Lidsey Surface Water Management Plan

West Sussex County Council

A Partnership between:

- West Sussex County Council
- Southern Water
- Arun District Council
- Environment Agency

Plan Design Enable

Notice

This report has been prepared as part of West Sussex County responsibilities under the Flood Water Management Act 2010. It is intended to provide context and information to support the delivery of the local flood risk management strategy and should not be used for any other purpose.

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Glossary

Term	Definition
AAD	Annual Average Damage. A statistical long term average amount of flood damage likely to be incurred each year. This can be considered as a rate of damage under a particular scenario.
ADC	Arun District Council
AStGWF	Areas Susceptible to Ground Water Flooding. A national data set which is held and maintained by the Environment Agency to assist with identifying the risk of ground water emergence within an area.
AStSWF	Areas Susceptible to Surface Water Flooding. A national data set which is held and maintained by the Environment Agency. This mapping is based on high level modelling which shows areas potentially at risk of surface water flooding.
Average Annual Damages	Average Annual Damages (AAD), Is the term used to describe the average monetary cost of flooding in an average year. The Average Annual Damages (AAD) value is a sum of each property's individual likely annual damages based on the properties risk. So if a property is at risk only for 1 in 1000, annually it is less likely to flood and therefore its annual damages will be lower. If a property floods in a 1 in 30, damages will be higher. By combining all these risks, we get the AAD. The AAD is not the cost of a single 1 in 30, 1 in 100 or 1 in 1000 event, but the probabilistic cost of flood damages in any given year, based on every property's / receptors risk of flooding.
BRE365	A Building Research Establishment document (ref: BRE365). This details the percolation testing and design of soakaways.
CDA	Critical Drainage Area. A discrete geographic area (typically a hydrological catchment) where multiple and interlinked sources of flood risk (surface water, ground water, sewer, main river, tide) cause flooding in one or more Local Flood Risk Zones during severe rainfall impacting on people, property or infrastructure.
CFMPS	Catchment Flood management Plan (CFMPs) give an overview of the flood risk across each river catchment
CIRIA	Construction Industry Research and Information Association
CSO	Combined Sewer Overflow. A CSO is an overflow arrangement which allows the combined sewer system to discharge combined flow (storm water and foul) into a designated watercourse or to sea. A CSO will operate and spill once capacity in the combined sewer system is exceeded typically following response to rainfall.
Culvert	A culvert is a structure that allows water to flow under a road, railroad, trail, or similar obstruction. Typically embedded so as to be surrounded by soil, a culvert may be made from a pipe, reinforced concrete or other material.
DEFRA	Department for Environment, Food and Rural Affairs
DEM	Digital Elevation Model represents the earth's surface and includes all objects on it
DTM	Digital Terrain Model represents the bare ground surface without any objects like plants and buildings
EA	Environment Agency
Extreme Storm	This is a term typically applied to a storm event which occurs less frequently than a

Event	1 in 30 year storm event (3.33% annual probability).
FCERM	Flood and Coastal Erosion Risk Management
FDGiA	Flood Defence Grant in Aid. A funding grant which can be applied for to support the reduction in flood hazard and impact.
Fluvial Flooding	Flooding linked to the exceedance from a river system i.e. river breaching its banks or flood plain.
FMfSW	Flood Maps for Surface Water produced by the EA.
FWMA	Flood and Water Management Act 2010
Ground Water Flooding	Flooding that occurs when water levels in the ground rise above surface levels. Most likely to occur in areas underlain by permeable geology.
Internal Drainage Board	An internal drainage board (IDB) is an operating authority which is established in areas of special drainage need in England and Wales with permissive powers to undertake work to secure clean water drainage and water level management within drainage districts. The EA operate as the IDB in the West Sussex region.
IAS	Impermeable Area Survey. This survey involves inspection and confirmation and recording as to the disposal method of surface water from roof and hard standing areas. This is typically undertaken through the use of dye and acoustic testing to determine which drainage system is used to dispose of the surface water. Southern Water owns this information.
Inundation	During or after a storm event surface floodwater ponds on the ground surface and enters the below ground drainage system via manholes and gullies. This reduces available capacity and can lead to hydraulic overload or flooding.
LDF	Local Development Framework
LFRZ	Local Flood Risk Zone
LLFA	Lead Local Flood Authority. Local Authority responsible for taking the lead on local flood risk management.
Local Plan	Local planning authorities must prepare a local plan which sets planning policies in a local authority area
LPA	Local Planning Authority
Main River	Main rivers are strategically important watercourses that carry significant flood risk. They are defined by Defra and shown on EA Main River Map. The EA have permissive powers to carry out work on main rivers
MHWL	Mean High Water Level observed over a period of time.
NPPF	The National Planning Policy Framework was published by the UK's Department of Communities and Local Government in March 2012, consolidating over two dozen previously issued documents called Planning Policy Statements (PPS) and Planning Policy Guidance Notes (PPG) for use in England.
National Receptor Database (NRD)	National Receptors Database. A geospatial database of risk receptors produced to provide a standardised method of assessing flood risk. The database contains points of residential properties, power infrastructure (substations) and vulnerable properties such as schools and hospitals.

National Soil Resource Institute	National Soil Resource Institute (NSRI) is a soilscapes viewer produced by Cranfield Soil and AgriFood Institute (CSAI) which is supported by Defra. Soilscapes conveys a summary of the broad regional differences in the soil landscapes of England and Wales.
Ordinary Watercourse	All watercourses that are not designated Main River are considered to be ordinary watercourses and are the responsibility of landowners. Ordinary watercourse does not imply a "small" river, although it is often the case that ordinary watercourses are smaller than Main Rivers.
Partner	A person or organisation has a direct responsibility for ownership and are required to take action or decisions relating to the SWMP.
PFRA	Preliminary Flood Risk Assessment
Pitt Review	An independent review of the summer floods on 2007 by Sir Michael Pitt. This produced a number of key recommendations to improve flood risk management in England.
Present Value Damage	The representation in a single value of damage incurred over a period of time. This value is generated through discounting. The discount rate is set by the Treasury and currently starts at 3.5%. Using the Treasury discount rates, £1/year over 100 years is discounted to a present value of £29.81.
Residential Receptors & Non Residential Receptors	See National Receptor Database
RTU	Restricted Toilet Use (RTU) is a term used to describe the loss of positive discharge from toilets at residential and commercial premises. RTU typically lasts for short period of time and may be triggered by storm response, inflow from groundwater and/or operational failure i.e. blockage in the public drainage system.
Saturation excess runoff	Runoff of rainwater from the land surface when the subsurface is saturated and cannot accommodate any further water
SMP	A Shoreline Management Plan (SMP) is a large-scale assessment of the risks associated with coastal processes and helps reduce these risks to people and the developed, historic and natural environments.
Stakeholder	A person or organisation affected by the problem or solution, or interested in the problem or solution. They can be individuals or organisations, includes the public and communities.
Sewer flooding	Flooding which occurs when the capacity of underground systems is exceeded due to heavy rainfall, resulting in flooding inside and outside of buildings. Note the normal discharge of sewers and drains through outfalls may be impeded by high water levels in receiving waters as a result of wet weather or tidal conditions. Sewer flooding can occur as a results operational failure (structural or operational) and or excessive inflow from groundwater or inundation from surface water.
Surface Water Flooding	Flooding which occurs when the capacity of underground systems is exceeded due to heavy rainfall, resulting in flooding inside and outside of buildings. Note the normal discharge of sewers and drains through outfalls may be impeded by high water levels in receiving waters as a result of wet weather or tidal conditions.
SFRA	Strategic Flood Risk Assessments

SIRF	Sewer Incident Report Form database. Southern Water's Operational database recording incidents of flooding. The SWMP has utilised details of reported flooding linked to hydraulic overload.
SUDS	Sustainable Urban Drainage Systems. Methods of management practices and control structures that are designed to drain surface water in a more sustainable manner than some conventional techniques.
Surface Water / Pluvial water	Water that exists on the land surface and has not entered a natural or manmade drainage system.
Surface Water or Pluvial Flooding	Flooding from Infiltration or Saturation excess runoff, leading to ponding in natural depressions in the landscape. Pluvial flooding may also occur if surface water cannot get into the natural and/or artificial drainage systems in adequate time leading to overland flows / ponding in natural depressions.
SWMP	Surface Water Management Plan
SWS	Southern Water Services
WAAD	A previously calculated Annual Average Damage, generated from historic flood data across a range of locations. This can be used as a high level estimate of the rate of damage per property, varying with the probability of flooding.
WPS	Wastewater Pumping Station
WRAP	Winter Rainfall Acceptance Potential
WSCC	West Sussex County Council
WTW	Wastewater Treatment Works

Executive summary

The ‘Lidsey’ Surface Water Management Plan (SWMP) is led by West Sussex County Council as part of its role as the Lead Local Flood Authority and is jointly funded by Southern Water Services (SWS).

Atkins was appointed in January 2013 by SWS, in partnership with WSCC, to produce a study to form the basis of the SWMP. This study has been named the Lidsey SWMP as the area covered generally matches that of Southern Water’s Lidsey wastewater drainage catchment covering Barnham, Eastergate, Elmer, Felpham, Middleton-on- Sea, Walberton, Woodgate and Yapton in West Sussex.

The study area includes a region of approximately 18.2 km^2 and contains 14,500 addressed properties. Localised flooding from coastal, fluvial, sewer, groundwater and surface water sources are known to occur within the Lidsey catchment. Often these sources of flooding are interdependent with one another. As such an integrated drainage study to assess the associated risk was required.

The SWMP is intended to bring together primary stakeholders to share data and expertise in order to evaluate flood risk from the varying sources of flooding and develop an agreed ‘Action Plan’ to reduce or mitigate flood risk both now and in the future. The SWMP provides an evidence base of historical flooding and also determines likely current and future flood risk.

This study has been produced in accordance with Surface Water Management Plan Technical Guidance (DEFRA, 2010) and follows the four phased approach:

Phase 1 – Preparation
Phase 2 – Risk Assessment
Phase 3 – Options
Phase 4 – Implementation and Review

Phase 1 – Preparation
Phase 1 included data collection, data gap analysis and building relationships with the Partners and Stakeholders. The key Partners in the study were:

- West Sussex County Council.
- Southern Water Services
- Arun District Council.
- Environment Agency.

Phase 2 – Risk Assessment
Phase 2 identified 27 Local Flood Risk Zones (LFRZs) which were subjected to flood risk assessments at strategic, intermediate and detailed level.

Questionnaires were issued to 393 properties within the catchment; 106 (38%) responses were returned. The responses were vital in understanding the flood mechanism, flood frequency and flood extents. Questionnaires were not issued to all LFRZs but limited to those where predicted surface water flood risk was in particular close proximity to occupied buildings.

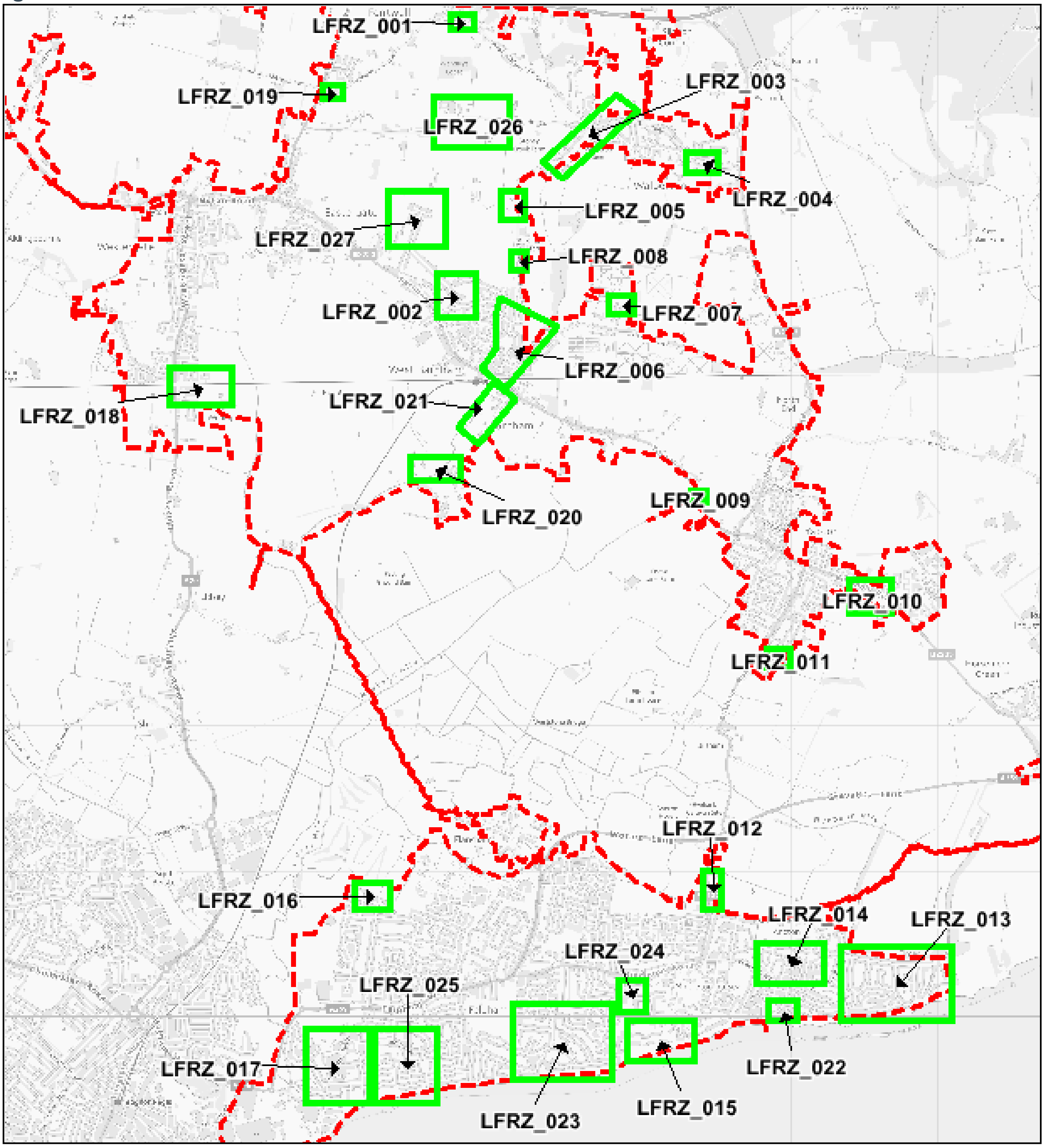
Integrated hydraulic modelling was completed at each of the LFRZs to assess flood risk in more detail from the multiple sources including consideration of surface water (pluvial flooding), sewer flooding, groundwater flooding, main rivers flooding and ordinary watercourses (where adequate drainage details was available).

Storyboards assessing flood mechanism and the source of flooding have been prepared for 26 of the LFRZs. Figure i shows the location of the LFRZs assessed.

A full analysis was undertaken of the integrated modelling which identified there are 592 residential properties and 215 non-residential properties at risk across the catchment for a 3.33% probability storm event.

An economic impact analysis for prioritising level of risk across the 27 LFRZs was carried out to provide high-level Weighted Annual Average Damage (WAAD) assessments in line with national assessment standards.

Figure i – Local Flood Risk Zones



Phase 3 – Options

Options were strategically assessed for each of the LFRZs using an integrated hydraulic model to determine the most appropriate method of reducing flood risk. This approach ensured assessment of the potential benefits from runoff retention, SUDS (water butts / permeable paving), public sewer infiltration reduction and sewer sealing, and increased conveyance. This assisted in providing a suitable screening of strategic options available within each LFRZ.

A high-level scoring system was used across each of the LFRZs to assess targeted options available and short list the preferred interventions. This approach aligns with the FCERM and Defra's SWMP Guidance.

