20 years). Therefore, rainfall events with a lower annual rainfall probability than 5% would be expected to result in surcharging of some of the sewer network.

As part of AW's obligation to Ofwat, they are required to undertake capacity improvements to alleviate sewer flooding problems to properties on their 'at risk register', with priority being given to more frequent property internal flooding problems. AW prioritises this programme of work on the basis of customers' willingness to pay and cost benefit analysis; the benefits to customers must be greater than the whole life cost of the scheme.

1.3.4 Essex and Suffolk Water

Essex and Suffolk Water is responsible for maintaining, improving and extending the water mains and other pipes under Section 37(1)(b) of the Water Industry Act 1991. If a water main bursts, it is Essex and Suffolk Waters responsibility to managing and repair this as the water undertaker.

[iv] Highways Act 1980: http://www.legislation.gov.uk/ukpga/1980/66/contents
[v] Civil Contingencies Act 2004: http://www.legislation.gov.uk/ukpga/2004/36/pdfs/ukpga_20040036_en.pdf
[vi] Main Rivers are watercourses shown on the statutory main river maps held by the Environment Agency, the Department of Environment, Food and Rural Affairs (in England) and the Welsh Assembly Government (in Wales). They can include any structure or appliance for controlling or regulating the flow of water into, in or out of the channel.
[vii] Water Resources Act (1991): http://www.legislation.gov.uk/ukpga/1991/57/contents
[viii] Water Industry Act (1991): http://www.legislation.gov.uk/ukpga/1991/56

1.3.5 Riparian Owners

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

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

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

1.3.6 Local Residents

Residents who are aware that they are at risk of flooding should have a responsibility to take action to ensure that they and their properties are protected.

Residents should report flooding incidents or potential problems (such as blockages) to the LLFA or appropriate organisation if known.

1.4 Consultation

Investigation of the flooding at Southend-on-Sea on 24th August 2013 has been undertaken in consultation with the key stakeholders and RMAs.

An initial meeting was held with the SBC Flood Group on 28th August 2013. Meetings were held with the EA and AW on 23rd September 2013, 9th October 2013, 31st January 2014 and 7th February 2014 to discuss the Flood Incident Report and asset ownership. In addition, the Multi Agency De-brief held on 27th September 2013 provided a valuable overview of flooding and Agency Responses within the Essex Region.

The EA and AW have provided information on flooding records obtained through their organisations as well as clarification of their response procedures and asset locations.

1.5 Site Description

SBC is located to the south of Essex and is bordered by the neighbouring boroughs of Castle Point to the west, and Rochford to the north. The Thames Estuary is to the south of the borough.

The borough is heavily urbanised with dense residential and commercial development.

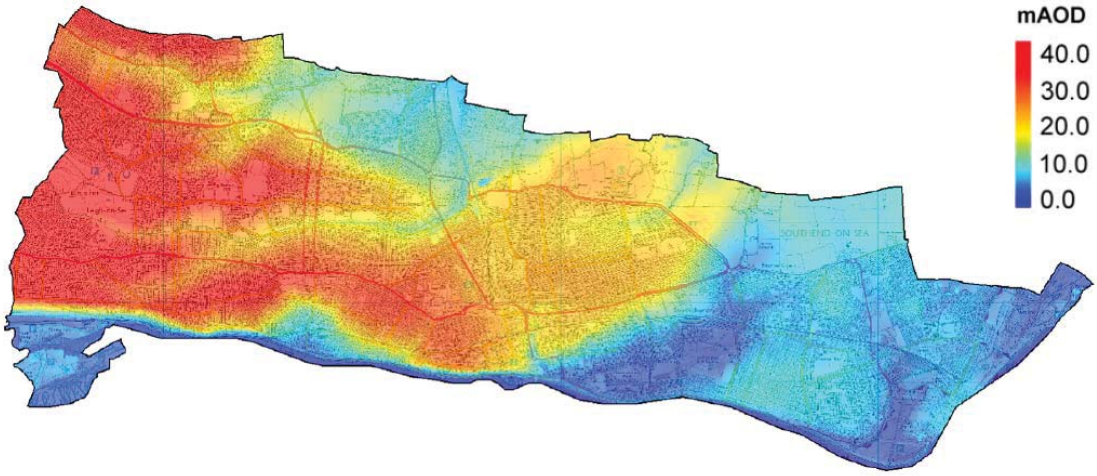
The topography of the borough can be seen in Figure 1-1. Elevations are approximately 45mAOD in the west of the borough decreasing to approximately 7mAOD in Shoeburyness in the east of the study area. The borough is bisected by a number of river channels which form valleys across the borough. These are most notably associated with Eastwood Brook and Prittle Brook to the west of the borough, which drain in a northerly direction towards Rochford. The southern boundary of the borough has steep slopes where the elevation falls from approximately 40mAOD to 4mAOD towards the coast.

[ix] Land Drainage Act (1991): http://www.legislation.gov.uk/ukpga/1991/59/contents
[x] Environment Agency (2012) Living on the edge – A guide to your rights and responsibilities of riverside ownership. http://www.environment-agency.gov.uk/homeandleisure/floods/31626.aspx

There are a number of Main Rivers and ordinary watercourses within Southend-on-Sea, these are plotted in Figure 1-2 along with the associated EA fluvial flood zones.

The bedrock geology is predominantly London Clay, with the superficial geology of River Terrace Deposits overlying the bedrock in the east of the borough and along the river channels of the Eastwood Brook and Prittle Brook. Around Shoebury and Southchurch there are superficial deposits of Tidal Flat Deposits overlying the bedrock.

Figure 1-1: Topography of Southend-on-Sea (extracted from the SBC Surface Water Management Plan)



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Legend

- Southend-on-Sea Borough Extent
- Flood Zone 3
- Flood Zone 2
- Flood storage areas
- Areas benefiting from flood defences
- Defences

Watercourses

- Main River
- Ordinary Watercourse
- Offline drainage ditch

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Scale at A3	Date	Drawn by	Approved by
1:50,000	Oct 2014	DS	EG

Rivers and Flood Zones

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Figure 1-2

Version 3

2 FLOOD INCIDENT DETAILS

2.1 Overview

Southend-on-Sea was subject to a significant flooding event on 24th August 2013 principally as the result of heavy rainfall coinciding with a spring tide[xi]. The following section details the conditions leading up to the flood event and the resulting impacts.

2.2 Weather Warnings and Flood Alerts

The Flood Forecasting Centre issue a flood guidance statement to all category one emergency responders (under the Civil Contingencies Act, 2004) twice a day. This update is intended to provide a weather forecast with an associated assessment of flood risk that is intended to inform any emergency response requirements. A yellow warning was issued on 23rd August 2013 and 24th August 2013, which correlates to a 'low likelihood of medium impacts' of flooding across the east of England. This indicated the possibility for surface water flooding and river flooding in small or urban catchments.

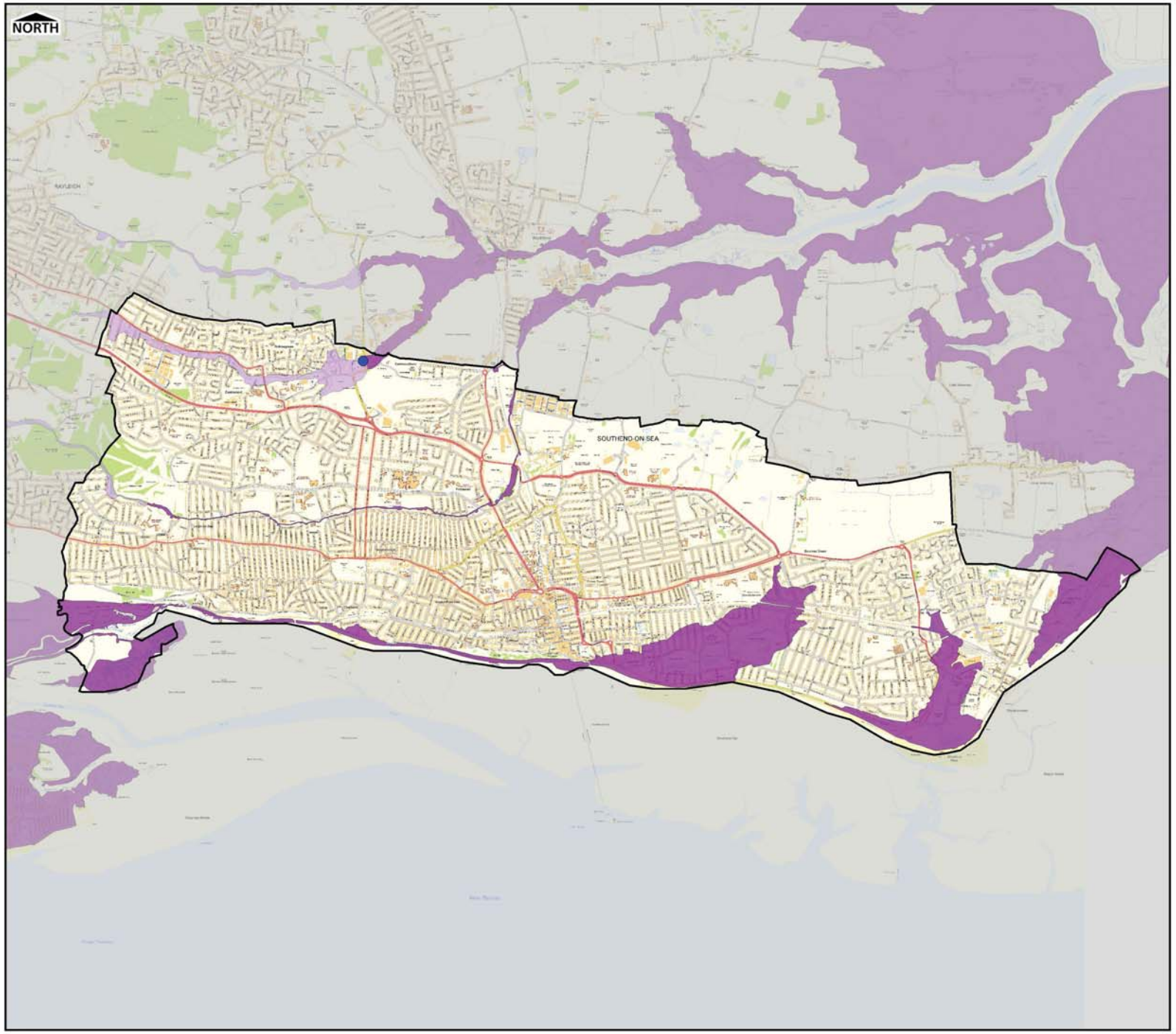
The Met Office forecast stated the potential for some heavy downpours which may lead to surface water flooding in places. The forecast indicated that 15 mm - 30 mm of rain would be likely, with the potential of 40 mm - 60 mm in places. The complex weather patterns present at the time resulted in a high level of uncertainty as to the precise location and magnitude of rainfall across the east of England.

The EA issued a series of flood alerts[xii] and flood warnings[xiii]. Figure 2-1 details the areas in which these warnings and alerts were issued. The following alerts and warnings were issued on the 24th August 2013:

- 09:34: Tidal flood alert (The Coast from St. Peter's Flat to Shoeburyness),
- 15:15: Flood alert (River Roach, Prittle Brook and Eastwood Brook at Southend),
- 16:00: Flood warning (River Roach, Prittle Brook and Eastwood Brook downstream Southend).

Tidal records indicate that the tide, recorded along the Essex Coast (from St Peters Flat to Shoeburyness) peaked at 14:52 at a level of 2.62mAOD.

[xi] Spring tides occur twice a month and result in more extreme tide levels. Spring tides are created when the sun, moon and earth are in alignment and the gravitational force is stronger. http://www.metoffice.gov.uk/learning/learn-about-the-weather/how-weather-works/tides/types-of-tides
[xii] Flood Alert: Flooding is possible. Be prepared.
[xiii] Flood Warning: Flooding is expected. Immediate action required.



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Legend

- Southend-on-Sea Borough Extent
- Flood Warning Area
- Flood Alert Only
- River Level Monitoring on Eastwood Brook

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Flood Investigation Report 24th August 2013

Scale at A3	Date	Drawn by	Approved by
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Environment Agency Flood Alert and Flood Warning Areas

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Figure 2-1

Version 2

2.3 Recorded Rainfall

The EA tipping bucket rain gauge located in Southchurch Park (Ordnance Survey National Grid Reference: 590000, 185000) recorded 58.8mm of rain to have fallen between 11:30 and 19:15 on 24th August 2013. Figure 2-2 shows the 15 minute rainfall data recorded by the Southchurch Park rain gauge. At the peak rainfall intensity, 54.8mm of rain fell within 4 hours (11:30 – 15:30).

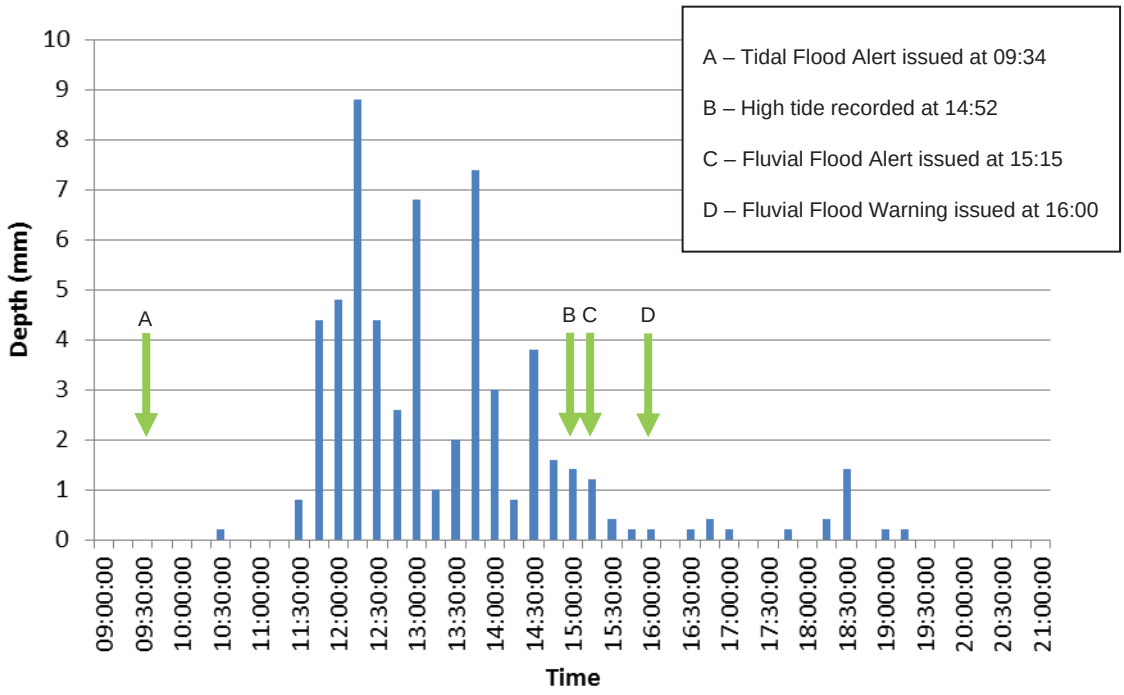
By comparison, the average monthly rainfall[xiv] for this area in August is 44.5mm.

Analysis of the rainfall at neighbouring rain gauges indicates that it is likely that the storm event passed across the borough in a north easterly direction and was focused within a narrow region across the south of Essex and Southend-on-Sea.

The Flood Estimation Handbook (FEH) CD-ROM (version 3) has been used to determine the corresponding likelihood of probability for this rainfall event. Based on the rainfall at its peak intensity the event return period is estimated to be between a 3.3% Annual Exceedance Probability (AEP) (1 in 30) and 2% AEP (1 in 50) chance of occurring in any given year. Further details are provided in Appendix A.

It should be noted that the spatial distribution and intensity of rainfall in such events is highly variable, therefore the rainfall recorded at this location may not be wholly representative of the magnitude of the event elsewhere across Southend-on-Sea.

Figure 2-2: 15 minute rainfall recorded at Southchurch Park on the 24th August 2013



2.4 Flood Records

Records of flooding relating to this incident have been gathered from a number of organisations. The records have been complied into one database which is currently held and

[xiv] Met Office Average Tables Shoeburyness Climate Period 1981 – 2010 http://www.metoffice.gov.uk/public/weather/climate/u10t0nxqf

managed by the SBC Emergency Planning officer. Many of the records were gathered at the time of the flood event; however a large number of flooding incidents were also reported following the event. It is likely that many flooding incidents have not have been recorded.

Records have been gathered from the following organisations and SBC departments:

- SBC Care Team,
- SBC Parks,
- SBC Out of Hours,
- SBC Council Tax,
- SBC Emergency Planning,
- SBC Asset Management,
- SBC Council Members,
- Essex County Fire and Rescue,
- Essex Police,
- EA,
- AW,
- Members of Parliament.

Figure 2-3 shows the location of flood records across Southend-on-Sea. Across the borough, the records of flooding can be summarised as follows:

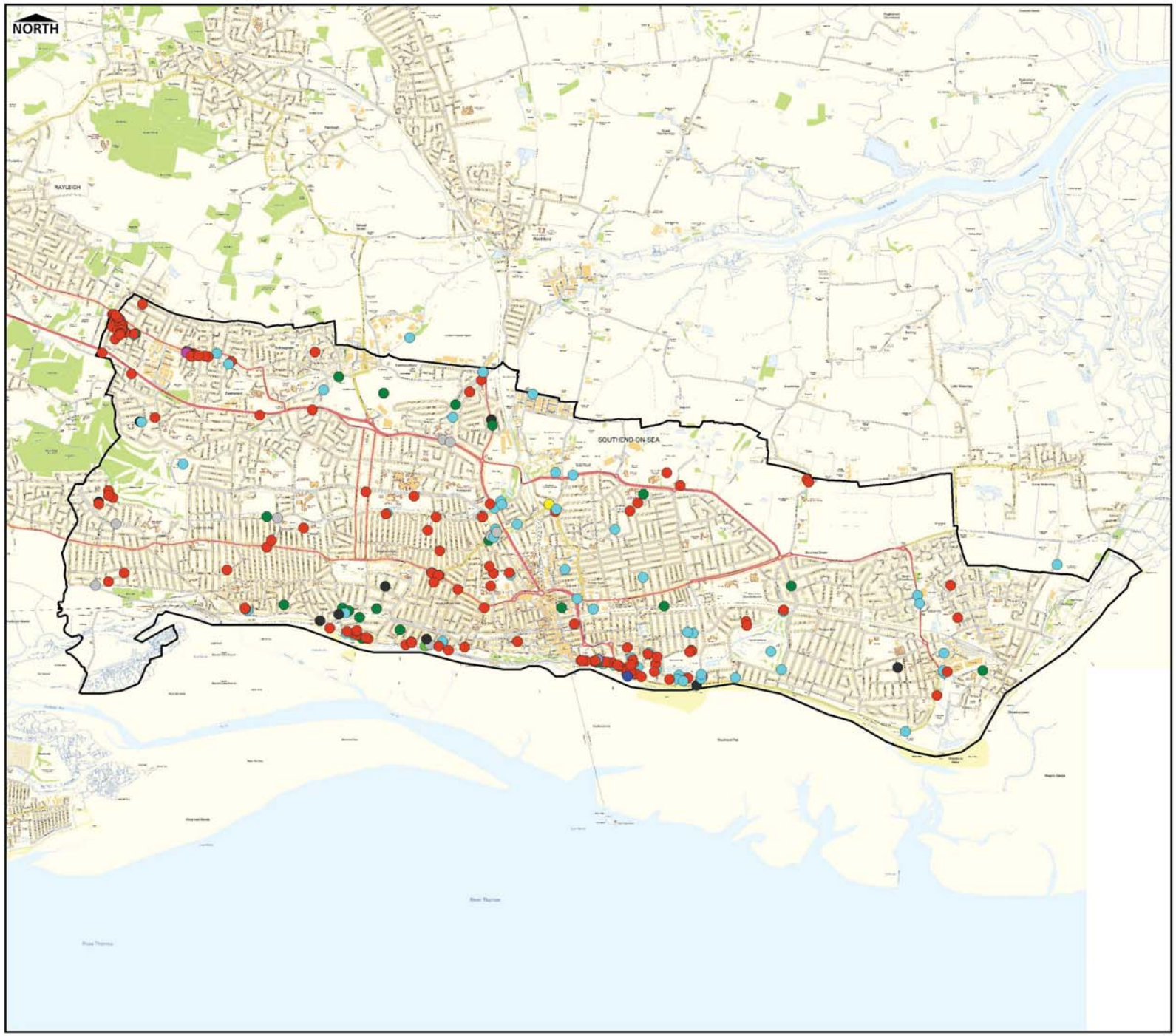
- A total of 255 incidents,
- 151 properties flooded internally, of which 3 were evacuated (including residents of sheltered accommodation),
- 61 incidents of flooding (not of properties),
- 20 records of missing or lifted manhole covers,
- 9 records of carriageway damage,
- 1 pumping station failure,
- 1 landslip,
- 1 report of the smell of gas,
- 1 report of damage to a car park, and
- 10 incidents where there was no evidence of flooding upon further investigation.

There was considerable flooding of the main access roads as well as residential roads within Southend-on-Sea. In particular, flooding was observed along the A127 Prince Avenue, A1197 Manners Way, B1015 West Street, Marine Parade and Thorpe Hall Avenue.

The spatial distribution of the flood records highlights three main clusters of flooding incidents within the town, in the areas of:

- Eastwood,
- Eastern Esplanade and Marine Parade, and,
- Chalkwell Esplanade.

The likely flooding mechanisms across the borough and in each of these areas will be discussed further in the following chapters.



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Legend

Southend-on-Sea Borough Extent

Flood Records

- Property evacuated
- Property flooding
- Flooding
- Missing/displaced mahole cover
- Landslip
- Smell of gas
- Pumping station failure
- Carriageway and car park damage
- Incident not found

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Scale at A3	Date	Drawn by	Approved by
1:50,000	July 2014	DS	EG

Flood Records from the 24th of August 2013

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Figure 2-3

Version 1

3 LIKELY CAUSES OF FLOODING

3.1 Overview

An assessment of the EA Flood Zones[xv] and mapping showing the Flood Risk from Surface Water[xvi] have been completed to develop an understanding of the mechanisms of flooding resulting from the rainfall on 24th August 2013. This, in conjunction with the records of flooding, has highlighted three main flooding mechanisms each of which is discussed in the following sections.

3.2 Fluvial and Surface Water Interactions

There are a number of locations where the flooding on 24th August 2013 can primarily be attributed to the combined effect of fluvial and surface water flooding.

As described in section 1.3, the topography of the borough is largely defined by the presence of rivers and the associated river valleys. Surface water runoff in these areas, will therefore tend towards the lowest point which coincides with the river channels. The effect of this can be seen in the Flood Risk from Surface Water mapping.

The watercourses within the borough have a very 'flashy' response to rainfall events, with a rapid rise and fall in water levels following rainfall. Of the rivers within Southend-on-Sea, as shown in Figure 1.2, the Eastwood Brook, Prittle Brook and C-X Ditch were observed to flood due to exceedance of their channel capacity. As the river levels respond rapidly to rainfall, the peak river levels are likely to occur soon after, if not at the same time as, the rainfall and the peak of the surface water runoff. This results in large volumes of water flooding low lying areas across the borough.

Evaluation of the flooding records suggests that incidents within the corridor of Eastwood Brook and C-X Ditch are a result of these combined sources of flooding. The mechanisms of flooding around Eastwood Brook area are discussed in further detail in Section 4. The Prittle Brook appeared to flood within Priory Park, with water backing up on Victoria Avenue.

Photograph 3-1 and Photograph 3-2 below illustrate the extent of flooding associated with the Barge Pier Ditch as it flows from the north towards Gunners Park.

[xv] Environment Agency (2014) Flood Map for Planning (Rivers and Sea http://maps.environment-agency.gov.uk/wiyby/wiybyController?ep=maptopics&lang=_e
[xvi] Environment Agency (2014) Risk of Flooding from Surface Water http://watermaps.environment-agency.gov.uk/wiyby/wiyby.aspx?&topic=ufmfsw#x=357683&y=355134&scale=2

Flooding adjacent to the Barge Pier Ditch at Jena Close and Campfield Road (Photographs provided by residents)

3.3 Surface Water and Sewer Flooding

Within the borough, there are a number of areas of low lying land that are not associated with river channels. These are mainly the areas of the sea front and Shoebury in the south and Eastwood in the north. In these areas, the topography is low in relation to the rest of the catchment area; resulting in the tendency for surface water to flow towards, and accumulate, in these areas.

There are three surface water pumping stations within the borough which function to pump surface water to the Thames Estuary against high tide levels. These are the Chalkwell Pumping Station, Eastern Esplanade Pumping Station and Lifstan Way Pumping Station.

The majority of the surface water drainage outlets across the borough are drained by gravity. These therefore follow the local topography, ultimately ending up in the lowest parts of the borough (i.e. towards the north or south). Where the capacity of the sewer networks is exceeded, flooding can result from either the inability to drain water away, or the surcharging of water levels within the sewer system which can lead to water emerging from road gullies and manholes.

In addition, the gravity drained surface water network within the south of the borough is thought to have been tide locked (on 24th August 2013) as a result of the high spring tide reaching its peak shortly after the peak of the rainfall event. Surface water in this area would therefore not have been able to drain freely, resulting in rainfall runoff from the catchment rapidly filling up in the surface water sewer network. The most notable effect of this is found along the sea front, where there is a rapid decline in the topography from the north. Chapter 5 and Chapter 6 discuss the flooding in this area in further detail.

Flooding incidents along Rochford Road can similarly be attributed to this mechanism. Examination of the AW network indicates there to be a large surface water sewer that runs in a northerly direction along the southern part of Rochford Road, before passing between the houses of Rochford Road and Alton Gardens. A combined storm sewer overflow discharges into the large surface water sewer, approximately half way along Rochford Road. The large surface water sewer ultimately discharges to a section of ordinary watercourse beyond the Manners Way roundabout, which is a tributary of Prittle Brook. Flooding within this area is likely to have been the result of capacity issues with this part of the sewer network. Records of lifted or lost manhole covers along Rochford Way and Manners Way are evidence of surcharging of the surface water sewers. The carriageway damage along Prince Avenue is

more likely to have been due to surface water runoff not been able to drain from the area as the sewer network was surcharged and unable to take this water.

3.4 Surface Water Flooding as a Result of Local Features

There are a number of points across the borough, where resulting flooding cannot be attributed to either of the above mechanisms. An initial examination of these locations indicates that these may have occurred as a result of blocked road gullies or local features within the topography that will have influenced the flow and ponding of surface water. Examples include a local depression of ground levels toward a property, footpaths at low elevation compared to the road levels that allow surface water to flow more easily from the roads into adjacent properties.

There are three records of property flooding within the Leigh-on-Sea area to the west of the borough. Examination of the topography shows a shallow depression in the land running across the area in a north easterly direction. The flooding of these properties was most likely due to the tendency for surface water to pond in these areas. A similar local variation in topography around the Temple Sutton area is present, potentially resulting in the flood incidents within this area.

There are records of flooding to areas adjacent to the railway line (the London to Shoeburyness line) that runs through the borough. The railway line is elevated at a number of locations along its route through Southend. The presence of the raised embankments could cause surface water runoff to either flow down the embankments, or cause water to pond behind the embankments where an overland flow path is obstructed. In both instances, this would result in the ponding of surface water at the foot of the embankments.

Within the Westcliff-on-Sea area, there are a number of property flood records. These occur in an area of relatively high topography, suggesting that flooding may have resulted from local obstructions to flow and from ponding within low areas.

Other isolated records of flooding are likely to be due to the local variations in topography and presence of urban structures. It is recommended that SBC follow up with residents affected by flooding with a questionnaire to gather additional information, determine any remaining risks and advise on potential property protection measures.

4 EASTWOOD

4.1 Overview

Eastwood is located in the west of the borough and the topography of the area is dominated by the valley and river channel associated with Eastwood Brook.