Phase 4 – Implementation and Review

A schedule of strategic opportunities have been identified and categorised under strategic, planning and management workflows. These look to address or positively influence general flooding issues within the SWMP area in its entirety including areas outside of the LFRZs assessed. These should be advanced by the Partners to assist with flood management.

Responsibility has been allocated for each action to dedicated Partner(s).

An action plan for each of the 27 LFRZs has also been produced detailing more specific locally targeted measures which should be advanced by the Partners and Stakeholders to seek long term solutions or interventions which will reduce the impact of flooding. These actions have been ranked based on the LRFZ prioritisation.

All Partners are committed to progress with these actions based on suitable strategic prioritisation within their respective organizations.

A selection of the 25 strategic actions detailed in the SWMP is detailed below:

SO Action 15 - **Undertake strategic feasibility studies**, in order of priority, to confirm the significant level of flood risk predicted by the study and use as justification for possible FDGiA funding applications.

SO Action 25 – Drainage Strategy Framework – Undertake a hydraulic appraisal of the public sewer system in relation to the catchment drainage systems. Progress the findings and recommendations from the Lidsey SWMP and infiltration reduction strategies.

SO Action 5 - Planning - Utilise the Flood / Hazard Maps presented in the SWMP to ensure suitable planning control is implemented within the Lidsey SWMP study area in areas prone to flooding. Refer to Appendix A - Plan 7, 8 and 9 for a 1 in 30, 1 in 100 and 1 in 1000 return period flood hazard plans. In addition, Appendix A – Plan 10, 11 and 12 provides plans of the predicted flood depths for a 1 in 30, 1 in 100 and 1 in 1000 return period.

SO Action 23 - Riparian Ownership - Raise awareness of riparian owner responsibilities to ensure maintenance duties are implemented.

SO Action 13 - Improve Hydrometric Data - Provide improved hydrometric data (continuous ground water monitoring and flow monitoring) for the Lidsey catchment where funding can be identified. This will assist with understanding drainage system response to ground water and rainfall. Also enable better understanding as the successful use of soakaway and allowances in SUDS designs.

SO Action 9 - Hydraulic Studies- Carry out more detailed studies including further investigation of the technical issues and consultation with local Stakeholders.

It is recommended that the SWMP action plan is used as a working document that is implemented and subjected to formal feedback and review, with new information being taken into account where appropriate, in order to maximise the flood risk management potential of the document. The responsibility for ensuring this document remains current shall sit with West Sussex County Council as the Lead Local Flood Authority.

1. Study Introduction

1.1. Introduction

The 'Lidsey' Surface Water Management Plan (SWMP) is led by West Sussex County Council, the Lead Local Flood Authority. The study was jointly funded by West Sussex County Council (WSCC) and Southern Water Services (SWS). In January 2013 Atkins was appointed by SWS, in partnership with WSCC, to produce a study to form the basis of the SWMP. The study has been named the Lidsey SWMP as the area covered generally matches that of the Southern Water Lidsey wastewater drainage catchment covering Barnham, Eastergate, Elmer, Felpham, Middleton-on- Sea, Walberton, Woodgate and Yapton in West Sussex.

This Surface Water Management Plan has been prepared by Atkins working in Partnership with West Sussex County Council (WSCC), Arun District Council (ADC), Southern Water Services (SWS) and the Environment Agency (EA), in accordance with the Surface Water Management Plan Technical Guidance issued by Defra in March 2010. In response to changing policy requirements, and better information this report should be subject to regular review and updated as required.

1.2. General Background

The Preliminary Flood Risk Assessment indicates that West Sussex has 76,600 properties identified as being at risk from surface water flooding. West Sussex has 80 settlements listed in the Defra's National Rank Order of Settlements to surface water flooding (Defra 2009). Within these 80 settlements approximately 29,000 properties are considered at risk. Westergate / Barnham / Yapton are ranked 321 out of 4,215 settlements nationally and 9th in West Sussex. Walberton is ranked 1,517th nationally and 26th in West Sussex as shown in Table 1.1.

Table 1-1- Defra's National Rank Order of Settlements to surface water flooding (Defra 2009)

National Settlement Rank (From 4,215 Total)	West Sussex County Settlement Rank (From 80 Total)	Settlement Name	Local Authority (County / Unitary)	Estimated Number of Properties at Risk from sever rainfall
321	9	Westergate / Barnham/ Yapton	West Sussex County	1000
1,517	26	Walberton	West Sussex County	90

As the Tier 1 Local Authority, West Sussex County Council is responsible for the management of local flood risk which includes both surface water and ground water sources. The Lidsey SWMP study area has been identified by West Sussex as an area susceptible to surface water flooding based on the Defra's National Rank Order of Settlements to surface water flooding (Defra 2009) and from persistent history of reported and confirmed flooding.

1.3. What is a Surface Water Management Plan?

A Surface Water Management Plan (SWMP) outlines the preferred surface water management strategy in a given location.

In this context, surface water flooding describes flooding from sewers, drains, ditches and watercourses (including main river watercourses) and ground water that occurs during or after heavy rainfall in urban areas. It includes:

- **Pluvial flooding** – flooding as a result of high intensity rainfall when water is ponding or flowing over the ground surface (surface runoff) before it enters the underground drainage network or watercourse, or cannot enter it because the network is full to capacity.

- **Foul Sewer flooding** – flooding which occurs when the capacity of underground systems is exceeded - surface water cannot enter the system resulting in flooding inside and outside of buildings. Normal discharge of sewers and drains through outfalls may be impeded by high water levels in receiving waters. Surface water should not enter foul designed sewer systems as this may lead to hydraulic overload and flooding.

- **Flooding from open-channel and culverted urban watercourses** which receive most of their flow from inside the urban area.

- Overland flows from the urban/rural fringe entering the built-up area, including **overland flows from ground water springs**.

The Surface Water Management Plan (SWMP) process is a framework through which key local Partners with responsibility for surface water and drainage in their area work together to understand the causes and effects of surface water flooding and agree the most cost effective way of managing surface water flood risk for the short, medium and long term. The process of working together as a Partnership is designed to encourage the development of innovative solutions and practices and optimise the use of resources. The purpose is to make sustainable surface water management decisions that are evidence based, risk based, future proofed and inclusive of stakeholder views and preferences.

The SWMP is the culmination of this collaborative process; a description of the level of risk posed and an agreement about who will do what to better manage these risks. A SWMP should establish a long-term action plan to manage surface water in an area and influence future capital investment, drainage maintenance, public engagement and understanding, land-use planning, emergency planning and future developments.

1.4. SWMP Aims and Objectives

An important part of an SWMP is the establishment of objectives. This ensures all Partners have a stake in the direction of the SWMP. The objectives will allow clarity and transparency throughout the scheme and help focus the Partners on the desired outcome and comprise of the following:

- **Develop understanding of surface water flood risk.** Consideration of growth, climate change and urbanisation shall be included within the SWMP study area.

- **Identify, define and prioritise Local Flood Risk Zones** (LFRZs) and undertake more detailed evaluation of the critical drainage infrastructure.

- Identify recommendations which provide an integrated management involving a holistic approach to **improve emergency planning and land use planning**. Production of flood mapping and flood risk mapping based on the data available will provide a clear overview of the predicted 'at risk' locations from main river / coastal flooding, surface water (Pluvial) flooding, ground water flooding.

- **Establish and develop Partnerships between key Stakeholders.** Provide a structure to enable data sharing, sharing of resources, skills. Promote coordination and collaboration.

- **Communicate flood risk to Stakeholders**. Identify the flood risk and critical flood risk assets. Agreement of mitigation measures, responsibilities and actions.

- **Identify 'Quick Win' opportunities** which will reduce flood risk or consequence of flooding. Any opportunities will become apparent during the Risk Assessment phases and will be communicated to the Partners. Identifying and implementing such activities may offer immediate improvements to the performance of the drainage assets and offer improved flood resilience to residents.

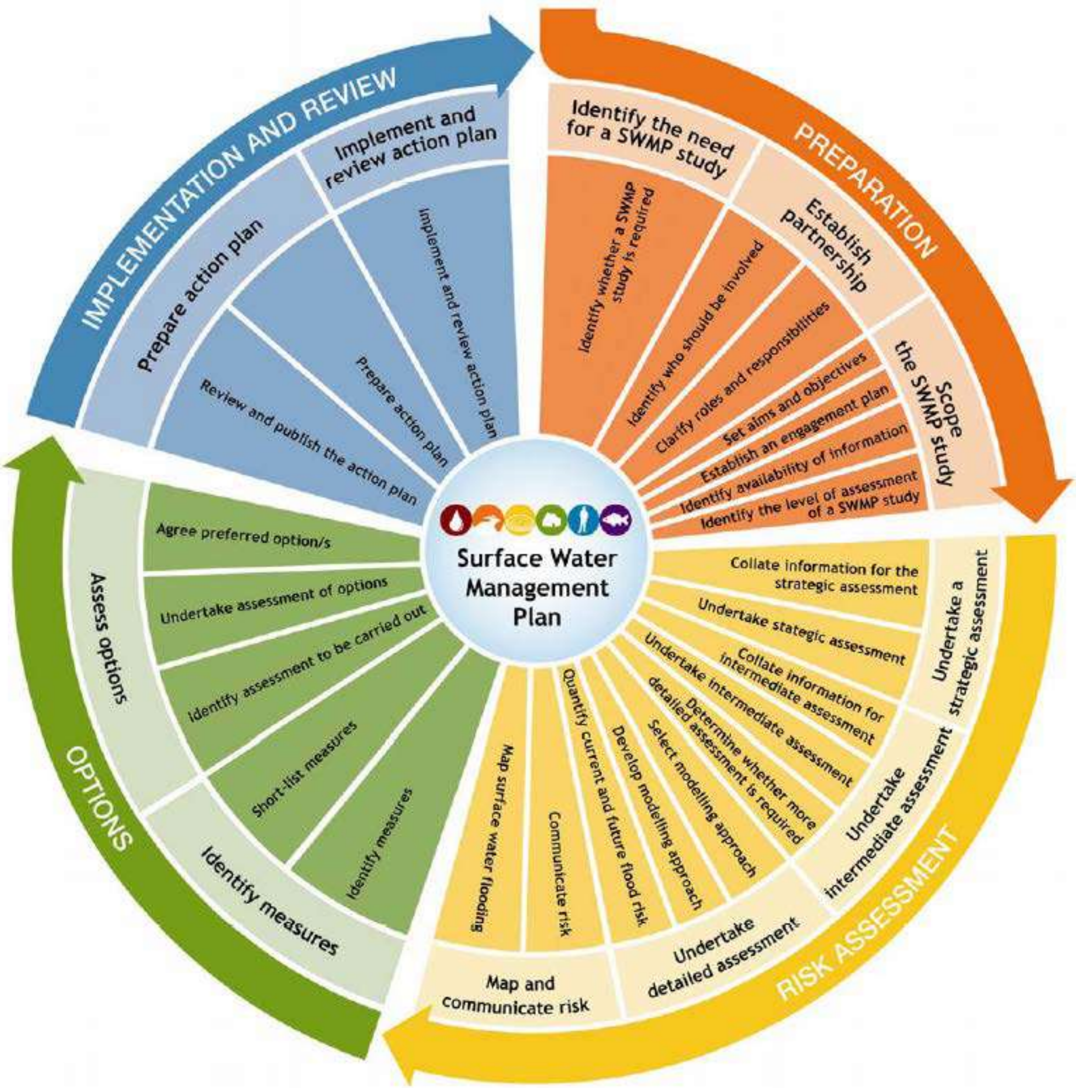
- The output from the SWMP will be a report documenting the work undertaken, the flood needs identified and an action plan of further work. Partners and Stakeholders shall take ownership and responsibility of the **"live action plan"** committing to delivering and maintaining this as a live document as measures and recommendations are progressed.

1.5. SWMP Process

The framework for undertaking a SWMP study is shown in Figure 1.1 and comprises four principal phases.

- The **Preparation** phase which primarily involves client engagement, driver identification, data gathering, data gap analysis and survey.
- The **Risk Assessment** involves the process by which risk of flooding is assessed. This includes aspects such as hydraulic modelling (commonly integrated urban drainage modelling) and flood mapping to identify the level of likely flood risk.
- The **Option Assessment** phase requires the confirmed flooding needs to be assessed with particular emphasis on resolving the confirmed risk.
- The **Implementation and Review** phase requires the review and monitoring of the confirmed flooding needs and the effectiveness of the schemes implemented.

Figure 1.1 - Surface Water Management Plan Wheel (taken from SWMP guidance)



1.6. Study Area

The Study area includes the full extent of the Lidsey wastewater drainage catchment which is located between the towns of Chichester Littlehampton, Bognor Regis and Arundel in West Sussex, and serves a population of approximately 30,800. The study area extends beyond the Lidsey Wastewater drainage catchment to include Felpham. The catchment is considered rural, covering an area of approximately 18.21 km^2. The extent of the study area is shown in Figure 1.2. It should be noted given the interactions of the rural landscape around the study area consideration of the rural areas immediately surrounding the study area has also been considered as part of this assessment. In addition flows routing into these water bodies was considered

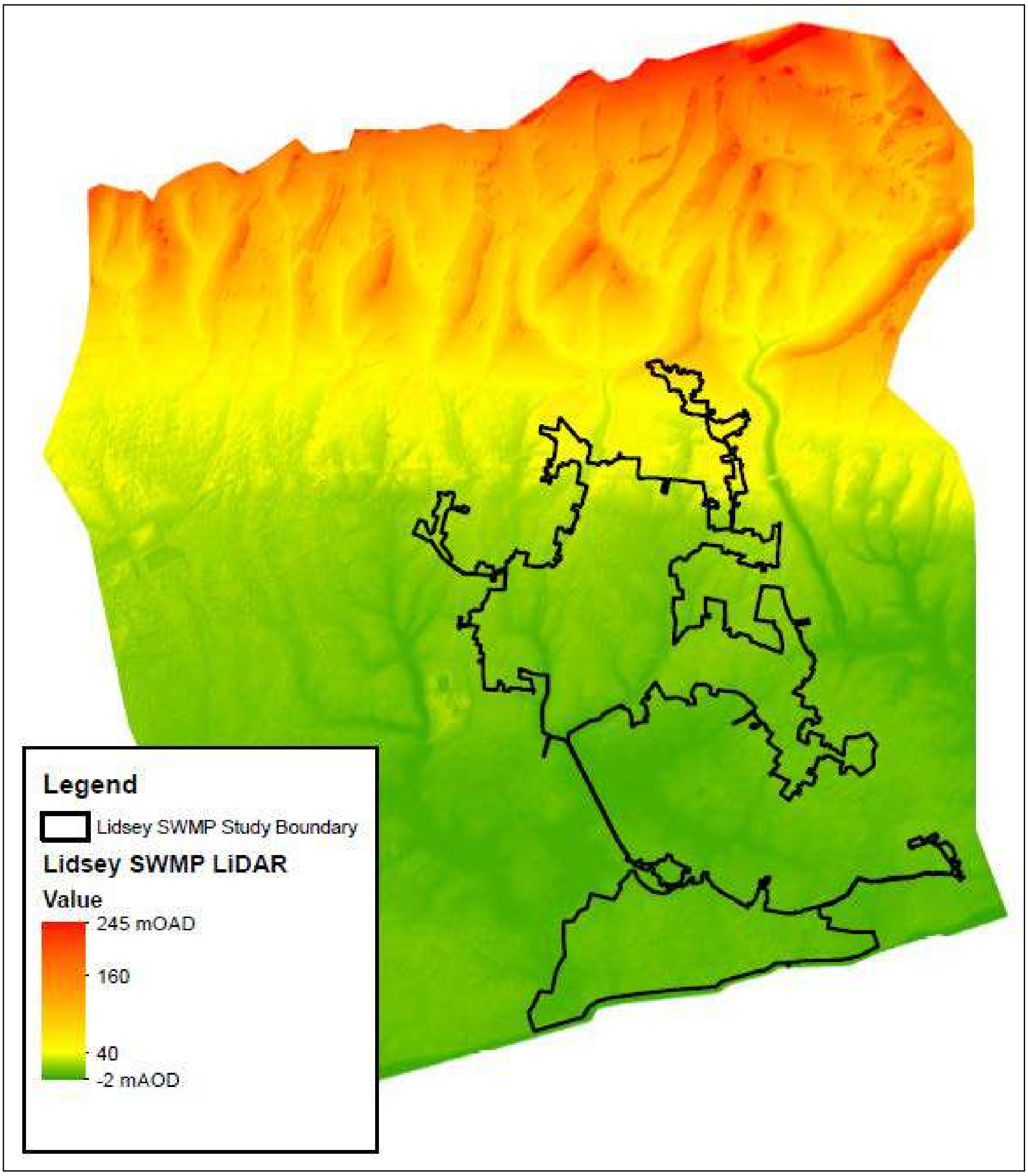
Figure 1.2 - Study Area

The topography of the catchment is generally flat with contours varying from 30m AOD at Slindon in the north, to 5m AOD at Middleton on Sea in the south as shown in Figure 1.3.

Geological maps show significant variance in the underlying strata across the catchment. To the south of the catchment, Middleton, Horsemere Green and Yapton are underlain by brickearth, comprising mainly silts in part contaminated with gravel, over Upper Chalk. Further North, Barnham, Eastergate, Westergate and Walberton are underlain by brickearth and river deposits over London Clay. In the far north of the catchment, Slindon is underlain by Reading Formation Clays and clayey gravel, over Upper chalk

The River Arun skirts the eastern edge of the Lidsey catchment, close to Horsemere Green and Climping. Barnham Rife flows from north to south through Barnham, before joining with the Lidsey Rife north of Flansham. Aldingbourne Rife flows north to south from Aldingbourne, in the west of the catchment, to Felpham, where it is joined by the Lidsey Rife and then discharges to the English Channel

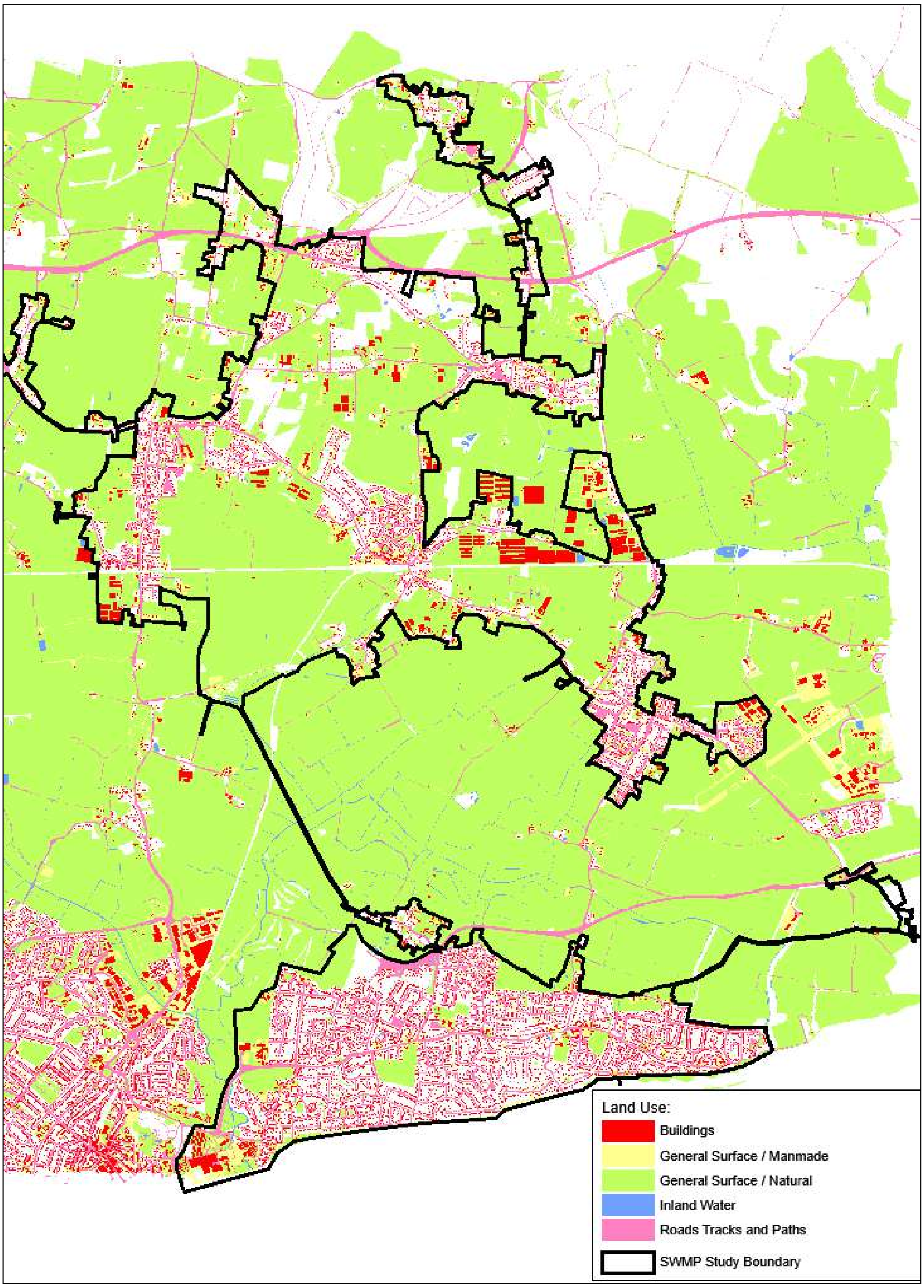
Figure 1.3 - Study area topography



1.7. General Land Use

The predominant urban land use of the study area is largely residential. Much of the study area is located in a rural setting with surrounding agricultural fields, nurseries and green field open spaces. A plan showing the study area and the land features derived from the OS Mastermap land use classifications is shown as Figure 1.4.

Figure 1.4 - General Land Use



1.8. Geology

The soil hydrology and geology has a significant influence on flood risk as it has direct bearing on rates of infiltration, runoff which directly influences ground water flooding. A review of the soil and geology has been undertaken as part of the catchment assessment.

1.8.1. Soil

Soil hydrology is a defining factor in runoff generation from the land surface, especially in rural areas. Infiltration of rainwater into a soil is dependent on the small amounts of storage between soil particles – soil porosity. Soils with a higher porosity (such as sandy soils) can potentially store more water than those with a lower porosity (such as clayey soils). Soils with a higher porosity can also absorb water more quickly. Water that cannot infiltrate into a soil (or that is not lost to evaporation) will form runoff over the land surface.

The hydrology of different soil types in the UK are summarised by their Winter Rainfall Acceptance Potential (WRAP types 1 - 4). These are generalised values which classify a soil type by how effectively it can absorb winter rainfall; Type 1 describes freely draining soils, where Type 4 defines poorly draining soils. There is a fifth soil type relating to peaty, waterlogged upland soils, however this is rarely used in the England. Descriptions of the various soil types are shown in Table 1.2

Table 1-2- Wallingford WRAP Soil Types

WRAP Type	Description
1	(i) Well drained permeable sandy or loamy soils and shallower analogues over highly permeable limestone, chalk, sandstone or related drifts. (ii) Earthy peat soils drained by dikes and pumps (iii) Less permeable loamy over clayey soils on plateaux adjacent to very permeable soils in valleys.
2	(i) Very permeable soils with shallow ground-water (ii) Permeable soils over rock or fragipan, commonly on slopes in western Britain associated with smaller areas of less permeable wet soils (iii) Moderately permeable soils, some with slowly permeable subsoils
3	(i) Relatively impermeable soils in boulder and sedimentary clays, and in alluvium, especially in eastern England (ii) Permeable soils with shallow ground-water in low lying areas (iii) Mixed areas of permeable and impermeable soils, in approximately equal proportions
4	Clayey, or loamy over clayey soils with an impermeable layer at shallow depth
5	Soils of the wet uplands, (i) with peaty or humose surface horizons and impermeable layers at shallow depth, (ii) deep raw peat associated with gentle upland slopes or basin sites, (iii) bare rock cliffs and screes and (iv) shallow, permeable rocky soils on steep slopes

The soil conditions for the study catchment are varied and contain WRAP soil classes 1, 2, and 3.

There are also local effects which can impede soil drainage, independent of the generalised soil hydrology. These include:

- Local compaction of soil caused by frequent trampling or use of heavy machinery when soils are wet. This can create an impermeable layer at, or beneath the surface of the soil.
- Changes in soil hydrology caused by land use or management e.g. arable farming.
- Waterlogged soil where either the soil storage has been fully utilised during a storm event, or the water table is relatively high and has utilised soil storage.

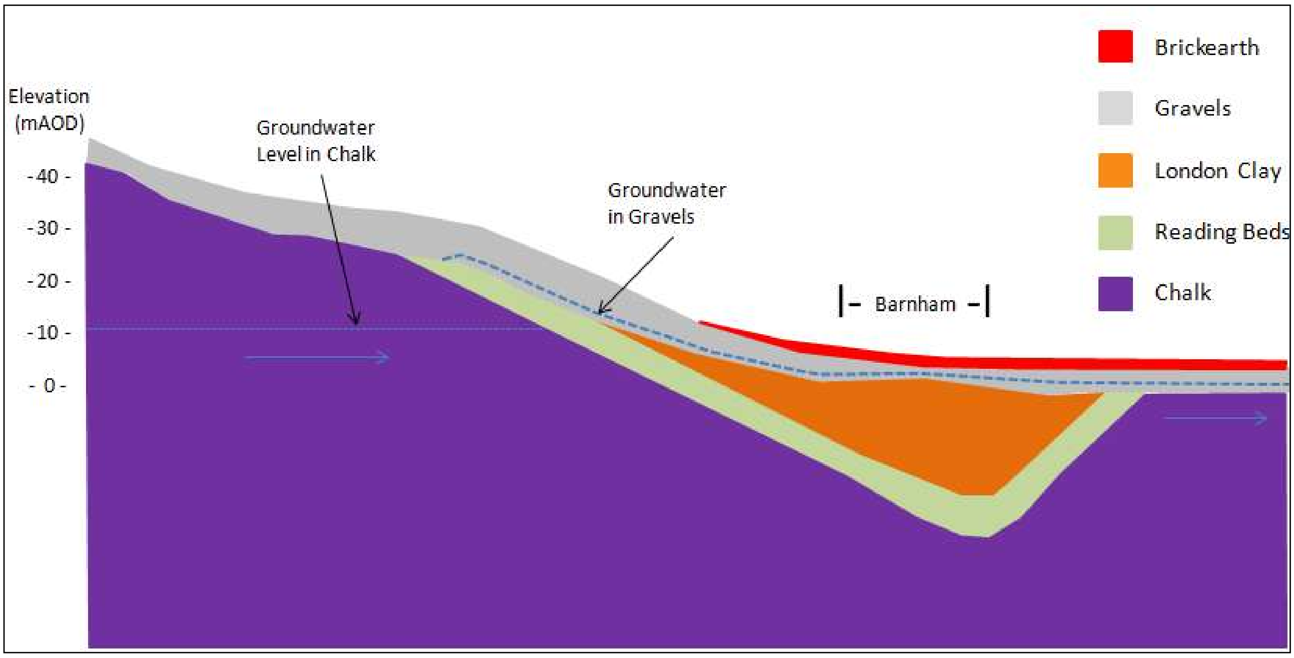
A review of borehole records provided on the British Geological Society (BGS) website indicates that the soil depth ranges from 1.0 to 3.0m but on average the depth of soil is approximately 1.5m. Thereafter, the boreholes indicate that the soil layer is largely underlain by brickearth geology which overlays upper chalk or gravels.

The Soilscapes Viewer (NSRI) indicates that the soil has a loamy texture and is freely draining, but considers Woodgate and Barnham to be "naturally wet" and affected by high ground water levels. This is further supported by local borehole records which substantiate high ground water levels typically during the winter months. Ground water readings of up to 0.3m below ground level have been recorded in central Barnham Village.

1.8.2. Geology

The geology of Barnham consists of superficial deposits, London Clay, and Chalk and is shown conceptually in Figure 1.5. The information presented in this figure has been derived from a report which was initially produced by the EA and provided by the Barnham Flood Group titled "Surcharging of Sewers in the Barnham Area" (Grey, 1998).

Figure 1.5 - Barnham Geology



While the bed thickness will vary across the catchment, British Geological Society (BGS) borehole records would suggest the typical profile is:

- 1 to 3m of brickearth (silt);
- 3 to 5m of raised beach deposits (sands and gravels);
- London Clay; and
- Chalk.

A detailed plan of the catchments geology is presented in Appendix A – (Plan 2).

Both the chalk and the superficial deposits (brickearth / gravels) are both aquifers which often work independently of one another. The exception of this is when groundwater levels in the chalk are high and reach into the superficial deposits. Rain falling on the South Downs feeds into the chalk aquifers and the superficial deposits receive rainfall on the coastal plains. Emergence of groundwater is generally not widespread and only tends to occur in discrete locations. Groundwater emergence typically occurs when the reading bed constricts the flow of water through the chalk. The locations of restrictions and emergence are not always fully known. It is not uncommon for groundwater emergence to change in its location and its frequency can often unpredictable which typically makes it difficult to manage and or mitigate.

1.9. Development

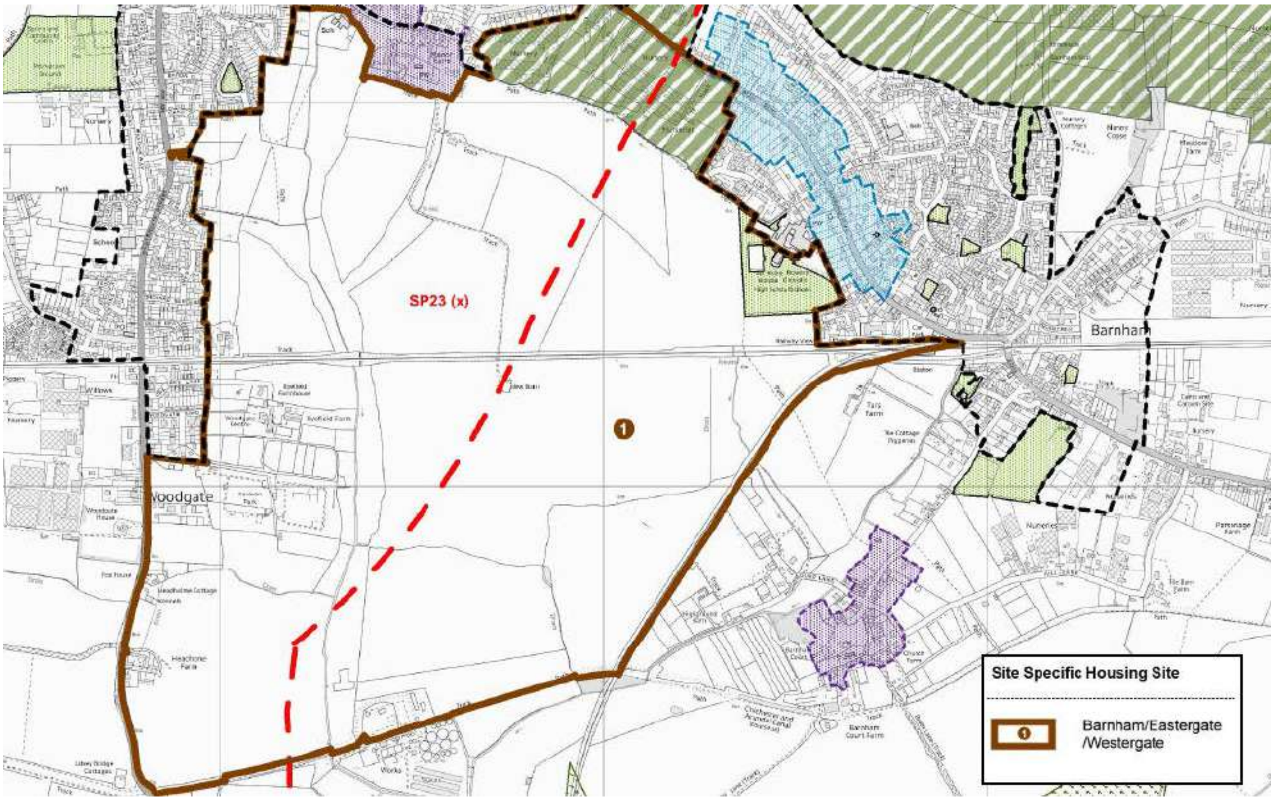
At the time of production the SWMP the latest version of the emerging Local Plan was the publication version of the Local Plan (Regulation 19) excluding the spatial portrait, employment and enterprise, housing allocations, transport, monitoring, and implementation sections, dated February 2014, which specifically included a section on water and was not expected to change,

The ADC Local Plan is currently being finalised and when complete will establish a defined plan for future sustainable growth for the area to 2029. It has been developed to guide developers and decision makers on the most appropriate forms of development for the ADC Local Planning Authority Area. The Local Plan seeks to safeguard new road routes, allocate land for significant housing development and protect other land from development. This strategic framework will help guide and determine future planning applications. The Local Plan is currently in draft form and is due to be issued in late 2014. The current available draft version available at the time of this report production is dated Summer 2013.