Eastwood Brook is a tributary of the River Roach that originates at Rayleigh Weir in Castle Point to the west of the borough. The river flows across Southend-on-Sea in a north easterly direction, parallel to Rayleigh Road, before joining the River Roach. Figure 4-1 provides an overview of the watercourses and associated structures along its length within this area. There are two tributaries to Eastwood Brook within Southend-on-Sea. The first is an ordinary watercourse that flows from Pound Wood and joins Eastwood Brook behind Glenwood Avenue along the boundary of the SBC administrative area. The second is classified as a Main River and joins Eastwood Brook behind Whitehouse Road. The upper section of this tributary is considered to be ordinary watercourse.

Eastwood Brook is heavily modified and flows through numerous culverted sections through the residential area of Eastwood. The watercourse flows through a relatively steep urban catchment, so its response to rainfall will be rapid and there will be little warning of flooding. The EA currently monitors the water levels of Eastwood Brook once it passes under the B1013, just before leaving Southend-on-Sea. As can be seen previously in Figure 2-1, the Eastwood area upstream receives flood alerts, but flood warnings are not available.

There are a number of riparian owners along the length of Eastwood Brook. The riparian owner is responsible for the maintenance of the channel on his land and to ensure that flow is not obstructed. The EA have permissive powers to maintain the channel if necessary.

The Eastwood Brook enters the borough to the west of Glenwood Avenue, at which point a drainage ditch originating from Pound Wood in the south, runs in a northerly direction along the border of SBC and joins Eastwood Brook to the west of Glenwood Avenue. The Brook is culverted for a section of 280m as it passes underneath the properties of Glenwood Avenue, before emerging to the east of Grovewood Avenue. A trash screen is located at the head of this section of culvert watercourse. The trash screen, as well as the culverted section of the watercourse, now falls under the responsibility of AW; however, at the time of the flood event in 2013, the trash screen was the responsibility of the EA.

The AW sewer network within the Eastwood area is predominantly separate i.e. foul and surface water are drained separately. Examination of the public surface water sewer network (shown in Figure 4.1) shows that there are a number of surface water drains that discharge to Eastwood Brook. Should water levels of the river rise above the drainage outlets, surface water would back up into the drainage network increasing the risk of surcharging and reducing the drainage conveyance capacity.

The Flood Risk from Surface Water mapping (Figure 4-2) shows a tendency for surface water flooding to occur along the length of the river channel within the Eastwood area. This is largely a result of the topography of the area channelling overland flow towards the lower lying river. Localised surface water flooding is also expected within a heavily urbanised environment due to the presence of structures that influence the flow of water. Recorded Flooding

As can be seen in Figure 2-2, there are two predominant clusters of flood records within the Eastwood area. The first of these is in the very west of the borough around Glenwood Avenue, Grovewood Avenue and Belgrave Road. The second cluster is further to the east along Eastwood Brook adjacent to Rayleigh Road. In both clusters, the majority of the flood records

are associated with properties adjacent to the Eastwood Brook and its tributary. It should be noted that flooding may have occurred elsewhere within the area that has not been recorded.

Within the Eastwood area there are 55 records of flooding, 48 of these are of internal property flooding including 2 properties that needed to be evacuated. The 2 evacuated properties provided sheltered accommodation. In addition, there is one record of a lifted manhole cover along Belgrave Road in close proximity to Eastwood Brook.

Flooding within the areas adjacent to Eastwood Brook was extreme and highly hazardous. Photographs taken at the time by residents suggest that water reached a depth of approximately 0.8 – 0.9m (almost covering the bonnet of a small car).

The severity of the flooding was of most concern in the area around Rayleigh Road, where Clyst Court, a residential property providing sheltered accommodation, flooded. Clyst Court is located approximately 150m from Eastwood Brook. The lower ground floor level of Clyst Court has finished floor levels below that of the adjacent Eastwood Brook channel. As the water levels of Eastwood Brook overtopped the channel bank and continued to rise, water accumulated behind the patio doors that provided access to these lower ground flats. In this instance, there were no injuries or fatalities as neighbours were able to evacuate the three elderly residents before the pressure of the flood water overwhelmed the patio doors. The flood depth within these flats reached approximately 1.5m and resulted in extensive damage.

In the vicinity of this property, neighbouring buildings were also cut off from the access road by the flood waters from Eastwood Brook. The access road became impassable to vehicles and access to these properties was only possible by boats deployed by Essex Fire and Rescue.

The Essex Fire and Rescue Service Log noted flooding at one property was not pumped away as there was nowhere to pump the water to as the river was full, i.e. there was nowhere to safely pump the water to.

Photograph 4-1 and Photograph 4-2 show examples of flooding within the Eastwood area.

It should be noted that Photograph 4-2 is of flooding within the corridors of Nestuda House which provides sheltered accommodation. The 16 residents of this property were evacuated.

External and internal flooding of properties within the Eastwood area (Photographs provided by residents)

4.2 Likely Causes

The principal cause of flooding within the Eastwood area is a combination of fluvial flooding from Eastwood Brook and surface water flooding resulting from the steep topography and heavily urbanised catchment. The analysis of the flow hydrographs shows that the rivers respond very quickly to rainfall events.

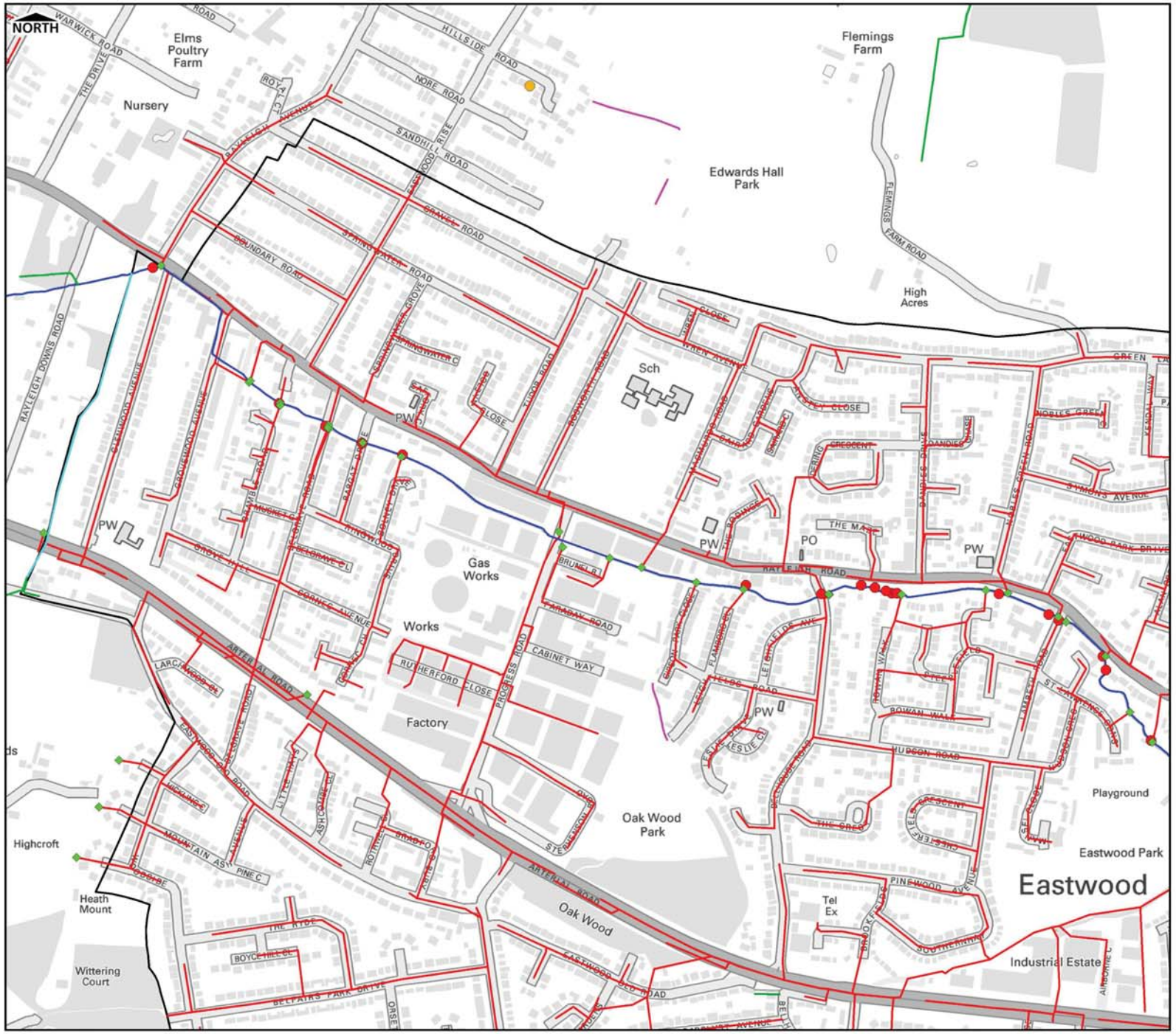
Fluvial flooding results when the volume of water flowing in a river exceeds the capacity of the river channel. The capacity of the watercourse is subject to a number of factors including channel width and the presence of structures above and around the watercourse. As Eastwood Brook passes through an urbanised area, there are a number of trash screens at the entrances to, culverts and service crossings within the channel along its length.

The presence of features such as trash screens could further enhance flooding upstream if they were to become blocked. The EA has confirmed that calls were received on 24th August 2013 from residents describing a potential blockage at the trash screen located to the west of Glenwood Avenue. Residents had undertaken some debris clearance on the morning of 24th August 2013 before this was taken over by EA Operatives who remained on site from approximately 13:30 until 23:00, ensuring the removal of debris accumulating at the trash screen. The EA has stated that this trash screen on Eastwood Brook remains predominantly clear from debris under normal flow conditions. Since this flooding event, the responsibility for the trash screen at Glenwood Avenue has been transferred to AW.

Upstream of Eastwood, the Eastwood Brook passes through the Borough of Castle Point. Following the review of the flooding event, it has been suggested that surface water from the Rayleigh Weir that had accumulated within the underpass of the Aerial Road (A127), was pumped to the Eastwood Brook during the flooding event. SBC are in the process of investigating this and will coordinate with the EA and ECC the impact of this discharge on the water levels downstream with the Eastwood area. The EA did not receive any other reports of operational failures or blockages on any of the other Main Rivers within SBC (that is Prittle Brook, Mucking Hall Brook, and Southchurch Park Watercourse). It is probable that flooding of these rivers can therefore be attributed to exceedance of channel capacity.

As described previously in section 3.3, in addition to fluvial flows, overland surface water runoff from the surrounding area would further exacerbate flooding within the low lying areas

associated with the river channel. There is one record of a displaced manhole cover in Belgrave Road. Examination of the AW sewer network location suggests that this is likely to be the result of the backing up of water from the Eastwood Brook into the surface water drainage network through the drainage outfall. As the surface water outfalls to the river are likely to have been restricted by high water levels, surface water would remain at the ground surface, being unable to discharge to the network.



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Legend

Watercourses

- Main River (Riparian Owner)
- Ordinary watercourse (Riparian Owner)
- Offline drainge ditch (Riparian Owner)
- Structures (Riparian Owners)
- Surface water sewers (Anglian Water)
- Surface water outfalls (Anglian Water)
- Pumping station (Anglian Water)
- SBC extent

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Flood Investigation Report 24th August 2013

Scale at A3	Date	Drawn by	Approved by
1:6,500	Sept 2014	DS	EG

Eastwood Rivers and Assets

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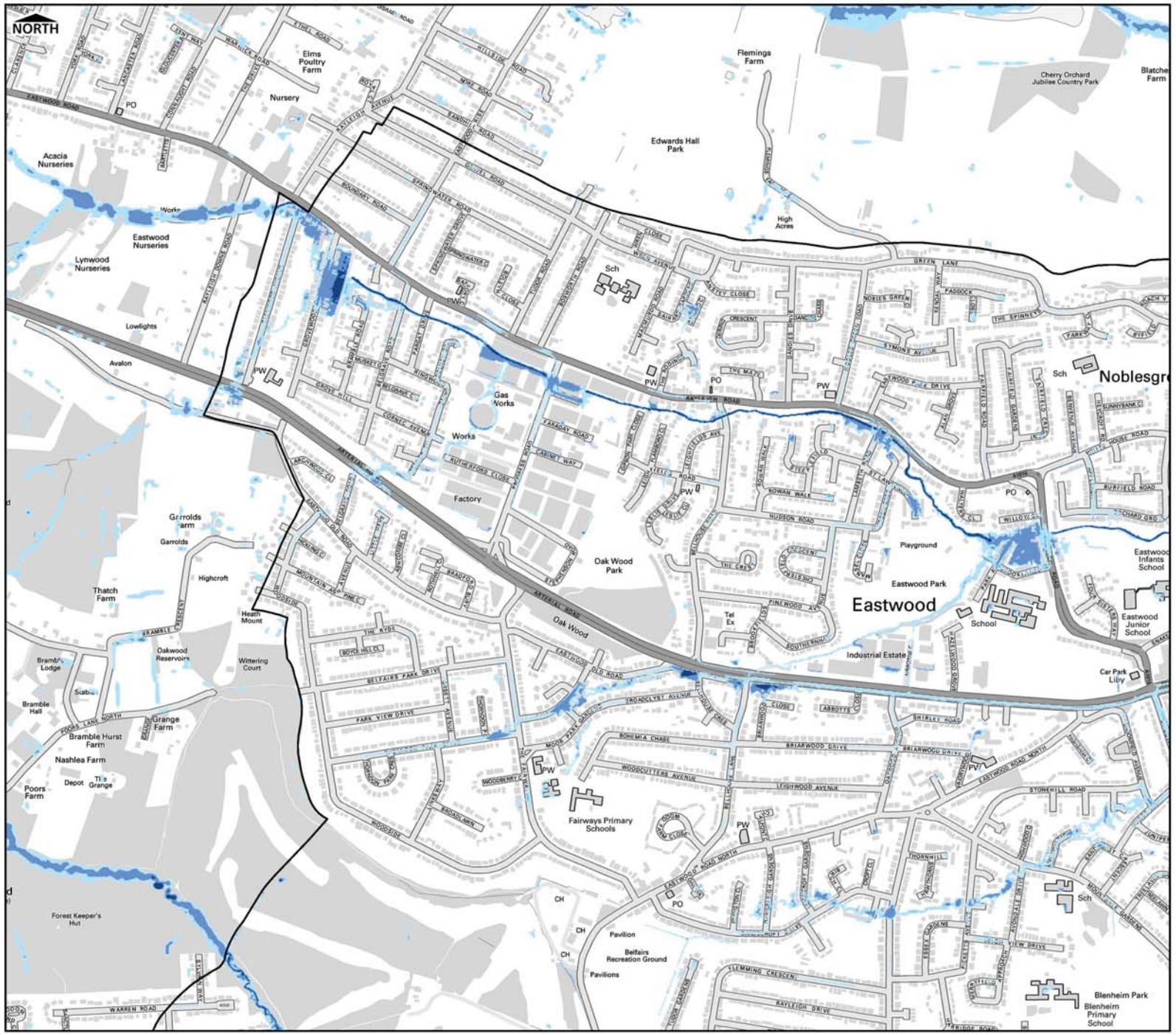
Figure 4-1

Version 2



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Legend

SBC extent

Flood Risk from Surface Water - Flood Depth (m)

- < 0.3m
- 0.3 - 0.9m
- > 0.9m

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Flood Investigation Report 24th August 2013

Scale at A3	Date	Drawn by	Approved by
1:10,000	Sept 2014	DS	EG

Eastwood - Flood Risk from Surface Water - Flood Depth 3.3% AEP (1 in 30 year event)

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Figure 4-2

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5 EASTERN ESPLANADE AND MARINE PARADE

5.1 Overview

Eastern Esplanade and Marine Parade are located along the southern boundary of the borough in areas of low lying topography. To the north of Marine Parade, the ground rises quite steeply with an approximate gradient of 1:2.5. The rise of the land to the north of the Eastern Esplanade is, however, more gentle. A bank runs diagonally across the borough, north of Eastern Esplanade, from Queensway at Marine Parade to Bournes Green with a slope of approximately 1:25.