Within the SWMP study area a single housing development site has been identified in Barnham / Eastergate / Westergate in the LP. The forecasted total number of housing units for this site is for 2,004; proposed for completion by 2028-2029.

Figure 1.6 has been extracted and adapted from the ADC Draft Local Plan.

Figure 1.6 - Local Plan Development Site



It should be noted that smaller scale infill development may also occur within the catchment placing additonal stresses on existing drainage infrastructure. Visability as to the extent and numbers of infill development is not currently clear.

1.10. Mechanisms and Sources of Flooding

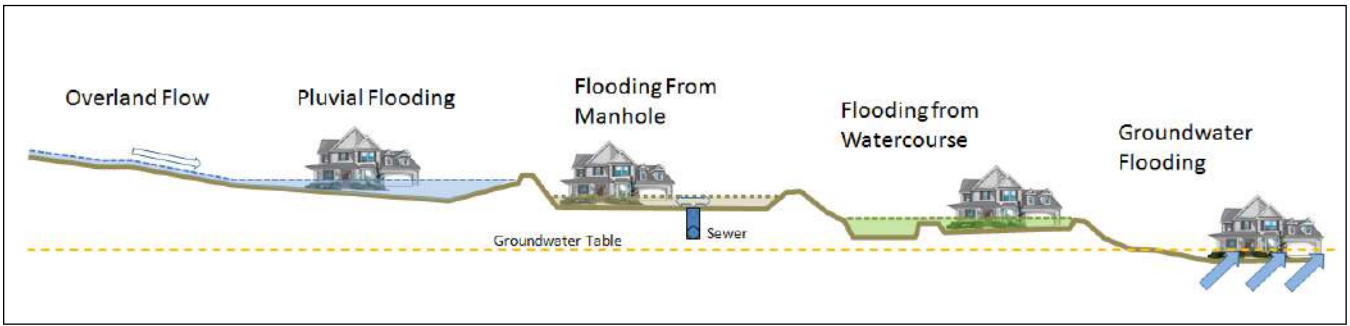
Extreme storm events will typically cause flooding from a number of different sources via a variety of flood mechanisms. Typical mechanisms that may have occurred in the past during the extreme flood conditions may include:

- **Overland Flow.** When water flows over the surface of the ground. This occurs for a number of reasons: the soil may be saturated and therefore be unable to absorb any more water; the underlying rock may be impermeable or the ground may be frozen. Dry hot conditions can also lead to hard baked grounds which can increase runoff from surfaces which are normally permeable i.e. fields or grassed verges. In urban areas impermeable surfaces such as roofs, roads, carparks, patios and driveways may also generate and contribute to overland flow once the capacity of the receiving drainage systems are exceeded.
- **Pluvial Flooding.** Surface water runoff; runoff as a result of high intensity rainfall when water is ponding or flowing over the ground surface before it enters the underground drainage network or watercourse, or cannot enter it because the network is full to capacity, thus causing flooding. In some instances the rate of infiltration into the ground is exceeded by the rate of rainfall which will also cause pluvial flooding.
- **Sewer Flooding.** Flooding which occurs when the capacity of underground systems is exceeded due to heavy rainfall, resulting in flooding inside and outside of buildings. Note that the normal discharge of sewers and drains through outfalls may be impeded by high water levels in receiving waters as a result of wet weather or tidal conditions
- **Fluvial Flooding.** caused by exceedance of a river's channel capacity from storm water from the catchment.
- **Ground Water Flooding.** caused by elevated ground water exceeding ground level at spring points. This is particularly of issue and risk in catchments containing chalk.

It is accepted that these sources of flooding may occur independent of one another or as a combination, e.g. pluvial flooding may subsequently cause hydraulic overload of the public foul / combined sewer system through surface water entering via manholes or property gullies. Given the type of flooding experienced in the Lidsey catchment the SWMP will consider flood risk from an integrated perspective to give a holistic view of flood risk and flood hazard.

These flood mechanisms are depicted in Figure 1.7.

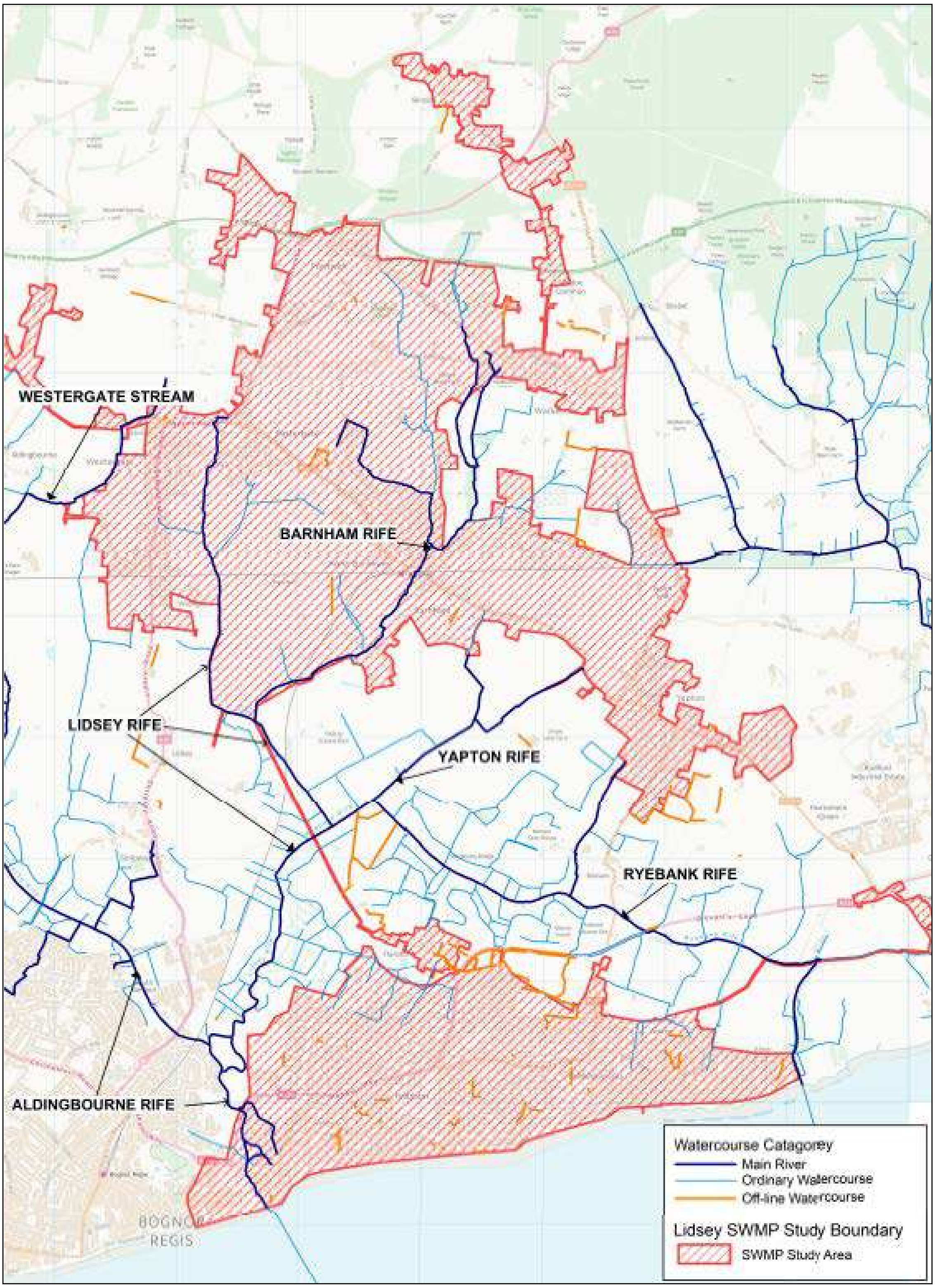
Figure 1.7 - Mechanisms and Sources of Flooding



1.11. Main Rivers / Culverted Watercourses (EA Assets)

Main rivers are strategically important rivers or watercourses that carry significant flood risk. They are defined by Defra and shown on EA Main River Map. The EA have permissive powers to carry out work on main rivers. Main rivers located in the Lidsey SWMP Study are shown in Figure 1.8.

Figure 1.8 - Main Rivers in the study area

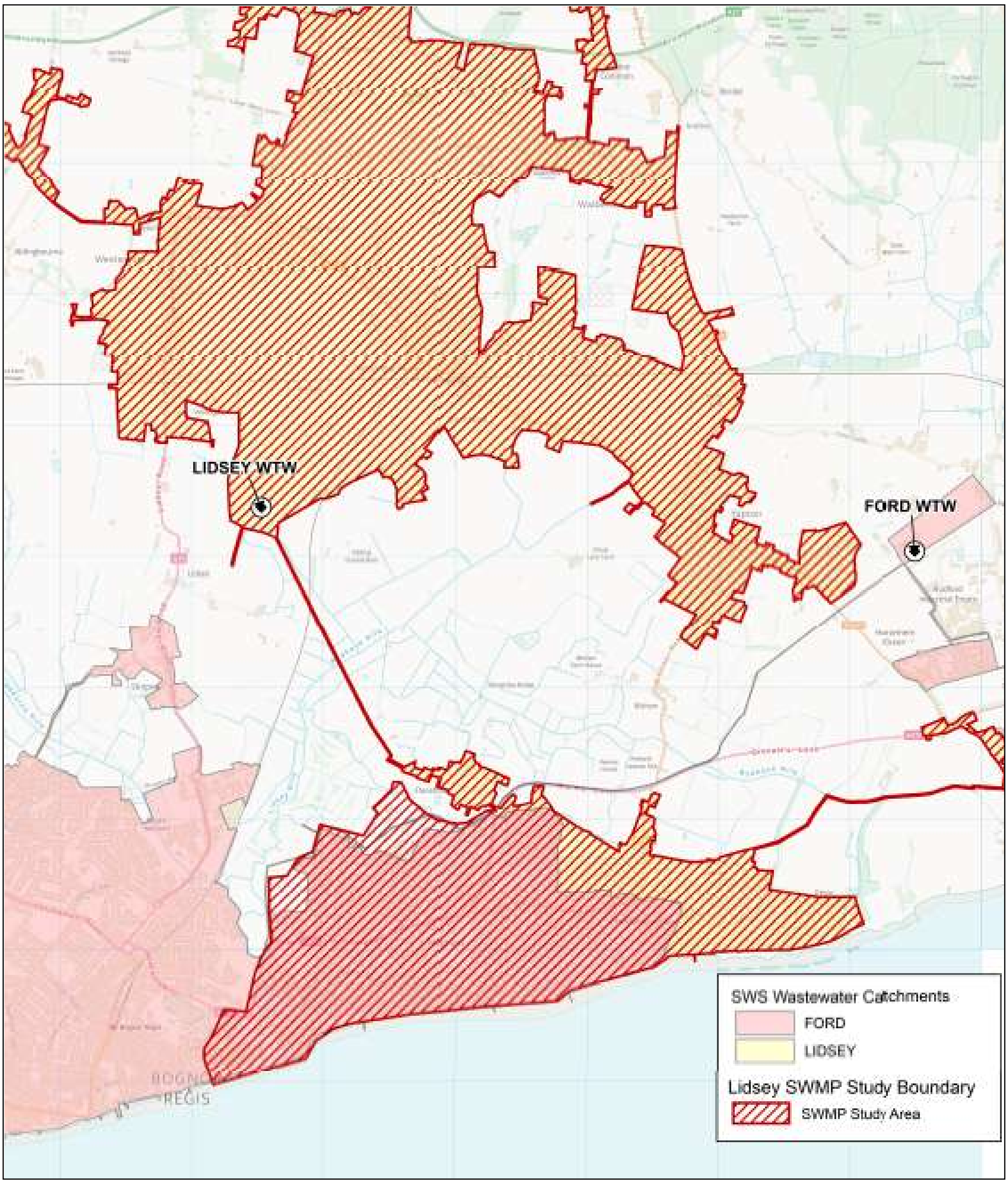


1.12. Public Sewer System (Southern Water Assets)

The public sewer system can comprise separate foul and surface water systems or a combined network. The majority of designated foul systems actually have some form of surface water response and so are considered combined.

The Lidsey SWMP study area overlaps with two Southern Water Services (SWS) wastewater treatment catchments; Lidsey and Ford as shown in the Figure 1.9. The Lidsey wastewater catchment is fully encompassed within the SWMP study area. The majority of Middleton and Felpham are located within the Ford wastewater catchment area. Both the Lidsey and Ford public sewer networks comprise of a mixture of separate and combined sewerage assets.

Figure 1.9 - SWMP and Wastewater Catchment Boundaries



Lidsey WTW is located approximately 800m south of Woodgate and 900m south west of Barnham. The public system is made up mostly of separate sewerage systems, with only very limited areas of combined sewer drainage. Flows arrive at the Lidsey WTW from three sources:

- Hoe Lane Wastewater Pumping Station (WPS) rising main;
- the 350mm and 375mm gravity sewers from Barnham; and
- a 450mm gravity sewer from Westergate.

The three gravity sewers drain to a 600mm diameter inlet sewer which flows to the terminal pumping station within the WTW compound. This terminal pumping station, and the rising main from Hoe Lane WPS, discharge at the inlet channel to the WTW. Following primary and secondary treatment at the WTW, effluent is discharged to the Lidsey Rife. Flows arriving at the WTW are consented to pass 129 l/s pass forward for treatment and all other flows in excess of 129 l/s discharge to storm.

Foul flows in the majority of Middleton (with the exception of Elmer) and Felpham region are pumped in a north-easterly direction to Ford WTW.

Southern Water’s sewer records show 149.8 km of foul sewers, 51.5 km of storm and 0.4 km of combined sewers in the SWMP study area. These records will not fully include those sewers which have been transferred in ownership to Water Company responsibility due to changes in regulation on 1 October 2011.

1.13. Highway Drainage Systems

The results from Impermeable Area Surveys (IAS) commissioned by Southern Water for wastewater modelling studies provide a good indication as to the disposal method of surface water in the urban regions of the SWMP study area. The survey results show that surface water disposal from roofs and hard standing (impermeable) surfaces primarily drain to soakaway systems which allow runoff to infiltrate into the ground. There are also urban areas served by separate public surface water sewers which convey rainfall runoff to a defined outfall point i.e. river (main or ordinary) or coastal outfall. The IAS and historic flow survey information also provide evidence that roofs and hard standing areas connect directly into the public foul sewer system. While the public combined sewer would have made allowances for surface water inflow as part of the original design, it is important to recognise the foul sewer system would not have been designed to accommodate these flows.