As can be seen in Figure 5-1, to the north and east of Eastern Esplanade, there is a Main River (Willingale Brook) that flows through Thorpe Hall Golf Course in a south westerly direction towards a pond within Southchurch Park East. There is an overflow from the pond that discharges to the Thames Estuary, The Lifstan Way Pumping Station (operated by AW) functions to lift the water and discharge it during high tides.

The Boating Lake within Southchurch Park west can receive excess surface water via a pumped inflow. Water from the lake can in turn be discharged to the Thames Estuary via the Southchurch Park B Pumping Station located within the southern part of the park.

The Flood Risk from Surface Water mapping shows there to be the potential for flood depths of between 0.3m to 0.9m for a 3.3% AEP (1 in 30 year) rainfall event along Marine Parade, Eastern Esplanade and Southchurch Park areas, as shown in Figure 5-2. It should be noted that this modelling is of surface water only, and does not consider the function of the sewer networks or pumping stations.

5.2 Sewer Network

The sewer network in this area is older than that for most of the borough, and as a result, there is a complex network of combined sewers that are drained from the catchment through a series of pumping stations.

There are a number of AW assets that are used to manage storm overflows from the combined component of the sewer network. Firstly there is a storm water storage tank in the north western corner of Southchurch Park that was constructed in response to previous flooding events. Flows in this are managed by associated pumping stations that discharge storm water to the south of the borough.

There is a second combined sewer pumping station (Eastern Valley Pumping Station) within the area, this is located to the west of Victoria Road and is maintained and operated by AW. This pumps combined sewage to the Southend-on-Sea Sewage Treatment Works. Should it become overwhelmed during storm conditions, as happened during the 24th August event, the system overflows to a storage tank, which when full, discharges via a combined storm overflow to the sea.

Although the sewer network is generally combined, there are some areas that are served by a separate surface water sewer network. The surface water within these areas is predominantly gravity drained to outfalls to the Thames Estuary. AW records indicate that the surface water outfalls along Marine Parade and Eastern Esplanade are at beach level and tend to be below the mean high water level. This includes a 675mm diameter pipe that discharges below the Southend Pier. These outfalls are all fitted with tidal flap vales that ensure sea water cannot flow back up into the sewers. During high tides, these outfalls become tide locked, restricting the discharge of surface water into the sea, however the surface water network has capacity to retain some water within the system until the outfalls become available. In the event that the

flap valves fail (e.g. stuck open) sea water will enter the system and reduce the storage capacity within the network. When the capacity of the network is exceeded there is the risk flooding of surface water flooding from the sewer network.

Of these gravity drained outfalls, three discharge beyond the sea wall at Hartington Road. Prior to discharge, at the junction of Hartington Road with Sea Way and Lucy Road, four surface water pipes converge within one inspection chamber, before discharging via three outfalls. The inflowing sewers have diameters of between 225 mm and 1350 mm, and drain surface water runoff from a large part of the central area of SBC.

As part of the surface water sewer network, there are two pumping stations in this area that operate to pump surface water to the Thames Estuary. As can be seen in Figure 5-1, one of these is the Eastern Esplanade Pumping Station, located opposite the junction of the Eastern Esplanade and Burdett Road. The second is the Lifstan Way Pumping Station, to the east at the junction of Lifstan Way and the Eastern Esplanade. The Eastern Esplanade Pumping Station operates one pump which discharges surface water at a rate of approximately 750 l/s. The Lifstan Way Pumping Station has one pump that operates at approximately 800 l/s and discharges water from the pond within Southchurch Park East.

5.3 Recorded Flooding

Flooding within this area on 24th August 2013 received the majority of the media attention. Flooding incidents within this area were predominately located along Marine Parade and Eastern Esplanade. There were also a number of incidents along roads in the area of Southchurch Park. All of the flooding records are within the areas of low topography and at the foot of the sloping bank areas.

There are a total of 53 records within this area, 25 of which are of property flooding. One of these records accounts for the flooding of a basement property, which was evacuated in Hartington Road, as a result of overland flow from a nearby surcharging sewer (see Photograph 5-2 overleaf).

The Eastern Esplanade Pumping Station failed during the flooding event. AW has described how the failure was due to high floodwaters overwhelming the electrics of the pumping station. AW has commented that should their pumping station have remained operational, it would have lessened the impact of the flooding experienced, but due to the nature of the severe weather that day, flooding may still have been experienced due to backing up of surface water within the sewer network.

The most notable instance of flooding from the sewer network is around the Hartington Road area, where there is also a record of a lifted manhole cover. CCTV footage in this area shows water surcharging between 14:54 and 17:00 hours, shortly after the peak rainfall.

Photographs 5-1 to 5-4 below show examples of flooding within the Marine Parade and Eastern Esplanade area.

Photograph 5-1

Photograph 5-2

Flooding at Marine Parade and surcharging sewers at Hartington Road (Photographs provided by residents)

Photograph 5-3

Photograph 5-4

Flooding of residential streets adjacent to Marine Parade and the Eastern Esplanade (Photographs provided by residents)

5.4 Likely Cause of Flooding

Flooding in this area is likely to be as a result of surcharging sewer systems and surface water flooding from overland flow. The steep sloping topography of the area, especially around Marine Parade, would have allowed for considerable volumes of surface water to runoff the ground surface from the land to the north. In addition, surface water runoff is made worse as land is heavily urbanised with a large percentage of impermeable area.

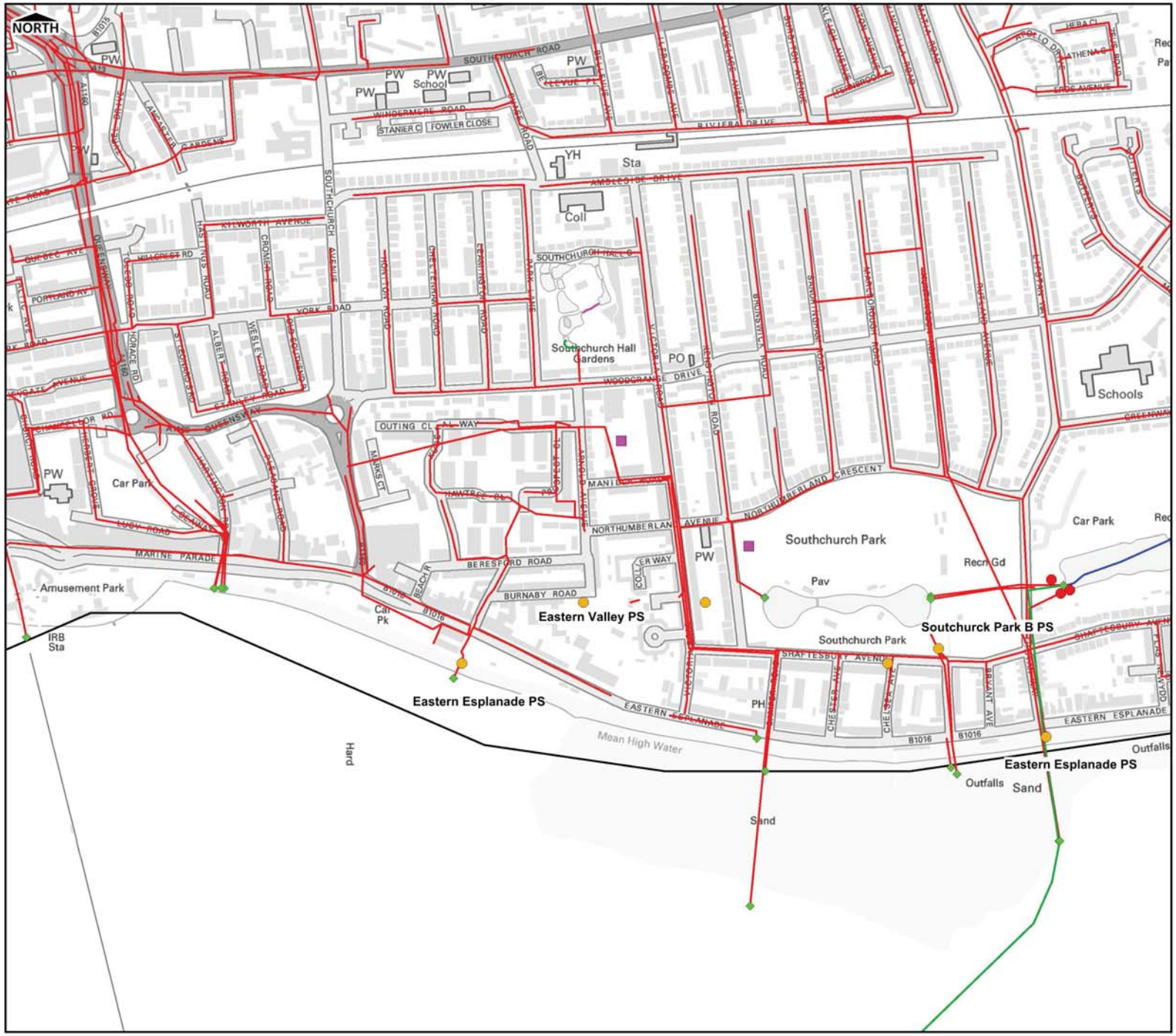
The failure of the Eastern Esplanade Pumping Station is likely to have resulted in the sewer network reaching its storage capacity at an accelerated rate, resulting in the surcharging of surface water sewers within the network drained by the pumping station.

As stated in Section 2, the peak rainfall recorded at Southchurch Park fell in a 4 hour period between 11:30 and 15:30. The peak tide level reached was 2.62mAOD at 14:52, coinciding closely with the end of the peak period of rainfall. The high tide within the Thames Estuary will

have caused the gravity drained surface water outfalls to become tide locked. Therefore surface water could not discharge to the estuary and remained within the network. Due to the intensity of rainfall and resulting volume of surface water runoff, the capacity of the network was exceeded, resulting in surcharging of sewers within the downstream part of the network.

With the exception of the Eastern Esplanade Pumping Station, all the surface water pumping stations operated as intended, discharging surface water against the tide.

The flooding at Hartington Road was caused by surcharging of the sewer network resulting in sewer flooding. Due to the high tide conditions, these sewers were not able to discharge, causing water to backup within the system. Surcharging at the manhole is most likely resulted from the culmination of high flows from the rest of the catchment overwhelming the sewer capacity. The flood waters from the sewer contributed to the flooding of Marine Parade and Hartington Road and the adjacent properties.



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Legend

Watercourses

- Main River (Riparian Owner)
- Ordinary watercourse (Riparian Owner)
- Offline drainge ditch (Riparian Owner)
- Structures (Riparian Owners)
- Surface water sewers (Anglian Water)
- Surface water outfalls (Anglian Water)
- Pumping station (Anglian Water)
- Storm overflow storage tank (AWS)

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Flood Investigation Report 24th August 2013

Scale at A3	Date	Drawn by	Approved by
1:6,500	Oct 2014	DS	EG

Eastern Esplanade & Marine Parade Assets

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Figure 5-1

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SBC extent

Flood Risk from Surface Water - Flood Depth (m)

- < 0.3m
- 0.3 - 0.9m
- > 0.9m

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Flood Investigation Report 24th August 2013

Scale at A3	Date	Drawn by	Approved by
1:10,000	Sept 2014	DS	EG

Eastern Esplanage & Marine Parade Flood Risk from Surface Water Flood Depth 3.3% AEP (1 in 30 year event)

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Figure 5-2

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6 CHALKWELL ESPLANADE

Chalkwell Esplanade is located to the west of Western Esplanade and runs along the southern extent of SBC. The cluster of flooding incidents in this area extends along the length of the Chalkwell Esplanade and the roads adjacent.

Chalkwell Esplanade is at a low point in the topography, with an elevation of approximately 4mAOD. The low lying land, predominantly along the coastline, extends inland in the Chalkwell area. To the north of the Chalkwell area, the land rises rapidly at a gradient of approximately 1:20 to a higher elevation of approximately 40mAOD. The Flood Risk from Surface Water mapping shown in Figure 6-1 detail the potential for surface water flooding in this location for a 3.3% AEP event (1 in 30 years).

The Prittle Brook Flood Relief Channel discharges to the Thames Estuary at the west end of Chalkwell Esplanade. The EA has confirmed that the flood relief channel was operating as expected during the flooding event.

The sewer network within this area is largely combined; therefore it drains both foul and surface water sewage. There is a large storm overflow storage pipe that runs from Cliff Parade along the sea front and up to the Western Valley Pumping Station. This functions to temporarily store stormwater overflow when the sewer network is at capacity. Floodwaters are pumped from the storm relief sewer via the Western Valley Pumping Station to the Southend-on-Sea sewage treatment works to the north west.

Chalkwell Pumping Station, located at the eastern end of Chalkwell Esplanade, functions to pump surface water into the Thames Estuary. The pumping station receives overflows from 5 large pipes draining from Chalkwell Esplanade and Chalkwell Avenue. These pipes draining to the pumping station have diameters ranging from 375mm to 1050mm. The Chalkwell PS discharges surface water at a rate of 800l/s. This pumping station experienced flooding, however, remained operational during the flooding event. The AW surface water sewer assets can be seen in Figure 6-2.

In addition, there are another 5 gravity drained surface water outfalls that discharge surface water at a level of approximately 300mm (1 foot) above beach level, below the mean high water level. As these outfalls are gravity drained, and are fitted with flap valves, they would become tide locked at high tide, therefore restricting the discharge of surface water over this stage of tidal cycle. Should the tidal flap valves fail and remained open, sea water would back up within the network, significantly reducing their capacity to retain surface water drainage. This component of the surface water drainage network is not connected to the storm relief network described above. Surface water would therefore accumulate within the piped network and when the capacity is reached, this would surcharge from the manholes located along the length of the sewers.

6.1 Recorded Flooding

The area of flooding is focused mainly along the Chalkwell Esplanade; however there are also a number of records to the north of the area. There were 30 records of flooding on 24th August 2013. Of these records, 14 are associated with flooding of properties. A landslip was recorded on the slope to the south of Clifton Drive.

A large number of records also indicate flooding of the roads from surcharging sewers as there were 6 incidents of missing or lifted manhole covers. These are distributed across the Chalkwell area indicating widespread sewer flooding.

6.2 Likely Cause

The predominate cause of flooding within this area is associated with the low lying nature of the land in relation to the land to the north, and the presence of a relatively steep slope surrounding the area. As the land to the north is heavily urbanised, the large impermeable surface area is likely to exacerbate surface water runoff, resulting in surface water flooding to the south.

The drainage network also appears to have been overwhelmed within local areas. Water surcharging from the sewers would have increased the extent of flooding in the low lying Chalkwell area.

The cause of the landslip to the south of Clifton Drive is potentially as a result of unstable ground resulting from the saturation of the soils. It is recommended that SBC undertake an investigation into the localised geology and slope stability.

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Legend

- SBC extent

Flood Risk from Surface Water - Flood Depth (m)

- < 0.3m
- 0.3 - 0.9m
- > 0.9m

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Flood Investigation Report 24th August 2013

Scale at A3	Date	Drawn by	Approved by
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Chalkwell - Flood Risk from Surface Water - Flood Depth 3.3% AEP (1 in 30 year event)

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Figure 6-1

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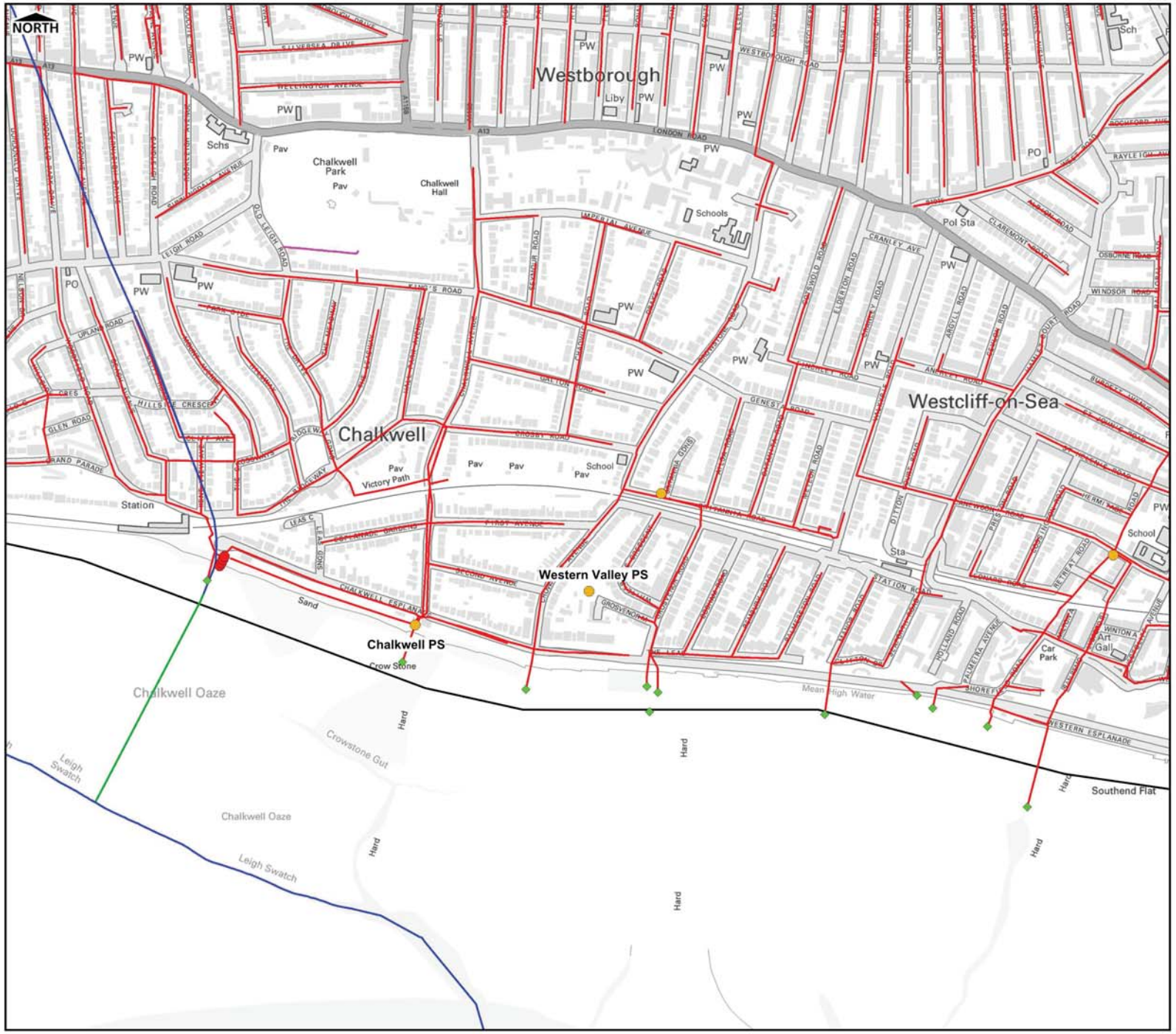

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Legend

Watercourses
- Main River (Riparian Owner)
- Ordinary watercourse (Riparian Owner)
- Offline drainge ditch (Riparian Owner)
- Structures (Riparian Owners)
- Surface water sewers (Anglian Water)
- Surface water outfalls (Anglian Water)
- Pumping station (Anglian Water)
- SBC extent

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Flood Investigation Report 24th August 2013

Scale at A3	Date	Drawn by	Approved by
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Chalkwell rivers and assets

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Figure 6-2

Version 2

7 FLOOD INVESTIGATION OUTCOMES

7.1 Overview

This section aims to outline a summary of the actions and proposed responses for each of the RMAs that operate within the SBC area.

7.2 Southend-on-Sea Borough Council

7.2.1 Summary of Actions Taken to Date

As described in Section 2.4, several departments within SBC were involved with the response to flooding within Southend-on-Sea.

As the event occurred on a Saturday, the majority of the direct response was completed by the SBC Environmental Care Team, which operated on a reactive basis to calls from the public. Over the Saturday and Sunday, 50 operatives were involved in SBCs response.

Additionally the Emergency Planner, Housing Officer, Social Care Officer, Environmental Health Officer and South Essex Home Group were involved in the response. This consisted mainly of evacuating residents where required and assistance with recovery following the event.

Since the flooding event, a number of actions have been completed, including, but not limited to:

- Maintenance of ordinary watercourses for which SBC are riparian owners;
- Installation of additional road gullies and linear drains in areas prone to flooding;
- Remedial works to gullies blocked or obstructed;
- Coordinate the investigation into the function of pumping stations upstream of the Eastwood Brook at the Rayleigh Weir within Castle Point with ECC and the EA;
- Notices served, as required, to riparian owners regarding maintenance of drainage ditches and ordinary watercourses; and,
- Drainage improvement works implemented within the area of Marine Parade.

7.2.2 Proposed Actions in Response to the Flooding Incident

Discussions with SBC have highlighted the following actions to be completed as a result of the flooding event:

LLFA responsibilities:

As the LLFA for Southend-on-Sea, SBC should publish the results of this Flood Investigation Report and notify the relevant RMAs and stakeholders.

SBC are coordinating with AW, the EA and riparian owners to further investigate causes of flooding and potential mitigation measures. Areas where this will initially be undertaken include, but are not limited to:

- Western Esplanade: investigation into the case of the land slip and mitigation measures;

- Main River and ordinary watercourses: continue determination of the ownership of assets along these sections of watercourse; and,
- Ordinary watercourses: develop a program for inspection of ordinary watercourse conditions and notify riparian owners of responsibilities where necessary.

Emergency response procedures:

SBC should utilise information on surface water flood risk presented in the Flood Risk from Surface Water mapping, as well as records of flooding, to assist with the review of emergency response procedures. Existing flood risk information along with information of vulnerable populations should be incorporated into the Multi-Agency Flood Plan and be disseminated to the relevant emergency responders.

WaterRIDE software has been purchased and utilised to inform Emergency Planning. Additionally, details of basement properties, which are considered to be more vulnerable to flooding, have been incorporated into the councils Emergency Planning datasets.

Responsibilities as Riparian Owners:

SBC, along with the EA and AW have actively sought to clarify ownership and responsibility of flood risk assets within Southend-on-Sea as part of the Councils responsibility as an LLFA (Section 21 of the FWMA).

This process has identified a number of assets that are owned by SBC. SBC should undertake a review of their existing maintenance schedule to include these assets. This should be implemented to ensure that the structures and watercourses, owned by SBC, do not obstruct flow and cause a potential risk to neighbouring properties.

As a riparian owner, SBC should undertake frequent maintenance and visual inspections of watercourses under their responsibility. This will ensure that flows within the ordinary watercourses are maintained as required.

Public engagement:

As well as notifying residents of the publication of this Flood Investigation Report, SBC should work with the EA and AW to provide residents with necessary information about flooding and how they can best protect their properties. Appendix B outlines a range of property level measures which may be appropriate for installation by residents.

SBC and the EA should work to engage with and inform all riparian owners of their responsibilities. Where riparian owners have not undertaken necessary measures to manage the flow of watercourse through their land, SBC should serve a notice under Section 28 of the Land Drainage Act.

7.3 Highways Authority (Southend-on-Sea Borough Council)

7.3.1 Summary of Actions Taken to Date

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

SBC Highways department operate bi-annual cycle of gully clearing and maintenance across the borough. In addition, the council will respond to any reports of blocked or damaged gullies

and highways drains as required. The clearing frequency will be reviewed to consider the more frequent clearing in flood prone roads.

Roadside drainage ditches that manage highway flooding are logged as part of the Councils Asset Register. The Asset Register provides details of the condition of these assets and should be used to inform the schedule of maintenance.

7.3.2 Proposed Actions in Response to the Flooding Incident

In light of the recent flooding events, SBC should review the Flood Risk from Surface Water mapping to identify where areas of highway are more susceptible to surface water flooding. Any areas that are identified should be incorporated into the maintenance schedule highlighting the need for frequent maintenance, especially during the autumn season when leaf debris is at its greatest.

7.4 Environment Agency

7.4.1 Summary of Actions Taken to Date

The EA has a standard operational procedure for response following the issue of a flood alert and flood warning. This initially involves the assurance of available personnel and resources to manage a potential flood event. “River runs” inspections are also undertaken to assess the condition of the Main Rivers and check that river flow is unimpeded. During the flood event, operatives attend known areas of increased flood risk, to check that assets e.g. culvert trash screens remain clear. Additionally, the EA opens an incident room to assist with the management of phone calls from members of the public.

During the flood event on 24th August 2013, the EA responded to calls from local residents to the blockage of the trash screen on the Eastwood Brook at Glenwood Avenue. The EA response involved their operatives removing debris from the trash screen throughout the duration of the event (from approximately 13:30 to 23:00). The EA received no additional reports of operational failures or flooding for any river within the SBC area.

The EA undertakes grass control and blockage removal maintenance on an annual basis along the length of the Main Rivers across the SBC area. As part of the blockage removal maintenance, the trash screens in the SBC area were scheduled for clearance on the weekend of 24th August 2013. Since the event on 24th August 2013, the EA has received a number of reports of debris within the main channels of Prittle Brook and Eastwood Brook. These have been cleared where found necessary.

7.4.2 Proposed Actions in Response to the Flooding Incident

The EA is looking into the installation of a flow gauging station to the west of Dawes Heath Road, along Eastwood Brook, upstream of Southend-on-Sea. This would be used to provide flood alerts and flood warnings to the area downstream, including Eastwood. The EA is working with Rochford District Council with the development of this scheme. It is anticipated to take up to 2 years to develop the gauging station.

The EA proposes to commence an investigation into the existing fluvial flood risk to people and property along sections of Eastwood Brook and Prittle Brook in 2015. However this is dependent upon securing the necessary funding. The EA will know if this is possible by February 2015 and propose to develop this project in conjunction with SBC, other risk management authorities and the local community.

The EA has undertaken discussions with SBC to determine the ownership and responsibility of assets located along the Main Rivers in the borough.

7.5 Anglian Water

7.5.1 Summary of Actions Taken to Date

AW is the sewerage undertaker for the SBC area and is responsible for maintaining the public sewerage network.

During the event of 24th August 2013, AW had staff available to respond to calls and flooding incidents in the area to the south of Chelmsford. When required, AW staff attended the flooding incident. Should further attendance have been required, this would have been provided.

AW outline that during the event, their assets were operating normally, with the exception of the Eastern Esplanade Pumping Station. As described in Section 5.3, this failed as a result of flood water inundating the electrical control panels, causing a loss of power.