Highway drainage maintenance is primarily the responsibility of West Sussex Highways which has a duty for general maintenance activities associated to the operational condition and drainage of adopted highways. Private (un-adopted) roads are not maintained by the County Council. Unadopted roads are generally in a condition not meeting the standard of adopted roads and the responsibility for repairs and maintenance lies with the street owners. These are usually the people who live on the road. The maintenance and management of motorways and trunk roads in West Sussex (A27, A23 and M23) is the responsibility of the Highways Agency.

Highway runoff is typically drained via gullies into soakaways or piped into local watercourse (main or ordinary).Highway drainage records are limited within the study area but, WSCC has provided as much information as possible to assist with the study. Within the study area there are 934 gullies registered on WSCC asset database, however, the actual number of gullies in operation will be greater than this. The database comprises the location of the gullies and date of previous cleansing works.

1.14. Ordinary Watercourses

All watercourses that are not designated Main River are considered to be ordinary watercourses. This includes every river, stream, ditch, drain, dyke, sluice, sewer (other than a public sewer) through which water flows. Note, ordinary watercourse does not imply a “small” river, although it is often the case that ordinary watercourses are smaller than Main Rivers. Maintenance of the watercourses is the responsibility of landowners but West Sussex County Council has permissive powers to carry out flood defence works

The Environment Agency is the Internal Drainage Board (IDB) within West Sussex. An IDB is a public body that has been established under statute in areas of special drainage need. The EA has permissive powers to undertake work to deal with matters affecting water levels, land drainage and flood risk in specified areas.

1.15. Drainage Layout

Appendix A - (Plan 2) – Drainage Layout provides a plan of the drainage assets in the study area. This includes public sewers, main rivers, ordinary watercourses and highway drainage systems. This information has been brought together from multiple data sources.

1.16. Lidsey Surface Water Management Plan

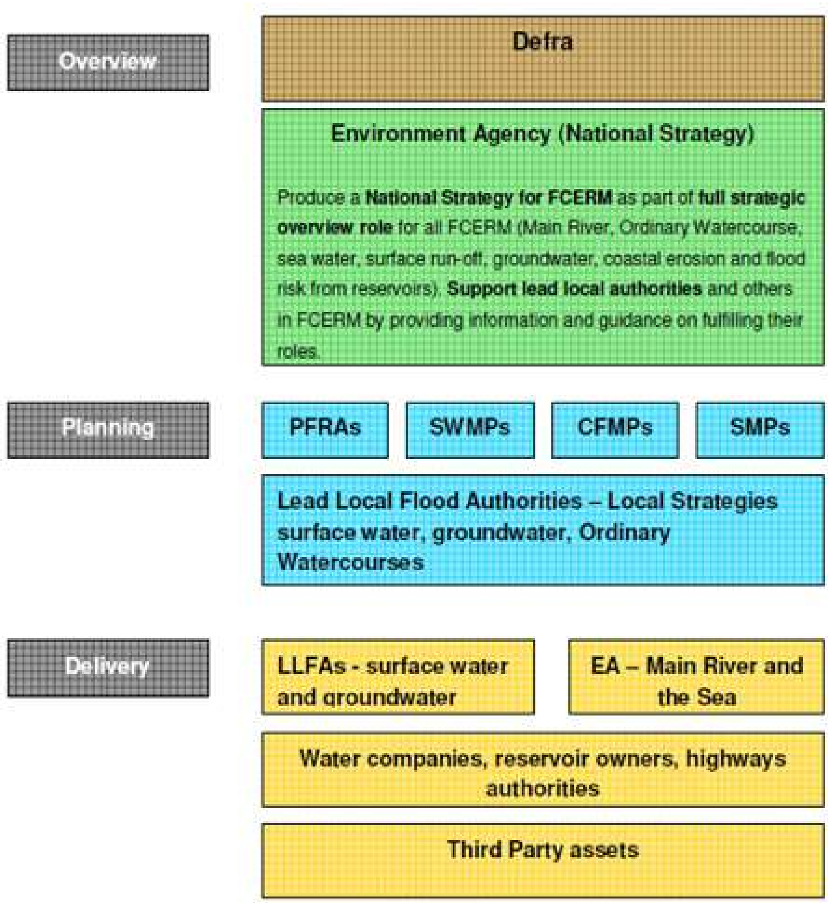
This report has been prepared to document the work undertaken as part of Lidsey SWMP. It has been structured to follow the SWMP process outlined in Section 1.5. Section 2 of this report discusses relevant Legislation and Related Studies. Sections 3 to 10 then cover the various stages of the SWMP process.

2. Legislation & Related Studies

2.1. Introduction

The SWMP should not be considered in isolation as the plan supports the overarching delivery of the National Strategy for Flood and Coastal Erosion Risk Management process (FCERM). Figure 2.1 illustrates how this SWMP resides in the delivery of local FCERM process, and where the responsibilities for this lie.

Figure 2.1 - National Strategy for Flood and Coastal Erosion Risk Management Process



Note: the Lead Local Flood Authority and responsibilities are outlined in section 3

2.2. Flood and Water Management Act

The Flood and Water Management Act 2010 (FWMA) addresses a number of recommendations from the Pitt Review which was initiated following the extensive flooding in 2007, and places responsibilities on the EA, Local Authorities and property developers (amongst others) to manage the risk of flooding. The Act provides a mechanism for Local Flood Risk Authorities (LFRA) to coordinate and manage flood risk on a local level, taking forward some of the proposals in previous strategy documents published by the Government including Future Water (2008), and the Flood Risk Regulation (2009).

Surface Water Management Plans (SWMPs) were introduced as a key tool to improve surface water management, focussing on reducing flood risk. They also influence the management of surface water for future development.

The FWMA reinforces the requirement to manage flooding in a holistic and sustainable manner. This view is aligned to the core principles in Making Space for Water (Defra, 2005) and later reinforced by the Pitt Review (Cabinet Office, 2008).

2.3. EU Floods Directive

The EU Floods Directive, transposed to Law in 2009 by the Flood Risk Regulations (2009), requires three outputs to be produced, as summarised below:

- **Preliminary Flood Risk Assessments** (PFRA). The LLFA and the EA were required to deliver PFRAs by 22 December 2011. (See Section 2.4.1)

- **Flood Hazard Maps and Flood Risk Maps.** For areas defined as National Flood Risk Area the LLFA and the EA were required to deliver the flood maps by 22 December 2012 to show flooding from sea, main river and reservoirs.

- **Flood Risk Management Plans**. Flood Risk Management Plans require delivery by 22 December 2015. The Flood Risk Management Plans will take forward the objectives and actions set out in Flood Risk Management Strategies. They will provide detail on the funding, timeline of delivery, arrangements and co-ordination of actions at the local level.

2.4. Links with Other Plans and Strategies

A SWMP should not be viewed as an independent document, but will need to interface with a number of other strategic plans. Relevant documentation is discussed in the following sections.

2.4.1. Preliminary Flood Risk Assessment (PFRA)

West Sussex County Council compiled information on significant local flood risk from a number of different sources (Districts and Boroughs, Southern Water, Sussex Fire and Rescue, and a public consultation) to prepare the PFRA. In addition the EA Flood Maps for Surface Water (FMfSW) were consulted in predicting the future risk from surface water flooding.

The PFRA is currently publicly available on the West Sussex website. www.westsussex.gov.uk

2.4.2. Strategic Flood Risk Assessments (SFRA)

Arun District Council prepared a Strategic Flood Risk Assessment (SFRA) to support the development of the Local Development Framework. The objective of the SFRA was to collate and review available information on flood risk within Arun District so that:

- an evidence based and risk based sequential approach can be adopted when making planning decisions, in line with PPS25;
- sustainability appraisals of the local development frameworks are supported; and
- further investigations for flood risk assessments can be identified for specific development proposals.

The Level 1 SFRA was intended to provide sufficient information to enable Arun District Council to apply the PPS25 Sequential Test to potential strategic development areas within the district when determining planning applications to ensure that development took place in areas of low flood risk.

Information was obtained from a variety of Stakeholders including the EA, Southern Water, WSCC Highways, the Internal Drainage Board and from within Arun District Council.

The SFRA is publicly available on the ADC website. www.arun.gov.uk. It should be noted that ADC are currently seeking to update the SFRA.

2.4.3. Level 2 Strategic Flood Risk Assessment (SFRA)

ADC prepared Level 2 SFRA to assist in the application of the Exception Test when determining planning applications on strategic sites which could not be located in lower flood risk flood zones. The focus of the

ADC Level 2 SFRA was on tidal flooding and the production of flood depth and hazard maps arising from the failure of existing flood defences.

The Level 2 SFRA is publicly available on the ADC website. www.arun.gov.uk.

2.4.4. Local Flood Risk Management Strategy (LFRMS)

WSCC has prepared a local flood risk strategy (consultation version) which sets out how WSCC intends to carry out its statutory responsibilities required by the Flood and Water Management Act 2010. The strategy is directly informed by the EA's National Strategy and the guiding principles of the Local Government Association Framework 'Living Document' (2nd Edition November 2011).

Flood risk has been managed between a number of authorities including West Sussex County Council, District and Borough Councils, the EA, Internal Drainage Boards, the Highways Agency and Southern Water.

The strategy defines the role that each of these organisations takes to ensure flooding from all sources is managed in a holistic and integrated way.

The strategy fully supports the existing planning process and reinforces the need for directing development away from the floodplain where possible. Responsible authorities are required to cooperate and share information, and the local flood risk strategy provides the tools to allow joint working.

Public consultation was undertaken on the Local Strategy from Monday 17 June 2013 until Monday 9 September 2013. The current versions of the strategy, maps and the consultation response document are available below. The work program that was included in the consultation is being updated and will be published on this page separately in Autumn 2014.

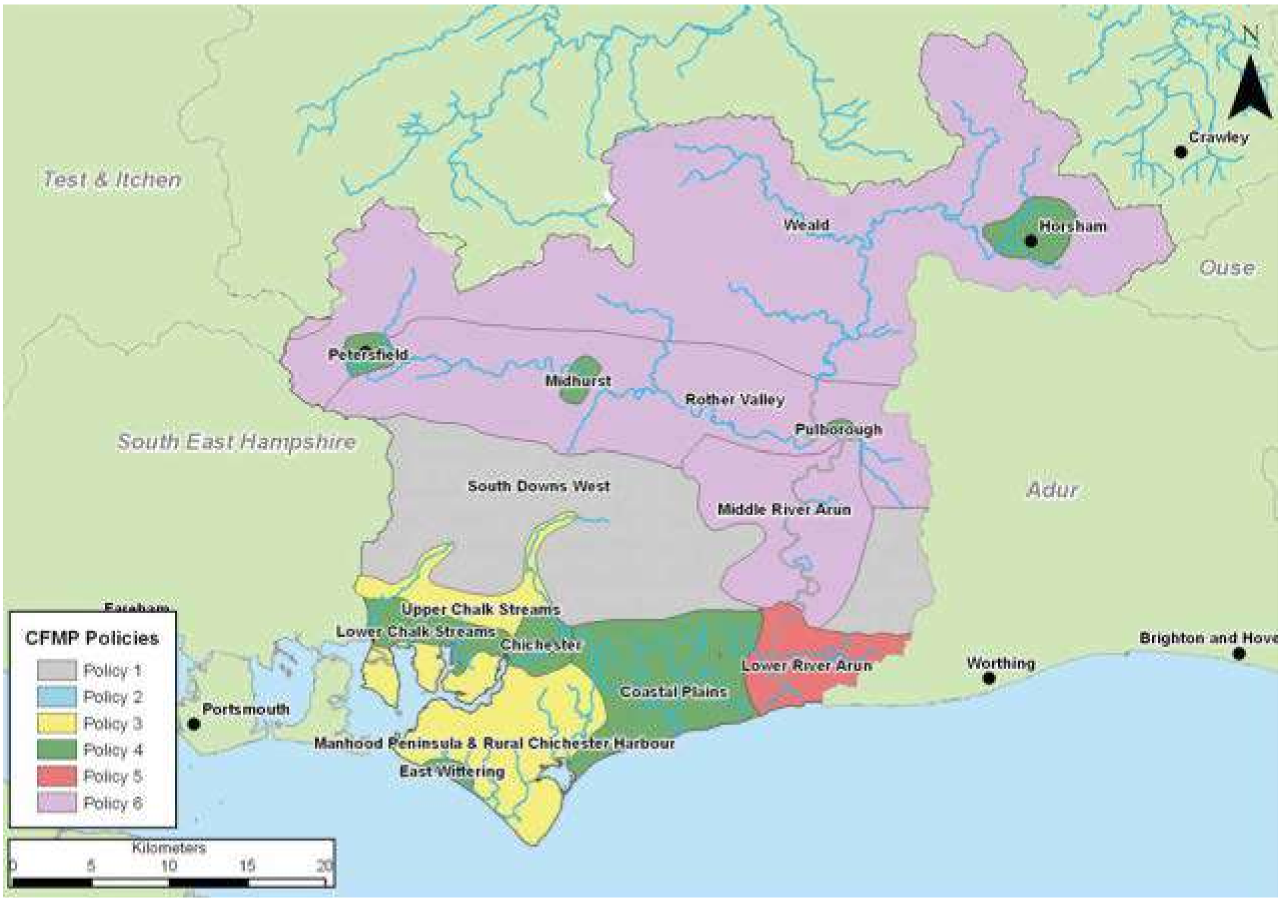
The current version of the Local Flood Risk Management Strategy is available on the WSCC website. www.westsussex.gov.uk

2.4.5. Catchment Flood Management Plan (Arun and Western Streams)

Catchment Flood Management Plans (CFMPs) give an overview of the flood risk across each river catchment. They consider all types of inland flooding, from rivers, ground water, surface water and tidal flooding, but not coastal flooding, (flooding directly from the sea), which is covered by a Shoreline Management Plan. The impacts of climate change are taken into account, along with the effects of how land is managed, and how areas could be developed to meet our present day needs without compromising future needs. CFMPs help the EA and other Partners plan and agree the most effective way to manage flood risk in the future.

The Lidsey SWMP study area is located within the Arun and Western Streams CFMP (Dec 2009) Coastal Plains, as shown in Figure 2.2.

Figure 2.2 - Catchment Flood Management Plans Policy Areas



The Arun and Western Streams CFMP recommended Policy 4 be applied to the Coastal Plains. This policy states:

> *Areas of low, moderate or high risk where we are already managing the flood risk effectively but where we may need to take further actions to keep pace with climate change.*
>
> *This Policy will tend to be applied where the risks are currently deemed to be appropriately– managed, but where the risk of flooding is expected to significantly rise in the future. In this case we would need to do more in the future to contain what would otherwise be increased risk. Taking further action to reduce risk will require further appraisal to assess whether there are socially and environmentally sustainable, technically viable and economically justified options.*

The Arun and Western Streams CFMP is publicly available on the EA website at www.environment-agency.gov.uk

2.4.6. Shoreline Management Plan

A Shoreline Management Plan (SMP) is a large-scale assessment of the risks associated with coastal processes and helps reduce these risks to people and the developed, historic and natural environments. Coastal processes include tidal patterns, wave height, wave direction and the movement of beach and seabed materials.

SMPs are non-statutory, high level policy documents on the same strategic level as CFMPs within the hierarchy of planning documents that are used to manage flood and coastal risks.

The documents are particularly important when looking at development in coastal areas as the SMP looks at aspects including land use, infrastructure, amenity and recreation, landscape, soils and geology, water and biodiversity.

The South Downs Coastal Group (SDCG) was set up in 1994 with the primary aim of producing a Shoreline Management Plan (SMP), covering the area from Beachy Head to Selsey Bill. SMPs are reviewed on a regular basis and though the original Plan was adopted in 1997, this was replaced with another in 2010. The current South Downs SMP (2006) was formally approval by the EA on 25th February 2010.