7.5.2 Proposed Actions in Response to the Flooding Incident

Since the flooding event, the pump and control panel in the Eastern Esplanade Pumping Station has been replaced by AW. Mitigation measures have been implemented to reduce the risk of future failure occurring. In addition, AW are planning to undertake refurbishment work of the Chalkwell Esplanade Pumping Station to include the installation of new pumps and mitigation measures to prevent damage of electrical panels.

Although this event is classified as an extreme event by Ofwat, as a RMA, AW should continue to contribute to any further investigations that SBC deem necessary.

As part of the assessment of the flood risk assets undertaken by SBC, a number of sections of drainage ditches and watercourse had been identified to be owned by AW. These were noted to be in a poor condition. AW were informed of this, and requested to undertake necessary maintenance during the flood group meeting on 9th October 2013. AW has since then clarified ownership and attended to the sites. The necessary works have been completed to clear the ditches and these have been incorporated into AW's maintenance schedule and will be maintained on a yearly basis.

8 OPTIONS

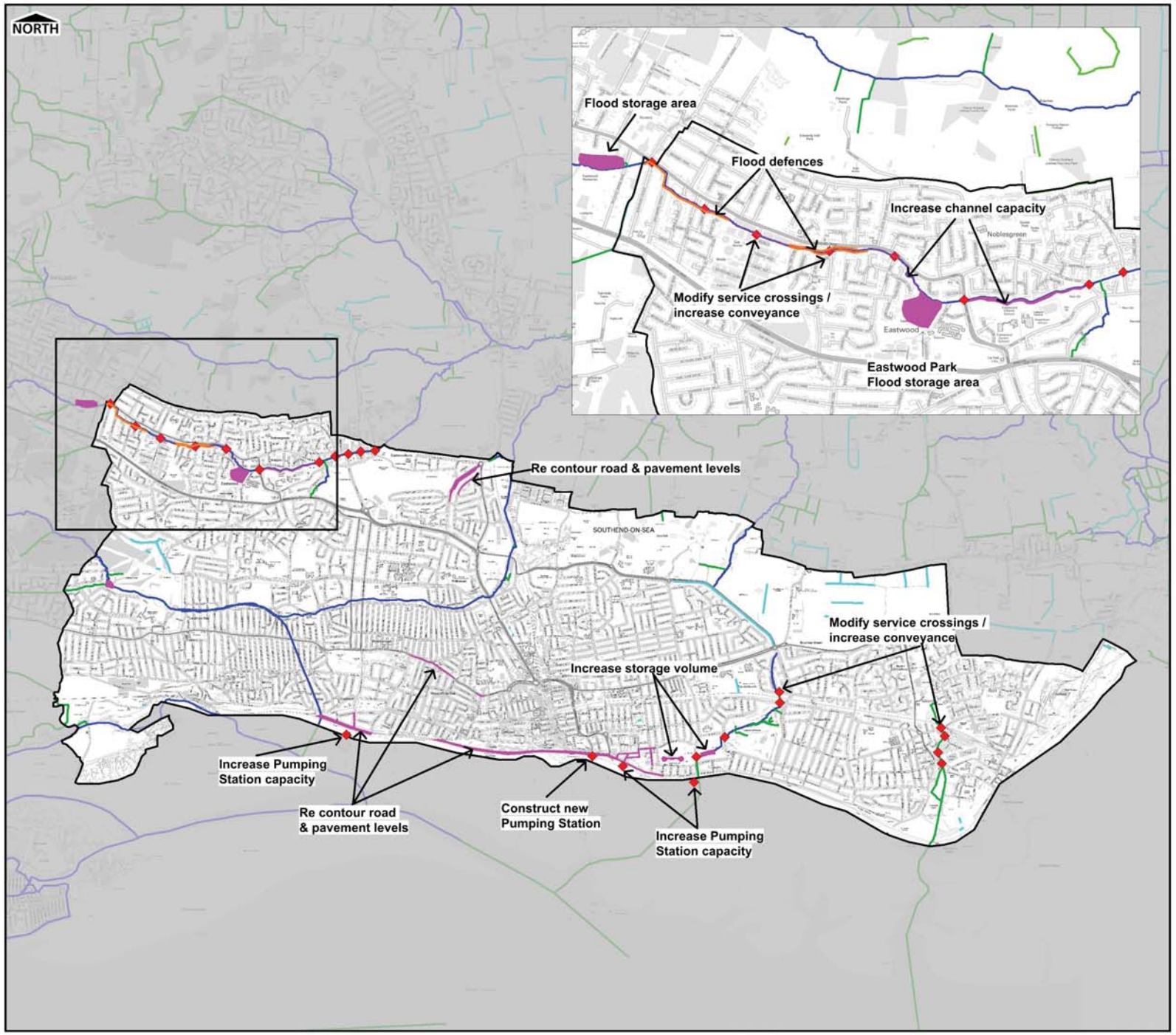
Following the investigation of flooding and the determination of the main flooding mechanisms within the SBC area, a number of potential measures have been identified to mitigate and manage any future flooding. All such measures are subject to the availability of funding. Figure 8-1 provides an overview of the locations of some of the options suggested, Table 8-1 describes these in further detail.

There are a large number of options for flood management that could be implemented at a borough-wide scale to assist in the management and mitigation of flooding. These borough-wide options tend to involve communication measures to enhance awareness of flooding and riparian ownership, improvements in maintenance, and the implementation of source control measures to assist with alleviating flood risk in the more vulnerable areas.

In addition a number of specific fluvial flooding options have been suggested for Eastwood Brook. As Eastwood Brook is classified as Main River, these would need to be developed in conjunction with the EA.

Specific options for Eastern Esplanade, Marine Parade and Chalkwell area have also been suggested focussing on managing the risk of flooding from the sewer and surface water sources.

For all of the options discussed below, further investigation would be needed to determine feasibility and consequences of such measures, including cost-benefit assessments. Sources of funding would need to be secured for all RMAs involved in order to proceed with the implementation of preferred options.



THIS DRAWING MAY BE USED ONLY FOR THE PURPOSE INTENDED

Legend

- SBC Council Extent

Potential Options

- Increase capacity / Flood storage area
- Flood defence
- Increase conveyance / modify service crossing

Rivers

- Main River (EA)
- Ordinary Watercourse (SBC)
- Offline drainge ditch

Southend-on-Sea Borough Council

Flood Investigation Report 24th August 2013

Scale at A3	Date	Drawn by	Approved by
1:50,000	Oct 2014	DS	EG

Potential Flood Management Options

Consultants

URS Infrastructure & Environment
6 - 8 Greencoat Place
London, SW1P 1PL

Figure 8-1

Version 2

Table 8-1 Potential options for flood risk management within Southend-on-Sea

Where	Option	Measures	Lead RMA	Supporting RMAs	Timeframe for Implementation
Borough Wide	Increase community awareness of flood risk	Update the SBC website to include information on flood risk, preparation measures and guidance documents. Include links to contacts for all other RMAs.	SBC	EA, AW	Short Term (< 1 year)
		Provide regular communication through publications of leaflets or articles within council magazines. This could be used to highlight key messages about flood risks and sources of further information.	SBC	EA, AW	Short Term (< 1 year)
		Assist with the formation of Flood Action Groups. Local residents within areas of flood risk, such as Eastwood, could be encouraged to form Flood Action Groups that act to represent communities and to work with SBC, the EA, AW and other organisations in the development of flood management options. In addition, Flood Action Groups are able to keep in touch with the residents, know the procedures for maintenance of assets within their area, create awareness, instigate "flood watchers" and have a say as the future flood risk to their community. For more information on setting up a Flood Action Group see the National Flood Forum website[xvii].	SBC	EA, AW	Short Term (< 1 year)
	Increase awareness of Riparian ownership & responsibilities	Communicate with riparian owners through group meetings, online resources and leaflets. Outline their obligations as riparian owners to maintain the flow of water through their sections of watercourse. Conduct this in conjunction with the EA to cover all rivers and drainage ditches across the Borough. For further information, refer to the EA's "Living on the Edge" guidance[xviii].	SBC	EA, AW	Short Term (< 1 year)
		SBC as the LLFA has the power to enforce the maintenance of a watercourse under Section 28 of the Land Drainage Act. If this is ignored by the riparian owner, SBC should carry out the necessary works themselves and recharge the person responsible for the full cost incurred.	SBC	-	Short Term (< 1 year)

[xvii] National Flood Forum: Forming a Flood Action Group http://nationalfloodforum.org.uk/?page_id=131

Where	Option	Measures	Lead RMA	Supporting RMAs	Timeframe for Implementation
	Planning Policy	Develop policies within the Core Strategy and Local Development Framework that encourages the use of Sustainable Drainage Systems (SUDS) where possible on all new developments.	SBC	-	Medium Term (1-5 years)
		Through Development Control Policy, SBC could ensure that developments within the Borough are achieving the required surface water attenuation measures to manage surface water runoff from the site. Where necessary, this should be supported by detailed drainage design.	SBC	-	Short Term (< 1 year)
	Property level protection	There are a wide range of property level resistance and resilience measures that could be implemented within the properties prone to flooding. Flood resistance measures include flood gates, air bricks etc. that aim to keep water out of the property. Flood resilience measures, such as raised services and waterproofed surfaces aim to reduce the impact of flooding and allow for faster recovery following a flooding event. These are described in more detail in Appendix B.	Residents	SBC	Medium Term (1-5 years)
	Restructure road and pavement levels	Identify areas where road levels could be reduced or footway pavement heights increased. This would enable larger volumes of surface water runoff to be retained within the road area before spilling into adjacent properties. It should be noted that the effect of this is largely based on the prevention of vehicles passing through the flood waters as the bow waves created can increase the propagation of flood waters into properties. The prevention of vehicles passing could be implemented through route diversions and the support of community groups.	SBC	Residents	Medium Term (1-5 years)

	Source Control measures	The urban area of SBC within Eastwood is extensively developed resulting in a large proportion of the land being covered in impermeable surfaces. This, along with the topography of the area encourages the rapid flow of surface water runoff towards the lowest points i.e. the river channel. The concept of source control options is to attenuate surface water at the point of its generation. Opportunities should be identified and investigated to install or retrofit measures such as green roofs, permeable paving, rain gardens, re-contoured road levels and swales. This would therefore act to reduce the volume of water entering the river channel or surface water drainage network. Further investigation into the feasibility of this, include cost-benefit assessment, would be required in order to support any applications for funding.	SBC	Residents & Developers (for new or re-developme nt)	Medium Term (1-5 years)
	Update Multi Action Flood Plan	As part of SBC emergency response procedure, SBC could undertake an exercise to identify properties of high vulnerability and at greatest risk of flooding from surface water and fluvial sources. The emergency response procedure should incorporate appropriate resources to ensure these properties can be attended, or road closures implemented to at short notice. The Flood Risk from Surface Water mapping should also be used to inform the safe evacuation routes for residents.	SBC	EA, ECC	Short Term (< 1 year)
Watercourses & Drainage Ditches	Revise maintenance schedules: Rivers and drains	Sections of river and drainage ditch that are owned by SBC should be incorporated into the asset maintenance contract. The type and frequency of maintenance should be reviewed to ensure that channels remain clear throughout the year.	SBC	-	Short Term (< 1 year)
		Ensure clear channel of communication for the public to report blockages or poor conditions of assets that need maintenance. Work with the other RMAs and riparian owners to enforce these requirements.	SBC	EA, SBC	Short Term (< 1 year)
	Revise maintenance schedules: Road Gullies and highways drains	The Flood Risk from Surface Water mapping and knowledge of flooding could be used to identify where areas of highway are more susceptible to surface water flooding. Any areas that are identified, could be highlighted to require frequent maintenance, especially during the autumn season when leaf debris is at its greatest.	SBC Highways	-	Short Term (< 1 year)

Eastwood Brook	Increase Channel Capacity	The capacity of Eastwood Brook could be increased to allow for larger volumes of water to be conveyed by the channel before overtopping of the river banks. Measures could be taken to increase the capacity of the river channel by deepening or widening the existing channel. The channel of the Eastwood Brook, as it passes through Eastwood, is intensely developed with little lateral space for expansion therefore opportunities for this may be limited. Further investigation would be needed to determine the feasibility of this option.	EA	SBC, AW	Medium Term (1-5 years)
	Flood Storage	Upstream storage of the Eastwood area: as Eastwood Brook flows from Rochford District Council towards Southend-on-Sea in an easterly direction, a potential option would be for the development of an online flood storage basin along Eastwood Brook upstream of Southend-on-Sea. The intention of this would be to attenuate the peak flow of Eastwood Brook before it reaches the urban area within SBC. This would allow for surface water to discharge to the brook from the Eastwood area before the main flow from the upper part of Eastwood Brook. This option would need to be developed in conjunction with Rochford District Council.	EA	SBC, RDC	Medium Term (1-5 years)
		A flood storage area within Eastwood Park could be developed to retain flows upstream of the Eastwood urban area. There is the potential for a number of options for offline flood storage within the park landscape.	EA	SBC	Medium Term (1-5 years)
	Flood Defences	Temporary or permanent flood defences could be developed along the sections of Eastwood Brook that are found to be more vulnerable to fluvial flooding. These would act to reduce the risk of flooding to properties by preventing the flow of fluvial water from the river channel. The impact on flooding downstream would need to be investigated as this may exacerbate downstream flooding. This option may be considered further following the outcomes of the investigation being completed by the EA.	EA	SBC	Medium Term (1-5 years)

Southern Coastline	Increase conveyance of flood waters	Increase pump capacity of the existing surface water pumps located within Southchurch Park and along the shoreline.	AW	SBC	Medium Term (1-5 years)
		Install a pumping station to intercept and pump surface water overflow from Marine Parade at the junction of Hartington Road.	AW	SBC	Medium Term (1-5 years)
		Install additional temporary pumping stations, along the southern extent of the borough. The intention of these would be to pump water to the Thames Estuary should rainfall events coincide with high tide levels.	AW, SBC	-	Short Term (>1 year)
		Undertake measures to ensure pumping stations are resilient to flooding. This would therefore reduce the risk of future pump failure should flooding occur.	AW	SBC	Short Term (>1 year)
		Undertake regular maintenance of tidal flap valves on sea outfalls to ensure functionality.	AW	-	Short Term (>1 year)
	Flood Storage	Investigate the potential to increase the storage capacity of the existing storage ponds within Southchurch Park and Southchuch Park East.	SBC	AW	Medium Term (1-5 years)
		Should opportunities arise as part of redevelopment works, there could be an option to increase drainage system capacity of the surface water network by enhancing pipe sizes, or installing additional storage in the downstream extents of the borough to allow for larger volumes of water to be retained within the network before surcharging occurs.	AW	SBC	Long term (>5 years)
		Where opportunities arise as part of redevelopment works, there could be the option to separate the combined sewer network across SBC into foul and surface water networks. This will assist with reducing foul flooding and enable increase capacity for surface water to be incorporated into the sewer network.	AW	SBC	Long term (>5 years)

9 NEXT STEPS

SBC's role as LLFA is to lead the management of flood risk within their administrative area. The next steps for SBC as the LLFA and the other RMAs, with respect to flood risk across the borough, are outlined below. SBC should provide an update on progress at each quarterly flood group meeting.