SMPs help inform the Statutory Planning process, strengthening the move to prevent development in flood risk areas, already started by the Department for Communities and Local Government: PPS25 Development and Flood Risk.

The SWMP recognises the influence and boundary conditions from the shoreline however flood risk specifically relating to coastal flooding is considered more appropriately within the SMP and its Coastal Defence Strategies and associated Schemes. For the SWMP study area The River Arun to Pagham Flood and Coastal Erosion Risk Management Strategy (2010) has been prepared.

2.4.7. Coastal Defence Strategies

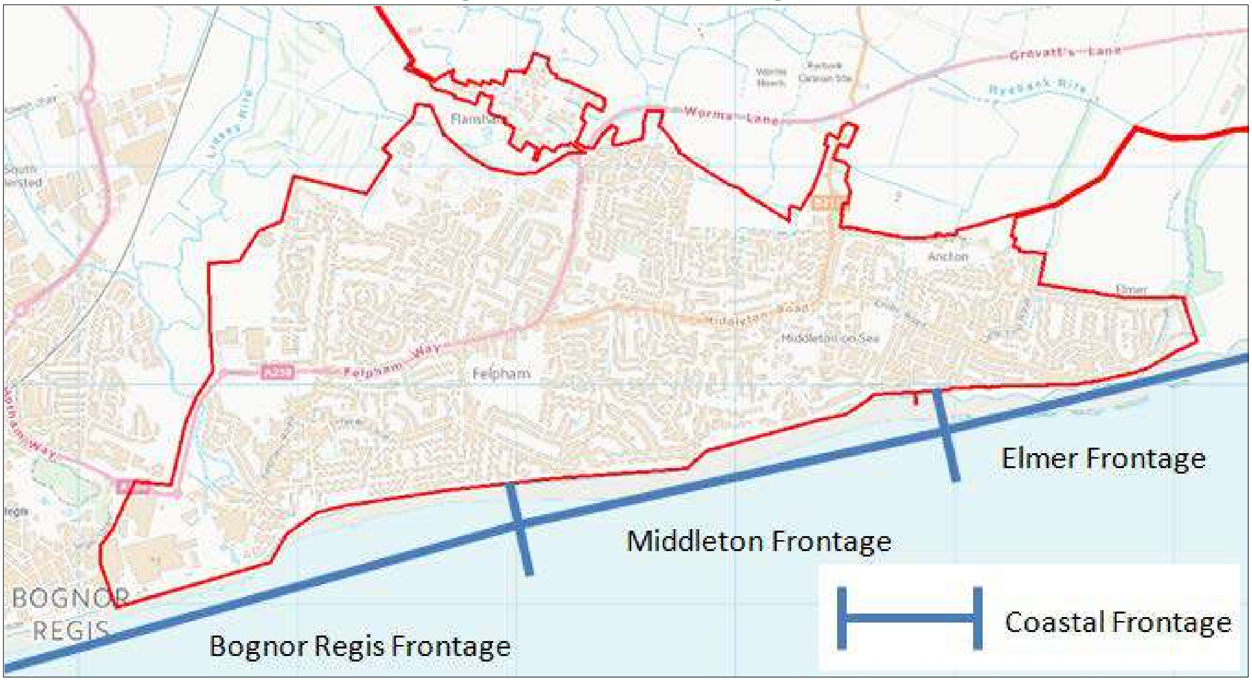
The River Arun to Pagham Coastal Erosion Risk Management Strategy (CERMS) (2010) was prepared to:

- Assessed flood risk.
- identify cost effective and environmentally acceptable means to provide sustainable flood and erosion risk management now and for 100 years; and
- ensure that the implementation of the Strategy will not result in the deterioration of the status of any water bodies or prevent them from achieving their stated Water Framework Directive (WFD) objective.

The coastal defence strategies for the coastal frontages within the SWMP study area has a preferred option to 'maintain' is applied to the current coastal frontages of Elmer, Middleton, Bognor Regis & Felpham. This option to maintain current defences would ensure these are maintained at their current levels, as sea levels rise flood risk increases over time.

The CERMS identifies that future funding for the preferred option from central government funds is uncertain and a risk to implementation of the strategy. The Elmer coastal frontage has a high Benefit Cost Ratio (BCR) and Outcome measure score (OM) over that of the Middleton, Bognor Regis & Felpham coastal frontages. As such, funding for Elmer is possible but more unlikely for Middleton, Bognor Regis & Felpham coastal frontages. The location of these coastal frontages are shown in Figure 2.3.

Figure 2.3 - Coastal Frontages



2.4.8. Aldingbourne Rife Integrated Fluvial Alleviation Works

The Environment Agency commissioned JBA consulting in 2013 to produce an integrated flood risk model (Infoworks ICM) to assess the combined interactions of fluvial and surface water flooding in the Aldingbourne Rife Catchment. The modelling will produce a range of current day and climate change outputs for a range of scenarios. As the model is looking at combined sources of flooding across the wider catchment, it will be used as part of the Aldingbourne Rife Integrated Flood Risk Management Plan & Works to appraise integrated options to reduce flood risk from multiple sources.

2.4.9. Aldingbourne Rife Integrated Flood Risk Management Plan & Works

The Environment Agency in partnership with West Sussex County Council, Arun District Council, Chichester District Council and Southern Water are leading on investigating a range of options and measures that can reduce flood risk from multiple sources across the Aldingbourne Rife catchment. Since the June 2012 floods highlighted the interactions between the various river, ditch and drainage networks, a holistic approach to flood risk management is required.

It is estimated that the project will be competed in the winter of 2015/2016

3. Phase 1 – Preparation

3.1. Introduction

Preparation is the first phase of the SWMP process, as discussed in Section 1.5. It primarily involves client engagement, driver identification, data gathering and gap analysis, as shown in Figure 3.1.

Figure 3.1 - Phase 1 of the SWMP process

3.2. Identify the Need for a SWMP

Historical flooding associated to surface water, ground water, fluvial, public sewer and coastal flooding has all been reported within the study area. In a number of locations this flood risk occurs on a frequent annual basis demonstrating the existing need for a SWMP. In addition the ADC Draft Local Plan has identified future housing development in Eastergate / Westergate and Barnham, the construction of which will need to consider the existing surface water management issues. As such, there are current and future needs to assess the surface water disposal systems in the defined study area.

3.3. Establish Partnership

3.3.1. Partners

The FWMA 2010 defines the unitary authority or the County Council is the LLFA, in this case West Sussex County Council. As such WSCC is responsible for leading the SWMP and managing the production of the study from conception through to delivery.

In order to maximise the benefits from the SWMP, it is important to ensure all Partners are identified in the preparation of the study and that all Partners work collaboratively to ensure both existing and future catchment flood risks are identified and managed appropriately. They are responsible for decision making and will share responsibility for the actions taken. For this Lidsey SWMP, the four key Partners involved are shown in Figure 3.2.

Figure 3.2 - SWSMP Partners

These Partners have supported the SWMP and have worked together to source the information and steer the direction of the SWMP. To support this partnership all partners have signed a data agreement to ensure the data used will be used solely for the benefit of the SWMP study and has been shared on a 'best endeavours' basis. The roles and responsibilities of each of the partners is outlined in the following sections.

a) West Sussex County Council

The Flood & Water Management Act 2010 created a new role for upper tier (Tier 1) authorities as "Lead Local Flood Authorities" with responsibilities for different aspects of flood and water management and to deliver flood risk alleviation and mitigation measures. The role of the LLFA is to take on responsibility for leading the co-ordination of flood risk management in their areas. It is not to take over the roles and responsibilities of these organisations. In carrying out the lead role, WSCC's key duties, responsibilities and powers, imposed by the Flood and Water Management Act 2010, include:

i. Investigate Flood Incidents – LLFA have a duty to assess and record significant flood events in their area in order to understand their cause and ensure that appropriate agencies play their role in the effective management of flooding incidents and recovery. An example of this duty being carried out by West Sussex relates to the June 2012 flooding which impacted on many towns across the county. A report was prepared and issued detailing the impact and actions to reduce future flood risk.
ii. Asset Register – LLFA have a duty to establishing and maintain a register of flood risk management assets, recording each structure, with details of ownership, condition. Those assets recorded shall be considered to have a significant affect on flood risk.
iii. SUDS Approval Body (SAB) – LLFA have a duty to approve, adopt and maintaining Sustainable Drainage Systems (SUDs) that meet National Standards for development. No commencement date has been set for this LLFA responsibility.
iv. Local Flood Risk Management Strategies - Developing, maintaining and applying, in consultation with key Stakeholders, a Local Flood Risk Management Strategy which will include risks from

surface water run-off, ground water and ordinary watercourses. Preparing Surface Water Management Plans for areas of greatest risk. Establishing local management arrangements with other key Stakeholders to ensure delivery of effective joined up management of flood risk.

v. Works Powers – LLFA have the powers to do works to manage flood risk from surface water runoff or ground water. LLFA have the power to exercise the Land Drainage Act 1991
vi. Designation Powers – LLFA have the power to designate structures and features that effect flood risk.
vii. Perform as a Category 1 responder to flood incident under the Civil Contingencies Act, including dealing with recovery and resulting homelessness.
viii. Maintain ditches and balancing ponds on District owned land.
ix. A duty to contribute towards the achievement of sustainable development in the exercise of flood risk management functions and to have regard to any ministerial guidance on this topic.

This SWMP shall be providing evidence to support the LLFA responsibilities for points i, ii, iii and iv.

b) **EA**

West Sussex Draft Local Flood Risk Strategy sets out the following list of responsibilities for the EA, which typify their national obligations:

i. Operate as the strategic overview of all types of flooding.
ii. Lead for flood risk management on Main Rivers and the coast.
iii. Responsible for EA reservoirs, and, to regulate and enforce the Reservoirs Act 1975 on other reservoirs with capacity over 10,000m³.
iv. Duty to be subject to scrutiny from Lead Local Flood Authorities.
v. Carrying out flood risk management functions in a consistent manner with the national and local strategies, reporting to ministers on flood risk management and implementation of strategies.
vi. Powers to request information for any person in relation to flood risk management concerning EA functions.
vii. Power to designate structure and features with flood risk significance.
viii. To be a statutory consultee to the Sustainable Drainage Systems Approving Body.
ix. To be a statutory consultee to local planning authorities on flood risk matters.
x. Perform as a Category 1 responder to flood incident under the Civil Contingencies Act.
xi. Consent and enforce applications for works on Main Rivers.
xii. A duty to contribute to sustainable development through flood risk management functions.

However for Lidsey SWMP the EA also operates as the Internal Drainage Board. for which it is responsible for the following:

i. Completion of maintenance work to a schedule to maintain drainage, as detailed on the EA website.
ii. Use statutory powers to ensure those responsible maintain the flow of water in a watercourse and to modify or remove inappropriate structures within channels. Take the appropriate action against those who inappropriately modify the watercourse.
iii. Responsible for reservoirs over 10,000m³ within their boundary.
iv. Power to exercise the Land Drainage Act 1991.
v. A duty to contribute towards sustainable development.
vi. Powers to undertake flood risk management works.
vii. Undertake consenting on ordinary watercourse within their boundary.
viii. Be a statutory consultee on the Sustainable Drainage Systems Approving Body.
ix. Work alongside and together with neighbouring Internal Drainage Districts.
x. Duty to be scrutinised from Lead Local Flood Authority democratic processes.
xi. Duty to act consistently with the Local and National Strategy.
xii. Power to designate structures and features that affect flooding.

c) **Arun District Council**

Arun District Council is a Tier 2 authority within the Lidsey SWMP study area. Districts and Boroughs have the following roles and responsibilities as a Risk Management Authority:

i. Power to designate structures and features that affect flooding.
ii. Duty to act consistently with the Local and National Strategy.

iii. Duty to subject to scrutiny from Lead Local Flood Authority democratic process.
iv. Power to exercise the Land Drainage Act 1991.
    i. Powers to maintain watercourses that are not the responsibility of the riparian owners, as prescribed by the Enclosures Act.
    ii. Use statutory powers to ensure those responsible maintain the flow of water in a watercourse and to modify or remove inappropriate structures within channels. Take the appropriate action against those who inappropriately modify the watercourse.
v. Perform as a Category 1 responder to flood incidents under the Civil Contingencies Act, including dealing with recovery and resulting homelessness.
vi. Perform as the local planning authority and a duty to encourage the appropriate development and promote sustainable development.
vii. Manage coastal protection.

d) **Southern Water Services**

Southern Water has the following roles and responsibilities as a risk management authority:

i. Duty to comply with the Water industry Act 1991.
ii. Duty to adopt new build sewers where they have been designed to meet with the current Sewer for Adoption standards.
iii. Duty to subject to scrutiny from Lead Local Flood Authority democratic process.
iv. Duty to have regard for the National and Local Strategies.
v. Manage public sewer flooding.
vi. Perform as a Category 2 responder to flood incidents under the Civil Contingencies Act.
vii. Adopt the principles established in the Drainage Strategy Guidance (OFWAT 2013) to support Partnership working.
viii. Apply the principles from the Sewerage Risk Manual (SRM) 4th Edition.

3.3.2. Stakeholders

A SWMP must also ensure that all relevant Stakeholders are identified. These are groups of people or organisations affected by the decisions made by the Partnership. For this study, the following potential Stakeholders were identified as potential contacts to assist with the study:

- Riparian owners.
- Residents and Business Owners.
- Local Flood Action Groups.
- West Sussex County Council and Arun District Council Planners.
- Local Councillors.
- Local Developers or regeneration agencies.
- The Highways Agency.
- WSCC Highways Authority.
- Local landowners / farm owners.
- Natural England.

The Stakeholders listed above will not all be involved in the Partnership / study directly, but may be involved in developing, permitting and possibly implementing actions the SWMP at a later stage.

A key stakeholder is riparian owners. A Riparian land owner is defined as an individual who owns land or property next to a river, stream or ditch. Guidance on this matter is available on the ADC website http://www.arun.gov.uk/main.cfm?type=LANDDRAINAGE .

Living on the Edge - A guide to your rights and responsibilities of riverside ownership (EA, 4th Edition, 2013) also provides clear explanation of the role of the Riparian Land Owners. This EA document details the following rights and responsibilities:

Rights

i. If your land boundary is next to a watercourse it is assumed you own the land up to the centre of the watercourse, unless it is owned by someone else.
ii. If a watercourse runs alongside your garden wall or hedge you should check your property deeds to see if the wall or hedge marks your boundary. If the watercourse marks the boundary, it is assumed you own the land up to the centre of the watercourse.
iii. If you own land with a watercourse running through or underneath it, it is assumed you own the stretch of watercourse that runs through your land.
iv. Occasionally a watercourse, especially an artificial one, will be the responsibility of a third party. This should be noted in your deeds.
v. Water should flow onto or under your land in its natural quantity and quality. This means that water should not be taken out of a watercourse if it could lead to a lack of water for those who need it downstream. It also means that a person cannot carry out activities that could lead to pollution of the water and therefore reduce the natural water quality within a watercourse.
vi. You have the right to protect your property from flooding, and your land from erosion. However, you must get your plans agreed with the risk management authority before you start work. Within the SWMP area this would be the Arun District Council or the EA.