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

Table 9-1: Next steps for RMAs

ID	Action	Details	Authorities Involved
01	Liaison	Under Section 19 (2) of the FWMA, SBC should publish the results of the flood incident report and notify any relevant RMAs, stakeholders and residents.	SBC
02	Recording/ liaison	Residents should report all flooding of an unacceptable nature to AW, the EA and SBC. SBC should continue to maintain and populate a record of all flood incidents including information on the date and time of flooding incidents, properties affected and how. This record should be reviewed in conjunction with local rainfall records to determine the return period of event resulting in flooding. SBC should regularly liaise with the RMAs and review this data to determine if further action/investigation are required.	SBC, EA, AW
03	Recording	SBC should follow up with residents that reported flooding with a questionnaire to acquire additional details of flooding (consequences, damage caused etc.) and to provide advice as to property level protection measures.	SBC, residents groups
04	Liaison	SBC should work with the EA to provide local homeowners with information on flood resilience measures. The best way for local residents to deal with the risk is to be prepared.	SBC, EA
05	Liaison	SBC should work with the local community and the EA to support community resilience. They should inform the local communities of the outcomes of the Flood Incident Report, and develop clear communication tools for reporting future flood events.	SBC, EA, Residence Groups
06	Recording/ liaison	The RMAs should work together to identify assets and ownership across the borough. These should be incorporated into the relevant authority's maintenance schedules.	SBC, SBC Highways, EA, AW
07	Surface water management	SBC should review their current maintenance schedule for watercourses under their ownership.	SBC
08	Enforcement	SBC should undertake regular surveys of watercourses to ensure riparian owners are maintaining their channels as required. If a riparian owner fails to carry out his responsibilities or if anyone else causes a watercourse to become blocked or obstructed, SBC should serve a notice under Section 28 of the Land Drainage Act. If this is ignored, SBC should carry out the	SBC, Riparian Owners

		necessary works themselves and recharge the person responsible for the full cost incurred.	
09	Investigation	Investigate the potential use of pumping station to manage surface water flooding at Rayleigh Weir, within Castle Point, upstream of Southend-on-Sea, and the resulting impact on the fluvial flows within the Eastwood Brook.	SBC, ECC, EA
10	Investigation	The RMAs should work together to determine potential options for the management of flood risk within the borough. These should include those discussed in Section 8 of this report.	SBC, SBC Highways, EA, AW
11	Enforcement	SBC should make sure that planning applications within their administrative boundary fully consider potential impacts on surface water drainage and where possible provide improvements to the existing situation in line with local and national policy.	SBC
12	Surface water management	SBC should incorporate the findings of this report to identify priority areas for emergency response. This should be incorporated into the Multi-Agency Flood Plan.	SBC
13	Liaison	RMAs should investigate options for management of flood risk across the borough, taking forward any feasible schemes.	SBC, EA, AW

10 USEFUL CONTACTS AND FURTHER INFORMATION

10.1 Contacts

Southend-on-Sea Borough Council

General Enquiries: 01702 215 000

Email: council@southend.gov.uk

http://www.southend.gov.uk/

Environment Agency

General Enquiries: 08708 506 506 (Mon – Fri 8am – 6pm)

Incident Hotline: 0800 80 70 60 (24 hrs)

http://www.environment-agency.gov.uk/

Anglian Water

Water and sewage service queries & general emergencies: 08457 145 145 (24 hrs)

http://www.anglianwater.co.uk/

10.2 References and Further Information

- Highways Act 1980: http://www.legislation.gov.uk/ukpga/1980/66/contents
- Water Resources Act 1991:http://www.legislation.gov.uk/ukpga/1991/57/contents
- Land Drainage Act 1991: http://www.legislation.gov.uk/ukpga/1991/59/contents
- Flood and Water Management Act 2010: http://www.legislation.gov.uk/ukpga/2010/29/contents
- Civil Contingencies Act 2004: http://www.legislation.gov.uk/ukpga/2004/36/contents
- Environment Agency Flood Warning Direct: https://fwd.environment-agency.gov.uk/app/olr/home
- Environment Agency 'Living on the Edge' a guide to the rights and responsibilities of waterside occupation: http://www.environment-agency.gov.uk/homesandleisure/floods/31626.aspx
- Environment Agency – River and Coastal Maintenance Programmes: http://environment-agency.gov.uk/homesandleisure/floods/109548.aspx

- Environment Agency – Prepare your Property for Flooding – how to reduce flood damage, flood protection products and services: http://www.environment-agency.gov.uk/homesandleisure/floods/31644.aspx
- Environment Agency – Make a Flood Plan: http://www.environment-agency.gov.uk/homeandleisure/floods/38329.aspx
- Anglian Water – Dealing with Flooding from Sewers http://www.anglianwater.co.uk/_assets/media/LED102_Dealing_with_flooding_from_sewer.pdf
- UKRLG code of Practice for Highways Maintenance: http://www.ukroadsliaisongroup.org/en/guidance/codes-of-practice.cfm
- National Receptors Database EA: http://www.geostore.com/environment-agency/WebStore?xml=environment-agency/xml/dataLayers_NRD.xml
- Appendix 3.1 of the Multi-Coloured Manual: http://www.environment-agency.gov.uk/research/planning/116707.aspx

APPENDIX A – RAINFALL DATA AND RETURN PERIOD CALCULATIONS

The rainfall return period has been estimated in order to determine the relative magnitude of the event of August 24th 2013 and allow for the comparison of standards of protection. The assessment of the return period has been made using industry standard techniques outlined in the Flood Estimation Handbook (FEH). The FEH CD-ROM provides catchment descriptors for four million UK catchments that drain an area of 0.5km^2 or more.

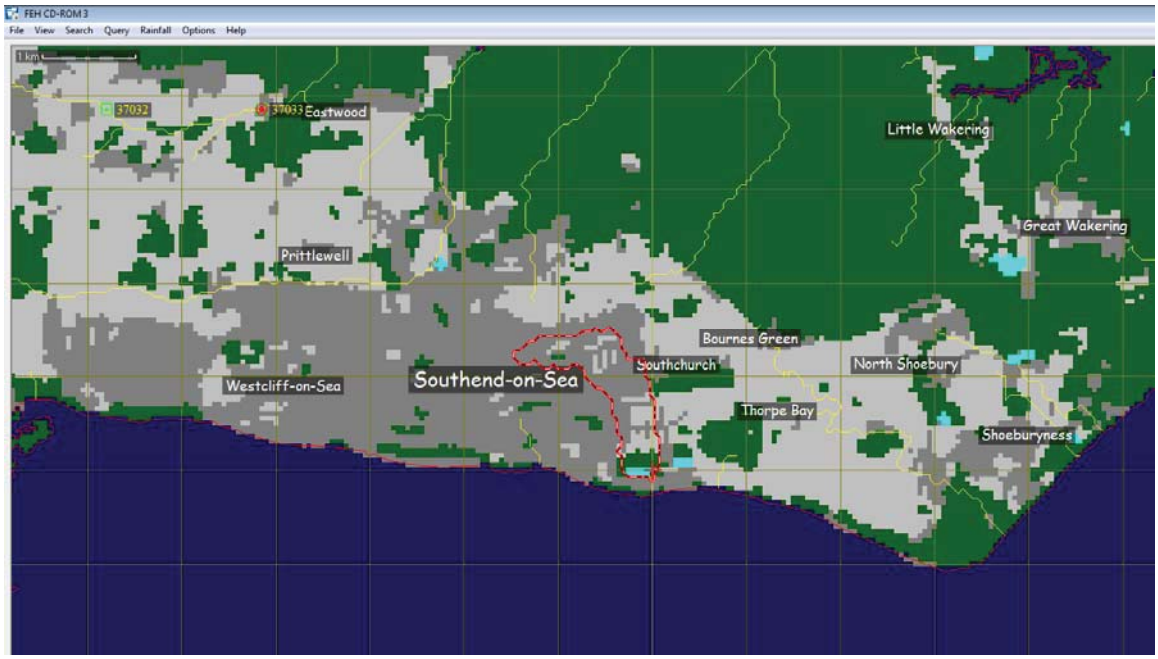
The method used involved determining the maximum depth of rain over a range of durations for the 1km^2 in which the rain gauge is situated.

Depth-Duration-Frequency is an empirical model based on the Generalised Extreme Value Distribution and is best used for analysing rainfall duration of between one hour and eight days and such models contain inherent uncertainty. The FEH (Volume 2, Section 2) notes that extrapolation beyond these thresholds (i.e. half an hour) is justified, however the resultant answers should be treated with less confidence due to the extrapolation.

The assessment has found that for a 4 hour rainfall event, the maximum rainfall depth is the equivalent of a 1 in 42 chance of occurring in any given year. Due to the limitations of the methodology used to determine this, it is considered that that the chance of this occurring should be considered to be between 1 in 30 and 1 in 50 within any given year.

The catchment associated with the Southchurch Park rain gauge is detailed in Figure A-1 below. The catchment descriptors of the 1km^2 area at the rain gauge location were used in these calculations.

Figure A-1 – Southchurch Park Catchment Area as shown in the FEH CD-ROM



Southchurch park Rain gauge data			Calculation of peak rainfall depths: duration (hours)										
Date	Time	depth (mm)	0.5	1	2	3	4	5	6	9	12	18	24
24/08/2013	00:15:00	.											
24/08/2013	00:30:00	.	0										
24/08/2013	00:45:00	.	0										
24/08/2013	01:00:00	.	0	0									
24/08/2013	01:15:00	.	0	0									
24/08/2013	01:30:00	.	0	0									
24/08/2013	01:45:00	.	0	0									
24/08/2013	02:00:00	.	0	0	0								
24/08/2013	02:15:00	.	0	0	0								
24/08/2013	02:30:00	.	0	0	0								
24/08/2013	02:45:00	.	0	0	0								
24/08/2013	03:00:00	0.2	0.2	0.2	0.2	0.2							
24/08/2013	03:15:00	0.2	0.4	0.4	0.4	0.4							
24/08/2013	03:30:00	0.2	0.4	0.6	0.6	0.6							
24/08/2013	03:45:00	0.2	0.4	0.8	0.8	0.8							
24/08/2013	04:00:00	.	0.2	0.6	0.8	0.8	0.8						
24/08/2013	04:15:00	.	0	0.4	0.8	0.8	0.8						
24/08/2013	04:30:00	.	0	0.2	0.8	0.8	0.8						
24/08/2013	04:45:00	0.2	0.2	0.2	1	1	1						
24/08/2013	05:00:00	.	0.2	0.2	0.8	1	1	1					
24/08/2013	05:15:00	0.2	0.2	0.4	0.8	1.2	1.2	1.2					
24/08/2013	05:30:00	0.2	0.4	0.6	0.8	1.4	1.4	1.4					

Southchurch park Rain gauge data			Calculation of peak rainfall depths: duration (hours)										
Date	Time	depth (mm)	0.5	1	2	3	4	5	6	9	12	18	24
24/08/2013	05:45:00	.	0.2	0.4	0.6	1.4	1.4	1.4					
24/08/2013	06:00:00	.	0	0.4	0.6	1.2	1.4	1.4	1.4				
24/08/2013	06:15:00	0.2	0.2	0.4	0.8	1.2	1.6	1.6	1.6				
24/08/2013	06:30:00	.	0.2	0.2	0.8	1	1.6	1.6	1.6				
24/08/2013	06:45:00	.	0	0.2	0.6	0.8	1.6	1.6	1.6				
24/08/2013	07:00:00	.	0	0.2	0.6	0.8	1.4	1.6	1.6				
24/08/2013	07:15:00	.	0	0	0.4	0.8	1.2	1.6	1.6				
24/08/2013	07:30:00	.	0	0	0.2	0.8	1	1.6	1.6				
24/08/2013	07:45:00	.	0	0	0.2	0.6	0.8	1.6	1.6				
24/08/2013	08:00:00	.	0	0	0.2	0.6	0.8	1.4	1.6				
24/08/2013	08:15:00	.	0	0	0	0.4	0.8	1.2	1.6				
24/08/2013	08:30:00	.	0	0	0	0.2	0.8	1	1.6				
24/08/2013	08:45:00	.	0	0	0	0.2	0.6	0.8	1.6				
24/08/2013	09:00:00	.	0	0	0	0.2	0.6	0.8	1.4	1.6			
24/08/2013	09:15:00	.	0	0	0	0	0.4	0.8	1.2	1.6			
24/08/2013	09:30:00	.	0	0	0	0	0.2	0.8	1	1.6			
24/08/2013	09:45:00	.	0	0	0	0	0.2	0.6	0.8	1.6			
24/08/2013	10:00:00	.	0	0	0	0	0.2	0.6	0.8	1.6			
24/08/2013	10:15:00	.	0	0	0	0	0	0.4	0.8	1.6			
24/08/2013	10:30:00	0.2	0.2	0.2	0.2	0.2	0.2	0.4	1	1.8			
24/08/2013	10:45:00	.	0.2	0.2	0.2	0.2	0.2	0.4	0.8	1.8			
24/08/2013	11:00:00	.	0	0.2	0.2	0.2	0.2	0.4	0.8	1.8			