Responsibilities

i. You must let water flow through your land without any obstruction, pollution or diversion which affects the rights of others. Others also have the right to receive water in its natural quantity and quality. You should be aware that all riparian owners have the same rights and responsibilities.
ii. You must accept flood flows through your land, even if these are caused by inadequate capacity downstream. A landowner has no duty in common law to improve the drainage capacity of a watercourse he/she owns.
iii. You must ensure banks are clear of anything that could cause an obstruction and increase flood risk, either on your land or downstream if it is washed away. You are responsible for maintaining the bed and banks of the watercourse and the trees and shrubs growing on the banks. You should also clear any litter and animal carcasses from the channel and banks, even if they did not come from your land. You may need your risk management authority's consent for these works. Your local authority can advise you on the removal of animal carcasses.
iv. You must leave a development-free edge on the banks next to a watercourse. This allows for easy access to the watercourse in case any maintenance or inspection is required. In some areas local byelaws exist which explain what you can and cannot do within certain distances of a watercourse. For more information on works near watercourses you should contact your risk management authority.
v. You must keep any structures, such as culverts, trash screens, weirs and mill gates, clear of debris. Discuss the maintenance of flood defences, such as walls and embankments, on your property with your risk management authority. They may be vital for flood protection.
vi. You must not cause obstructions, temporary or permanent, that would stop fish passing through.
vii. You have a legal obligation to notify the EA and the relevant risk management authority if you would like to build or alter a structure that acts as an obstruction to a watercourse. In some cases it may be an offence if you do not notify the EA / risk management authority of any change to an obstruction.

3.4. Scoping the SWMP Study

3.4.1. Aims and Objectives

The objectives of the SWMP are to:

- Develop Partnership with key Partners and Stakeholders which encourages sharing of data, ideas and funding in order to provide a common aims and objectives.
- Provide an understanding of current and future surface water flood risk in and around the study area.
- Identify the Local Flood Risk Zones (LFRZs) and map flood risk in these areas in further detail.

- Develop a list of agreed actions aimed at reducing flood risk within the SWMP study area. These actions shall have a dedicated owner who is responsible for implementing the recommended measures.

3.4.2. Engagement Plan

An engagement plan was implemented to ensure good communication between Partners and with those who are affected by any proposed works. A communication strategy was developed as part of Lidsey SWMP to provide a framework for effective communication and is included in Appendix B.

3.4.3. Data Collection

Obtaining all available and relevant data is an important activity in the development of an SWMP. This data helps assess the frequency, location and extent of previous flooding incidents and also helps understand where there are gaps in the data that may need further investigation.

The quality of the data received needs to be formally recorded so that any uncertainty or weakness in the data is understood and documented. For this reason, all data received and utilised as part of the SWMP has been assigned a Data Quality Score (DQS) following the guidance table shown in the Surface Water Management Plan Technical Guidance, Living Draft Version 1 dated February 2009. This table is reproduced in Table 3.1 for information.

Table 3-1- Data Quality Scoring Methodology

Data Quality	Description	Explanations	Example
1	Best of breed.	No better available; not possible to improve in the near future.	High resolution LiDAR. River/sewer flow data.
2	Data with known deficiencies.	Best replaced as soon as new data are available.	Typical sewer or river model that is a few years old.
3	Gross assumptions.	Not invented but based on experience and judgement.	Location, extent and depth of much surface water flooding. Operation of un-modelled highway drainage. ‘Future risk’ inputs e.g. rainfall, population.
4	Major assumptions.	An educated guess.	Ground roughness for 2d models.

For the SWMP, the data outlined in Table 3.2 has been obtained and utilised as part of the study.

Table 3-2- Data Collected

Data	Source	Data Quality Score	Study Purpose
Local Flood Risk Management Strategy	WSCC	1	Assess Flood Risk
Preliminary Flood Risk Assessment	WSCC	1	Assess Flood Risk
Strategic Flood Risk Assessments (SFRA)	ADC	1	Assess Flood Risk
West Sussex County Council Report on June 2012 Flood Event (Nov 2012)	WSCC	1	Determine evidence of historical flooding and flood mechanism
Historic Records of Flood Events (SWS SWMP Sewer Incident Report Forms (SIRF) Database. EA Historic Flood Outlines, ADC Flood Reports / Plans,	All	2	Determine evidence of historical flooding
Ground Data (LiDAR data)	EA	1	Produce a Digital Terrain Model (DTM) of the study area.
EA 5m Composite Ground water Model	EA	2	Infill into the Digital Terrain Model (DTM) in areas where data gaps in LiDAR data exist.
Detailed River Network	EA	2	Provides location of main rivers and other watercourses. Surface or below surface. River type i.e. primary, secondary or tertiary).
Sewer Asset Data	SWS	1	Details location of public sewerage assets.
Hydraulic Model (LIDS 1D Infoworks Wastewater Model)	SWS	2	Current model for LIDS & Current models for FORD (Bognor)
Location of Critical Infrastructure	EA and SWS	1	Assess flood Impact
Geology / Soil Data / Hydrogeology	EA / SWS / Barnham Flood Group	2	Integrated modelling Ground condition assessment and assessment of ground water flood risk.
Ground Water Data	ADC and EA	1 & 2	Integrated modelling Ground condition assessment / flood mechanism assessment / Optioneering appraisal
Environmental Data	SWS	2	Assist with understanding environmental constraints
Targeted Questionnaires issued to the residents	Targeted Residents	1	Provide further evidence base to inform and confirm flood risk / flood extent and flood mechanism
Mastermap Background (Mapinfo format)	SWS	1	Plan production / reporting and study planning
National Receptor Database	EA	1	Assess flood Impact
Areas Susceptible to Ground water Flooding (AStGWF)	EA Via ADC	1	Assess flood risk
Areas Susceptible to Surface Water Flooding Intermediate (AStSWF)	EA Via ADC	2	Assess flood risk
National Flood Zone 2	EA Via ADC	1	Assess flood risk

National Flood Zone 3	EA Via ADC	1	Assess flood risk
Flood Map for Surface Water (FMfSW) 30 yr.	EA Via ADC	1	Assess flood risk
Flood Map for Surface Water FMfSW) 100 yr.	EA Via ADC	1	Assess flood risk
Flood Map for Surface Water DTM (FMfSW DTM)	EA Via ADC	1	Assess flood risk
Ground Water Vulnerability (GWV)	EA Via ADC	1	Assess flood risk
Historic Flood Map (nat_hfm)	EA Via ADC	1	Provide evidence of historical flooding
Impermeable Area Survey data	SWS	2	Assist with hydraulic appraisal. Integrated Model Build
Gully Data	WSCC	2	Assist with hydraulic appraisal.
Hydrocast (Rainfall database)	SWS	1	Live radar rainfall system. Both forecast and historic rainfall record system.

A data agreement relating to the sharing of data has been prepared for Lidsey SWMP. This protocol covers data provided for the express purpose of undertaking the SWMP. The Partner agreement stipulates that:

- Data is shared on a 'best endeavours' basis, with no guarantee of absolute accuracy. Appropriateness of the data is to be assessed by the receiving party.
- Data is shared for the specific purpose of the study, and is not to be used by any party for any other purpose without the express consent of the data provider.
- Data concerning individual properties or persons is not to be released outside the steering group without the express consent of the data provider.
- Summary of data, or derived data, for publication in the final report must be approved by the data provider before publication.
- Data is to be 'time limited' – i.e. not to be used for any purpose beyond the completion of the final report, without the express consent of the data provider.
- Data of 'broad equivalence' is to be made available in exchange – e.g. highway drainage records for sewer records, overland model data for underground model etc. To be agreed on a case-by-case basis.

Information collected from questionnaires returned as part of the study has been used to inform the SWMP. All information supplied is held by West Sussex County Council, and will remain secure and confidential in accordance with the requirements of the Data Protection Act 1998. Personal details will only be used for the purpose for which it was collected, and will not be used for marketing purposes or passed on to any third parties (with the exception of Atkins who are processing the data on behalf of West Sussex County Council, and who must also comply with the requirements of the Data Protection Act) without your consent to do so. [Note - Here "Processing" means obtaining, recording or holding data, or carrying out any operation or set of operations on the data.]

It should be noted that the following datasets provided by the EA have been made available to the LLFA for the purpose of local flood management activities:

- Flood Map for Surface Water
- EA Flood Zones (fluvial and coastal)
- Areas susceptible to ground water
- National Receptor Database

Some figures used within the production of this report contain open source Ordnance Survey Mapping. This information is acknowledged under the Ordnance Survey data © Crown copyright and database right [2014].

Some of the datasets and information used in the production of the SWMP have been restricted. This information primarily relates to identification of individual property flooding of which information originated from Local Authorities, SWS, Residents and local Flood Action Groups.

3.4.4. Level of Assessment

A SWMP can be undertaken at various levels of assessment based on the needs of the study area, as outlined in the Defra SWMP Guidance document and summarised below:

1. **Strategic Assessment** (County Scale) – Outline Maps produced to inform spatial and emergency planners. Prioritised list of further investigations and assessment. Provide a broad understanding of areas susceptible to allow prioritisation of future work.

2. **Intermediate Assessment** (Large Town or City) – Determine Local Flood Risk Zones (LFRZs). Identify immediate intervention activities or ‘quick wins’. This assessment both aims to inform spatial and emergency planners.

3. **Detailed Assessment:** (Known flooding ‘wetspot’) - LFRZ or Critical Drainage Area (CDA) requires a detailed assessment of the cause of flooding. Investigation shall determine the mechanism of flooding and test / define mitigation measures. This is typically supported by detailed local hydraulic modelling.

Given the nature of the problems and the data available a Detailed Level of Assessment is considered appropriate.

4. Phase 2a - Strategic Assessment of Local Flood Risk

4.1. Introduction

Phase 2 of the SWMP is Risk Assessment and comprises three levels study as outlined in Figure 4.1. This section focuses on the Strategic Assessment of Local Flood Risk.

Figure 4.1 - Phase 2 of the SWMP process

Historical reports of flooding have been obtained from all of the Partners. This information has been provided in plans, reports, databases and photographic evidence. In addition residents have also provided useful information relating to flooding experienced, through direct discussion, email and completion of questionnaires. These sources have provided useful information as to the extent and flood depth in specific locations around the catchment and have been used in the verification of the hydraulic model developed as part of the SWMP study. This information has been used to prepare the Strategic Flood Risk Assessment.

4.2. Historic Flooding

4.2.1. Historic incidents

Historic flooding in the Lidsey SWMP study area has been obtained from multiple sources including Strategic Flood Risk Assessment, EA historic flooding data, SWS SIRF database, ADC flood extent plans. In addition this was supported by general local knowledge from all partners, stakeholders and residence questioned. The worst years for flooding are 1993/1994, 1997 and 2012. Flooding from multiple sources has been reported including fluvial, pluvial, sewer and ground water. Table 4.1 summarises the reported flooding incidents where evidence has been obtained from public sources. It is appreciated that this may not include all flood incidents since 1990 but demonstrates that flooding within the study area has been a long standing problem which warrants further analysis under the SWMP.

Table 4-1- – Reported Flooding

	Timeline																							
Source of Flooding	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Fluvial Flooding*																								
Pluvial Flooding*																								
Sewer Flooding**	1		2	21	67	15		49	3	1	9		5	14	2		9	11	26	35	37	1	227	
Groundwater Flooding***																								

Reported Records

* Based on multiple sources (Partners and Residents)
** Based on SWS SIRF incidents relating to hydraulic overload. Numbers determine count of incidents recorded in period.
*** Inferred due to limited gorundwater data.

It is worth highlighting that the high number of sewer flooding incidents related to 'hydraulic overload' was a consequence of an extreme storm event in June 2012 which was estimated to be a 1 in 200 year storm event (0.5% annual storm probability) storm event. The current design target as detailed in the Sewers for Adoption sets a 1 in 30 year standard for design.

To assess the overall local flood risk in the catchment efforts have been made to collate as much meaningful information relating to the historic locations of flooding. Information provided by both Partners and Stakeholders has been used to determine historic flood locations. In addition to this information historical flooding reported as part of the Strategic Flood Risk Assessment has been utilised, specifically for surface water and fluvial flooding sources. Appendix A – (Plan 3) Historic Flooding has been prepared to provide an overview of the reported flooding locations and the associated source. It should be noted that precise dates of flooding events have been difficult to fully establish in particular pluvial flooding incidents. However, the sites / areas identified provide a fair understanding as to susceptible locations within the catchment where flooding has historically occurred. Given WSCC now has a duty to maintain a register of flooding records an improved and consistent source of data should be available in the future. .

4.2.2. Questionnaires

In support of the flood history records collected from Partners and Stakeholders 393 of document questionnaires were issued to residents in areas which are predicted and potentially prone to be at risk of flooding based on the StSWF flood maps. Questionnaires were sent to gain further insight and understanding of the impact flooding on the local areas. In addition, details regarding the source and extent of flooding were requested. The information provided on the questionnaires has been used to provide further support the SWMP study. The information collected from the questionnaires has not been referenced in the reporting process to comply with the Data Protection Act (1998).

In total, 106 (38%) out of 293 questionnaires issued were returned. Information received including the completed questionnaires, supporting reports, extended accounts of flooding and photographs. This data has been a major source for the calibration of the integrated model and general understanding of the local flood mechanisms in the catchment.

4.3. Pluvial Flooding / Surface Water Flooding

4.3.1. Description

Pluvial flooding describes flooding which typically occurs after periods of intense rainfall which is unable to enter the ground or existing drainage systems, either above or below ground. Pluvial flooding can be triggered or exacerbate by saturated soil or hard baked soil (during dry hot periods) which may lead to overland flow during intense rainfall. This type of flooding is typically rapid and short-lived as flood water is typically conveyed away through existing drainage systems, disposed of via infiltration into the ground or lost through evaporation. The extent and frequency of pluvial flooding is also a function of the local climate, rainfall, geology, slope, soil type, vegetation cover, land use type and land use management being applied.

4.3.2. Causes & Impacts

Pluvial flood pathways typically develop along kerbed roads, railway lines and drainage channels. These features often channel the pluvial flood water towards local depressions, towards the bottom of hills and into valleys. Overland runoff can be increased where large impermeable area features exist e.g. car parks or compacted ground possibly caused by over stocked arable farmland.

In the urban area, primarily on a local scale, pluvial flooding can directly impact on residential and commercial premises. In addition critical infrastructure including roads, railways, telecommunications and electricity can be susceptible to pluvial flooding. Loss of agricultural crops and amenity value from recreational facilities or land may also occur as a consequence of pluvial flooding.

Pluvial flooding can lead to inundation of the public wastewater sewer system through direct inflow into manholes or connected inspection chambers of property sink gullies. As a consequence this can lead to hydraulic overload and flooding / pollution from the foul or combined sewer system. This mechanism of surface water inundation and inflow has been confirmed in specific areas of the study catchment.

4.3.3. Historic Records

Historical pluvial flooding locations in the catchment are shown in Appendix A – Plan 3, based on information collected from the SWMP Partners. Many of these locations are predicted to be within zones of flood risk within the EA Flood Map for Surface Water (FMfSW). Appendix A – Plan 4, 5 and 6 shows the FMfSW for 1 in 30 year, 1 in 100 year and 1 in 1000 year storm events respectively.

4.4. Main River (Fluvial) Flooding

4.4.1. Description

Fluvial flooding is a result of the capacity of the main rivers being exceeded and the excess river water leaving the channel, flooding adjacent land or property Surface water and fluvial flooding typically interact where surface water cannot be receive or conveyed by a main river. Where watercourses are defended, through raised banks or levees, this can sometime lead to ponding of surface water behind the rivers defences. In the Lidsey SWMP study area the EA has responsibility for Main Watercourses as discussed in Section 3.4

High water levels in the main rivers may also influence and impact on the performance of the sewer system through the surcharging of outfalls which can lead to hydraulic overload and potentially cause flooding of properties both internally and externally. Limiting free discharge from surface water outfalls may also affect the performance of combined sewer overflows (CSOs) which are used in combined sewerage systems when high surcharge occurs during rainfall. Within Barnham, the Marshalls Close CSO is operated using a pumped arrangement to ensure the overflow can operate when water levels in the Rife exceed and drown the outfall. Flooding from the main river in Barnham Lane during June 2012 flood incident is shown in Figure 4.2.