Southchurch park Rain gauge data			Calculation of peak rainfall depths: duration (hours)										
Date	Time	depth (mm)	0.5	1	2	3	4	5	6	9	12	18	24
24/08/2013	11:15:00	.	0	0.2	0.2	0.2	0.2	0.2	0.6	1.8			
24/08/2013	11:30:00	0.8	0.8	0.8	1	1	1	1	1.2	2.6			
24/08/2013	11:45:00	4.4	5.2	5.2	5.4	5.4	5.4	5.4	5.6	7			
24/08/2013	12:00:00	4.8	9.2	10	10.2	10.2	10.2	10.2	10.4	11.6	11.8		
24/08/2013	12:15:00	8.8	13.6	18.8	19	19	19	19	19	20.2	20.6		
24/08/2013	12:30:00	4.4	13.2	22.4	23.2	23.4	23.4	23.4	23.4	24.4	25		
24/08/2013	12:45:00	2.6	7	20.6	25.8	26	26	26	26	26.8	27.6		
24/08/2013	13:00:00	6.8	9.4	22.6	32.6	32.8	32.8	32.8	32.8	33.6	34.4		
24/08/2013	13:15:00	1	7.8	14.8	33.6	33.8	33.8	33.8	33.8	34.6	35.4		
24/08/2013	13:30:00	2	3	12.4	34.8	35.6	35.8	35.8	35.8	36.6	37.4		
24/08/2013	13:45:00	7.4	9.4	17.2	37.8	43	43.2	43.2	43.2	43.8	44.8		
24/08/2013	14:00:00	3	10.4	13.4	36	46	46.2	46.2	46.2	46.8	47.8		
24/08/2013	14:15:00	0.8	3.8	13.2	28	46.8	47	47	47	47.4	48.6		
24/08/2013	14:30:00	3.8	4.6	15	27.4	49.8	50.6	50.8	50.8	51	52.4		
24/08/2013	14:45:00	1.6	5.4	9.2	26.4	47	52.2	52.4	52.4	52.6	54		
24/08/2013	15:00:00	1.4	3	7.6	21	43.6	53.6	53.8	53.8	54	55.2		
24/08/2013	15:15:00	1.2	2.6	8	21.2	36	54.8	55	55	55	56.2		
24/08/2013	15:30:00	0.4	1.6	4.6	19.6	32	54.4	55.2	55.4	55.4	56.4		
24/08/2013	15:45:00	0.2	0.6	3.2	12.4	29.6	50.2	55.4	55.6	55.6	56.4		
24/08/2013	16:00:00	0.2	0.4	2	9.6	23	45.6	55.6	55.8	55.8	56.6		
24/08/2013	16:15:00	.	0.2	0.8	8.8	22	36.8	55.6	55.8	55.8	56.6		
24/08/2013	16:30:00	0.2	0.2	0.6	5.2	20.2	32.6	55	55.8	56	56.8		

Southchurch park Rain gauge data			Calculation of peak rainfall depths: duration (hours)										
Date	Time	depth (mm)	0.5	1	2	3	4	5	6	9	12	18	24
24/08/2013	16:45:00	0.4	0.6	0.8	4	13.2	30.4	51	56.2	56.4	57		
24/08/2013	17:00:00	0.2	0.6	0.8	2.8	10.4	23.8	46.4	56.4	56.6	57.2		
24/08/2013	17:15:00	.	0.2	0.8	1.6	9.6	22.8	37.6	56.4	56.6	57		
24/08/2013	17:30:00	.	0	0.6	1.2	5.8	20.8	33.2	55.6	56.6	56.8		
24/08/2013	17:45:00	0.2	0.2	0.4	1.2	4.4	13.6	30.8	51.4	56.8	57		
24/08/2013	18:00:00	.	0.2	0.2	1	3	10.6	24	46.6	56.8	57	58.4	
24/08/2013	18:15:00	0.4	0.4	0.6	1.4	2.2	10.2	23.4	38.2	57.2	57.2	58.8	
24/08/2013	18:30:00	1.4	1.8	2	2.6	3.2	7.8	22.8	35.2	58.6	58.6	60.2	
24/08/2013	18:45:00	.	1.4	1.8	2.2	3	6.2	15.4	32.6	58.6	58.6	60.2	
24/08/2013	19:00:00	0.2	0.2	2	2.2	3	5	12.6	26	58.8	58.8	60.4	
24/08/2013	19:15:00	0.2	0.4	1.8	2.4	3.2	4	12	25.2	59	59	60.6	
24/08/2013	19:30:00	.	0.2	0.4	2.4	3	3.6	8.2	23.2	58.8	59	60.6	
24/08/2013	19:45:00	.	0	0.4	2.2	2.6	3.4	6.6	15.8	58.8	59	60.6	
24/08/2013	20:00:00	.	0	0.2	2.2	2.4	3.2	5.2	12.8	58.8	59	60.6	
24/08/2013	20:15:00	.	0	0	1.8	2.4	3.2	4	12	58.8	59	60.6	
24/08/2013	20:30:00	.	0	0	0.4	2.4	3	3.6	8.2	58	59	60.6	
24/08/2013	20:45:00	.	0	0	0.4	2.2	2.6	3.4	6.6	53.6	59	60.6	
24/08/2013	21:00:00	.	0	0	0.2	2.2	2.4	3.2	5.2	48.8	59	60.4	
24/08/2013	21:15:00	.	0	0	0	1.8	2.4	3.2	4	40	59	60.2	
24/08/2013	21:30:00	.	0	0	0	0.4	2.4	3	3.6	35.6	59	60	
24/08/2013	21:45:00	.	0	0	0	0.4	2.2	2.6	3.4	33	59	59.8	
24/08/2013	22:00:00	.	0	0	0	0.2	2.2	2.4	3.2	26.2	59	59.8	

Southchurch park Rain gauge data			Calculation of peak rainfall depths: duration (hours)									
Date	Time	depth (mm)	0.5	1	2	3	4	5	6	9	12	18	24
24/08/2013	22:15:00	.	0	0	0	0	1.8	2.4	3.2	25.2	59	59.8	
24/08/2013	22:30:00	.	0	0	0	0	0.4	2.4	3	23.2	58.8	59.8	
24/08/2013	22:45:00	.	0	0	0	0	0.4	2.2	2.6	15.8	58.8	59.6	
24/08/2013	23:00:00	.	0	0	0	0	0.2	2.2	2.4	12.8	58.8	59.6	
24/08/2013	23:15:00	.	0	0	0	0	0	1.8	2.4	12	58.8	59.4	
24/08/2013	23:30:00	.	0	0	0	0	0	0.4	2.4	8.2	58	59.2	
24/08/2013	23:45:00	.	0	0	0	0	0	0.4	2.2	6.6	53.6	59.2	
25/08/2013	00:00:00	.	0	0	0	0	0	0.2	2.2	5.2	48.8	59.2	60.6
Maximum depth (mm)		8.8	13.6	22.6	37.8	49.8	54.8	55.6	56.4	59	59	60.6	60.6
Return Period			1 in 3 year	1 in 7 year	1 in 20 year	1 in 37 year	1 in 42 year	1 in 38 year	1 in 35 year	1 in 31 year	1 in 25 year	1 in 20 year	1 in 16 year

APPENDIX B – PROPERTY LEVEL FLOOD PROTECTION OPTIONS

Overview

The flooding event on the 24th August 2013 resulted in 148 properties flooding internally. The source of flooding across the borough, as described in the Flood Investigation Report, is a combination of fluvial, surface water and sewer flooding. The following sections outline a range of options for property protection that residents could implement.

There are a wide number of flood resistance and flood resilience measures available. Flood resistant measures aim to prevent flood water from entering the property and should be considered where there is shallow flooding (<600mm). Flood resistant measures can also provide time for residents to evacuate and move valuable positions away from flooding. Flood resilience measures aim to reduce the impact of flood waters that may enter a property. Resilience measures are intended to minimise the damage caused and allow for faster recovery following the flood event.

Initial steps: Prior to the implementation of flood protection measures, the level of flood risk to the property should be understood. It is also important to consider the future impacts of climate change, as flood levels may increase or the flood extent may become greater. For information on flooding from rivers or the sea and the flood risk from surface water, refer to the Environment Agency (http://www.environment-agency.gov.uk/). Further information to prepare for floods can be found at the National Flood Forum website (http://nationalfloodforum.org.uk/).

As stated by the Communities and Local Government (2007) for flood depths greater than 0.6m, it is likely that structural damage could occur in traditional masonry construction due to excessive water pressures. In these circumstances, the strategy should be to allow water into the building i.e. “water entry strategy”

Flood Evacuation Plans: For buildings located in an area of flood risk, a flood evacuation plan should be prepared, if there is not one already, to ensure the safe evacuation in the time of a flood.

Flood evacuation plans should typically include information on how an alarm will be raised, the safest route from the building and a safe place for retreat. Further guidance can be found on the Environment Agency and National Flood Forum websites (see above).

Property Level Flood Resistant Measures

Flood guards for doors and windows: There are a number of commercial flood guards for doors and windows that can be installed on a property to resist the entry of flood water. These typically can withstand flood depths up to 0.5m. It should be noted that deeper flood waters have the potential to cause structural damage. A structural assessment of the property should be undertaken to determine the suitability of this measure.

Alternative sandbags: Conventional sandbags can be used to retain shallow flood waters, however they are heavy and difficult to store. There are a range of modern alternatives that are easier to use and more effective. These are filled with highly absorbent materials, which when dry, are light weight and can be stacked against doors and openings into the property. They function to absorb water quickly, expanding and forming a barrier.

Alternative sandbags offer a quick and simple solution to preventing the inflow of flood waters. They can easily be stored away and used when necessary.

Permanent flood doors and windows: These are permanent flood resistant measures. Flood doors are designed to look and function as a normal door, but with the ability to resist

the inflow of flood waters. The main advantage of these features is that no advanced warning is required to put in place the necessary measures.

Air brick covers: In order to prevent the inflow of water into properties though openings such as air bricks, there are covers available that can be fitted to the external wall prior to a flood and removed following the flood. These normally require an external permanent fitting to be installed to allow for the attachment of the covers.

Flood alarms: These systems can be installed and set up to send an automatic alarm when flood waters reach a certain level. The alert is sent by telephone to warn the property owner of the potential risk. This may prove to be most beneficial during the night or when away from the house so that necessary arrangements can be made. These are usually used for properties at risk of fluvial flooding, but if suitable, could easily function to warn of rising surface water levels.

Non-return valves: To avoid letting flood waters enter the property through drains and pipes, non-return valves can be fitted on all drain outlets. Non-return valves act to automatically close when water flows back through the drains during a time of a flood. This will prevent contaminated water from flowing back into the property. Non-return valves do not restrict the flow of water out of the system as required under normal conditions.

Typically these would be suitable in low lying areas and areas liable to sewer flooding after heavy rainfall events, where the drainage network is more susceptible to inundation.

Toilet seals: As described above, some properties may be susceptible to the back flow of water into their property following heavy rainfall. Toilet seals prevent the back flow of water through the toilet by blocking the toilet pan. Toilet seal products typically need to be placed in the toilet and then inflated to form an airtight seal.

Property Level Flood Resilience Measures

Flooring: Concrete can be damaged during floods. Resilience can be improved by using a denser concrete screed or mixing in a suitable waterproofing compound. Additionally, floors should ideally be laid with ceramic tiles or rugs, rather than carpet, as these can more easily be moved out of the way ahead of a flood.

Internal wall render: Plastered walls can be replaced with lime plaster or a waterproof concrete render to minimise the damage to the walls surface. Plasterboard should be fitted lengthways so as to minimise the amount that would need replacing following a flood.

Raised services: Within the rooms vulnerable to flooding electrical sockets could be raised to a higher level on the walls. Additionally, items such as televisions or boilers could be mounted on the wall to avoid contact with the ground.

Replaced interior fittings: Fittings that are made out of wood or chipboard will be more susceptible to damage and degradation should they be in contact with flood waters. Plastic or stainless steel units could be used as an alternative to wood.

Flood Defences

Flood Barriers: There are many commercial options available for demountable flood barriers. Flood barriers can typically retain flood waters from 1.5 to 2.4m depth and can be set up around a property to ensure that flood waters do not reach the property. The storage, maintenance and deployment of flood barriers is typically undertaken by a multiagency partnership.

The feasibility of this would need further investigation and should be completed alongside consultation with the Environment Agency and SBC.

There are a wide range of options available. Some of the more advanced options include permanent flood barriers which rise as the water level in the associated river channel rise. Under normal conditions, the barriers remain at a lower level so as to cause minimal disruption. This has the added advantage of being automatic, therefore not requiring the presence of personal to construct the wall. Given the short lead time (the time between the peak rainfall and peak river levels) to flooding of many of the rivers within Southend, this sort of system could prove to be very beneficial to ensuring that the wall is in place before maximum water levels are reached.

Bunds: A permanent resistance measure could be developed, where there is sufficient space, to prevent flooding from rivers. These could be developed where there is a community, or multiple properties at risk of flooding. Development of such measures would require risk assessment and design to prevent breaching or overtopping, and to ensure that the risk of flooding is not increased elsewhere. The development of such schemes should be undertaken with consultation of the Local Authority and Environment Agency.

Costs

The Defra (2007) Flood resistance and resilience scoping study outline indicative costs for many of the flood resistance and resilience measures listed above. The report estimates that the implantation of temporary property level resistance measures (including door and window guards, air brick covers etc.), is approximately £2,000 to £4,000 per property.

The report estimates that for implementation of permanent property resistance measures (flood doors, windows, air bricks etc.) the cost per building would be in the region of £3,000 to £10,000.

The cost of a temporary flood barrier is estimated to be between £5,500 and £12,000 per property. This may prove to be less costly per property when assembled to protect a number of buildings.

It is estimated that to make a house resilient to flooding, that is through the modification of walls, doors, floors, resilient units and raising of electrical sockets and appliances, would cost between £24,000 and £30,000 per property.

The majority of the measures above would require ongoing maintenance to ensure they function as intended when required.

Further Information

Further information on flood preparation and property level resilience and resistance measures can be found here:

- Environment Agency: http://www.environment-agency.gov.uk/default.aspx
- National Flood Forum: http://nationalfloodforum.org.uk/
- Blue Pages: http://www.bluepages.org.uk/
- Communities and Local Government (2007) Improving the Flood Performance of New Buildings: Flood Resilient Construction https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/7730/flood_performance.pdf

- Defra (2007) Flood resistance and resilience solutions: an R & D Scoping study. http://archive.defra.gov.uk/environment/flooding/documents/manage/frrs-scope.pdf