Figure 4.2 - Barnham Lane June 2012

4.4.2. Causes & Impacts

Main river flooding can directly affect the rivers flood plain, the flat areas adjacent to watercourses where water flows in time of flood, or would flow but for the presence of flood defences. Specific Flood Zones relating to the probability of river and sea flooding, ignoring the presence of defences developed by the EA is available on the EAs website. These zones are described as indicated in the Table 4.2. Flood Zones 2 and 3 are shown in Appendix A – Plan 7.

Table 4-2- Flood Zones

Zone	Definition
Zone 1 Low Probability	Land having a less than 1 in 1,000 annual probability of river or sea flooding or sea flooding. (Shown as 'clear' on the Flood Map – all land outside Zones 2 and 3)
Zone 2 Medium Probability	Land having between a 1 in 100 and 1 in 1,000 annual probability of river flooding; or Land having between a 1 in 200 and 1 in 1,000 annual probability of sea flooding. (Land shown in light blue on the Flood Map)
Zone 3a High Probability	Land having a 1 in 100 or greater annual probability of river flooding; or Land having a 1 in 200 or greater annual probability of sea flooding. (Land shown in dark blue on the Flood Map
Zone 3b The Functional Floodplain	This zone comprises land where water has to flow or be stored in times of flood. Local planning authorities should identify in their Strategic Flood Risk Assessments areas of functional floodplain and its boundaries accordingly, in agreement with the EA. (Not separately distinguished from Zone 3a on the Flood Map)
Note: The Flood Zones shown on the EA's Flood Map for Planning (Rivers and Sea) do not take account of the possible impacts of climate change and consequent changes in the future probability of flooding. Reference should therefore also be made to the Strategic Flood Risk Assessment when considering location and potential future flood risks to developments and land uses	

4.4.3. Historic Records

Historical flooding from fluvial flood locations has been confirmed within the catchment. Appendix A – Plan 3 shows the location of fluvial flooding within the catchment.

4.5. Ordinary Watercourse Flooding

4.5.1. Description

All watercourses in England and Wales have been classified as either 'Main River' or 'Ordinary Water courses'. The Water Resources Act (1991) defines a main river as *"a watercourse shown as such in the Main River Map".* The main difference between a main river and an ordinary watercourse is the perceived importance and potential to cause large scale flooding. The Floods and Water Management Act defines any watercourse not a main river is an ordinary watercourse. ordinary watercourses may comprise of dykes, ditches, streams, rivers, culverts and land drains.

In the Lidsey SWMP study area Local Authorities have responsibilities for ordinary watercourses as discussed in Section 3.3.

4.5.2. Causes & Impacts

Flooding from ordinary watercourses occurs when water levels in the channel exceed height of the banks and spill flood water out into adjacent land or drown outfalls of connecting surface water drainage systems. The main reasons for water levels rising include:

- Water levels in the ordinary watercourse can rise in response to heavy and prolonged rainfall. This can be exacerbated by saturated soils leading to inflows from ground water and greater activated runoff areas.
- High flows in the Main River causing flows to back up into the ordinary watercourse.
- Blockages and restrictions in the ordinary watercourse inhibiting its drainage capacity and increasing in channel headlosses.
- Siltation removing available capacity in the ordinary watercourse and consequently increasing water levels.

4.5.3. Historic Records

Given much of the responsibility for ordinary watercourses comes under Riparian ownership, records linked to flooding from these drainage assets is limited and localised. Site visits conducted as part of the SWMP identified a number of issues surrounding the condition and general upkeep of ordinary watercourses within several of the Local Flood Risk Zones (LFRZs). A general recommendation from the SWMP is that efforts should be made to ensure Riparian owners are made aware of their responsibilities to enforce they maintain their drainage asset ensuring it is in a satisfactory operable condition.

4.6. Ground Water Flooding

4.6.1. Description

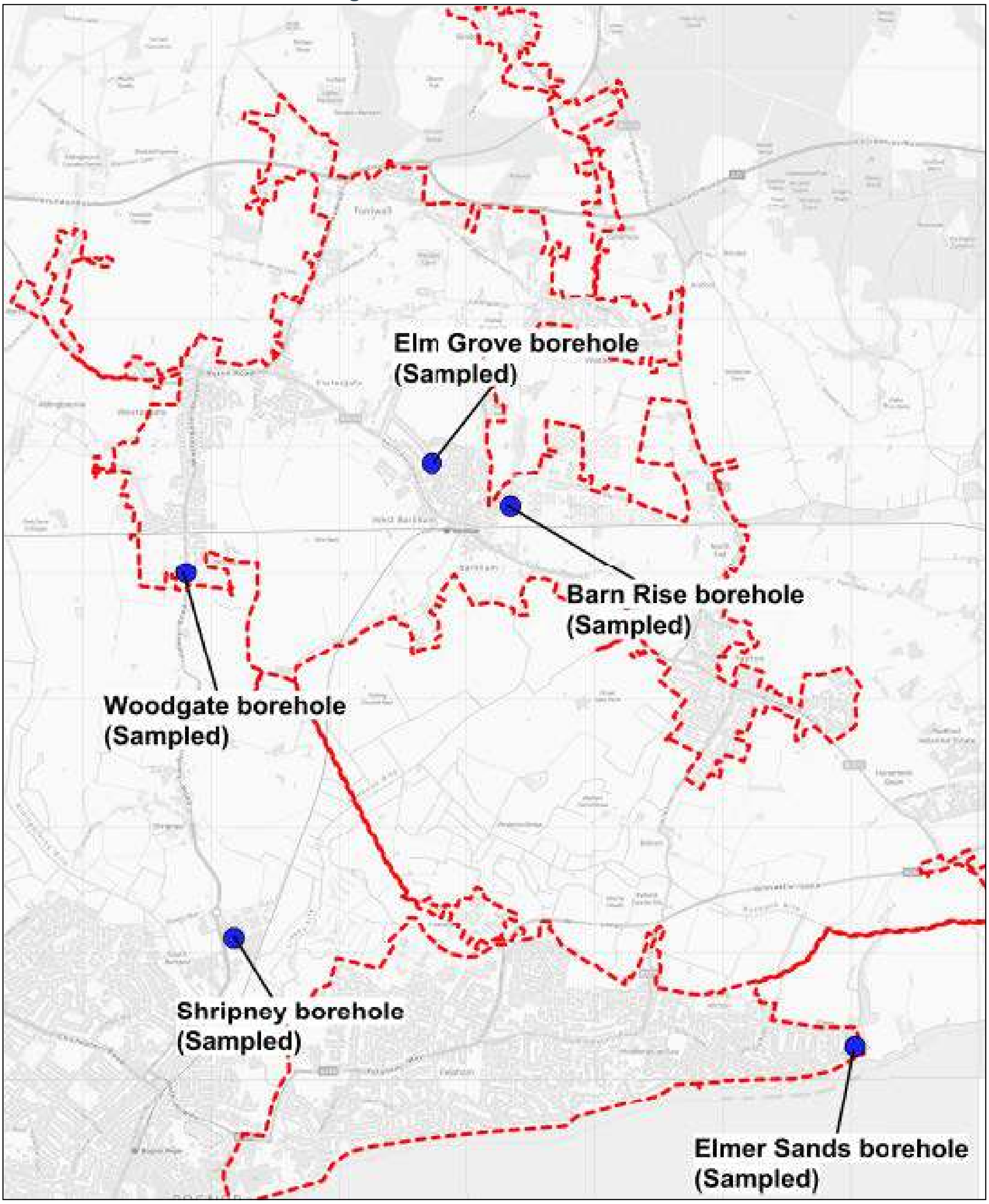
The British Geological Society defines ground water flooding as "*the emergence of ground water at the ground surface away from perennial river channels or the rising of ground water into man-made ground, under conditions where the 'normal' ranges of ground water level and ground water flow are exceeded*." Given the nature of ground water flooding this is sometimes difficult to fully establish without the use of long term ground water data.

4.6.2. Historic Ground Water Readings

Available data has been used where possible to establish ground water conditions within the Lidsey SWMP study area. This information has been used in both the integrated hydraulic modelling and also to establish the risk of ground water flooding in the Local Flood Risk Zones.

Data from the five boreholes shown in Figure 4.3 has been used in the study. The data obtained from the boreholes is derived from spot measurements and telemetered readings; the latter being more useful as it provides a better understanding of ground water levels at a given time in response to seasonal conditions.

Figure 4.3 - Borehole Locations



The geology of the catchment is influenced by the presence of a chalk aquifer which is largely sealed by a brickearth, as shown in Figure 1.4, which offers resistance to a wider emergence of ground water from the aquifer during periods of high pressure. The EA Susceptibility to Ground water flooding map is shown in Appendix A – Plan 8.

4.6.3. Historic Ground Water Records

Ground water flooding has been reported in Elm Grove, Barnham, Nyton Road / Northfields Lane, Westergate and Wandleys Lane, Eastergate. In addition there is a high risk of ground water flooding in the Elmer Sands estate which is a contributing factor to localised flooding. The location of historical ground water flooding in the catchment is shown in Appendix A – Plan 3.

4.6.4. Impacts of Ground Water

High ground water levels can lead to flooding of properties both internally and externally. Flooding of highway, farmland and public space may also occur as a consequence. As with pluvial flooding ground water may interact and inundate both the public sewer and highway drainage systems given they are not designed to cater for ground water inflows.

4.6.5. Management of Ground Water Flooding

Ground water flooding cannot be easily resolved and as such measures to reduce the impact of ground water are considered the most appropriate method of managing this flood risk. The Defra document, Making Space for Water – Ground water Flooding (November 2006), appraised the typical approaches to managing ground water flood risk. This identified the following interventions which should be considered by WSCC.

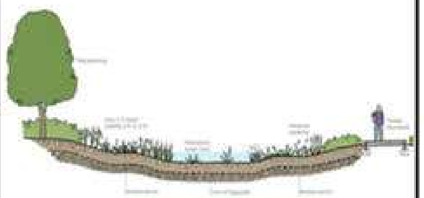
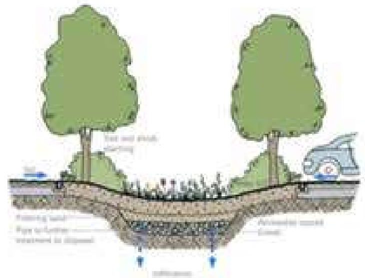
Table 4-3- Management of Ground Water Flooding

Intervention	Description and Benefit
Traffic Management	Reduce car traffic and impact of vehicles to reduce likelihood of bow waves.
Temporary defences	Install sandbags to protect properties and critical infrastructure.
Pumping of Ground water	Wider scale pumping of ground water is generally impractical. There are limited examples of this being an achievable approach to managing ground water flood risk.
Basement protection	Pumping of localised ground water i.e. within a basement is something which is generally practical using a sump pump arrangement. Making basements watertight is also practical and achievable. It is understood that there are examples of basement properties within the study area which successfully utilise this approach to mitigate ground water flooding based on questionnaire responses.
Development control	Suitable planning control needs to be in place to either limit development or only permit flood resilient development in areas of ground water flood risk.
Improve surface water conveyance	To reduce the impact of ground water flooding improved conveyance away from the point of ground water flooding may reduce the impact of ground water flooding. Often this is difficult to implement as ground water occurs in topographically low areas. Improved conveyance of underground drainage assets i.e. highway drainage systems may assist.
Flood Action Groups	Development of flood actions groups to represent local residents and assist with developing and implement flood action plans with assistance from the LLFA.
Improved Warning System	Providing early warning of pending flooding would allow residents to install temporary flood defences to mitigate the impact of flooding

4.6.6. Ground water Impact on SUDS

SUDS utilises a number of approaches to dispose and retain surface water through the source / pathway and receptor process. One of the most predominant methods in the SUDS ‘source control’ is to utilise available capacity in the ground to effectively dispose of the surface water. Figure 4.4 shows the nine most common approaches to source control typically available. Of these nine surface water disposal methods only two (Green Roofs and Rainwater Harvesting) are considered appropriate in areas where ground water flooding or high ground water levels occur as the remaining methods all seek to utilise capacity in the ground to remove surface water.

Figure 4.4 – Ground Water influence on SUDS

Source Control					
Green Roofs (Interception) ✓		Ponds and Wetlands ?		Swales ?	
Detention Basin ?		Rainwater Harvesting (Harvesting tanks/pump / Water Butts) ✓		Bioretention Basin / carpark pods ?	
Permeable Paving ?		Soakaways ?		Bioretention Street Planting ?	

Within the Lidsey catchment ground water is considered to be a major constraint to both existing and future drainage infrastructure. As such this needs to be key consideration when introducing new development drainage or retrospective drainage improvements in existing urban areas.

It is appreciated that there may be potential to utilise some of the nine source control methods which uses the ground to dispose of surface water given ground water conditions may vary markedly across the areas of the catchment. However, prior to considering the use of either Ponds & Wetlands, Swales, Detention Basins, Bioretention Basins / Carpark Pods, Permeable Paving and Soakaways or other soakaway drainage techniques suitable monitoring needs to be undertaken to establish ground water conditions during periods of prolonged wet weather. This would ensure confidence exists in the performance of such drainage infrastructure to enable effectual drainage during high ground water conditions.

Arun District Councils Draft Local Plan Section 20.3 Sustainable Drainage Systems stipulates, in addition to the winter percolation testing in accordance with BRE365, up to six months of ground water monitoring within the winter period is conducted to assess the use of SUDs. Given the exceptional high ground water conditions in the Lidsey catchment six months of ground water monitoring is considered to be a minimum period. There is a risk that ground water levels may not represent sever conditions over the currently recommended six months of monitoring as a potential consequence of a relatively dry winter period more longer term data would provide a greater degree of confidence in the ground water characteristics to inform future SUDs designs. As such, it is recommended that improved collection of hydrometric data relating to ground water is implemented in the Lidsey SWMP study area in strategically targeted areas.

A new report titled Water. People. Places. A guide for master planning drainage in developments was produced by WSCC and eight other Lead Local Flood Authorities (September 2013). This document details the available SUDS features and their design. It also states in sites with shallow ground water 'In this instance SUDS should be selected and designed to be on the surface or shallow in depth to avoid infiltration'. This document will be used to determine acceptability of SUDS.

4.7. Public Sewer Flooding

4.7.1. Description

Flooding from the public sewer system is caused when the capacity of the drainage system is exceeded. This mechanism of flooding is termed hydraulic overload and is caused by excessive inflows from ground water (infiltration), surface water inflow or increases in dry weather flow caused by un-consented discharges. Surface water may enter the drainage system via direct impermeable connection (piped connections) and indirect connections (surface water inundation via manholes and inspection covers).

Public sewer flooding can also be caused by operational / structural failures including:

- Blockages in the sewer caused by Fat, Oil, Grease (FOG), root intrusion or silt build-up.
- Mechanical and electrical failure at Pumping Stations and WTWs may also contribute to operational failure.
- Structural deterioration of pipes leading to fractures, holes and collapses. leading to joint displacement

The SWMP does not focus on operational or structural performance of the public sewer system which is the responsibility of SWS.

It has been widely reported that public foul manholes surcharge and flood in Lidsey SWMP study area. Figure 4.5 shows evidence of foul manholes surcharging and flooding in Barnham during an extreme storm event in June 2012. It should be noted that this storm event exceeded the current 1 in 30 year (3.33% annual probability of frequency) design capacity of the public sewer system.

Figure 4.5 - Flooding from Public Manholes (June 2012)

4.7.2. Historic Sewer Flood Records

SWS are responsible for the public sewerage system in the study area. The network includes foul, surface water and combined systems.

The Sewage Incident Report Form (SIRF) database created and maintained by SWS details all reported incidents of sewer flooding. For the purpose of the SWMP SWS has released information relating to all recorded flood incidents in the study area associated to 'Hydraulic Overload'. This relates to locations where there is insufficient capacity in the sewer system to convey and retain wastewater (foul and surface water) and where flooding or surcharge was recorded. A review of this data highlighted the following:

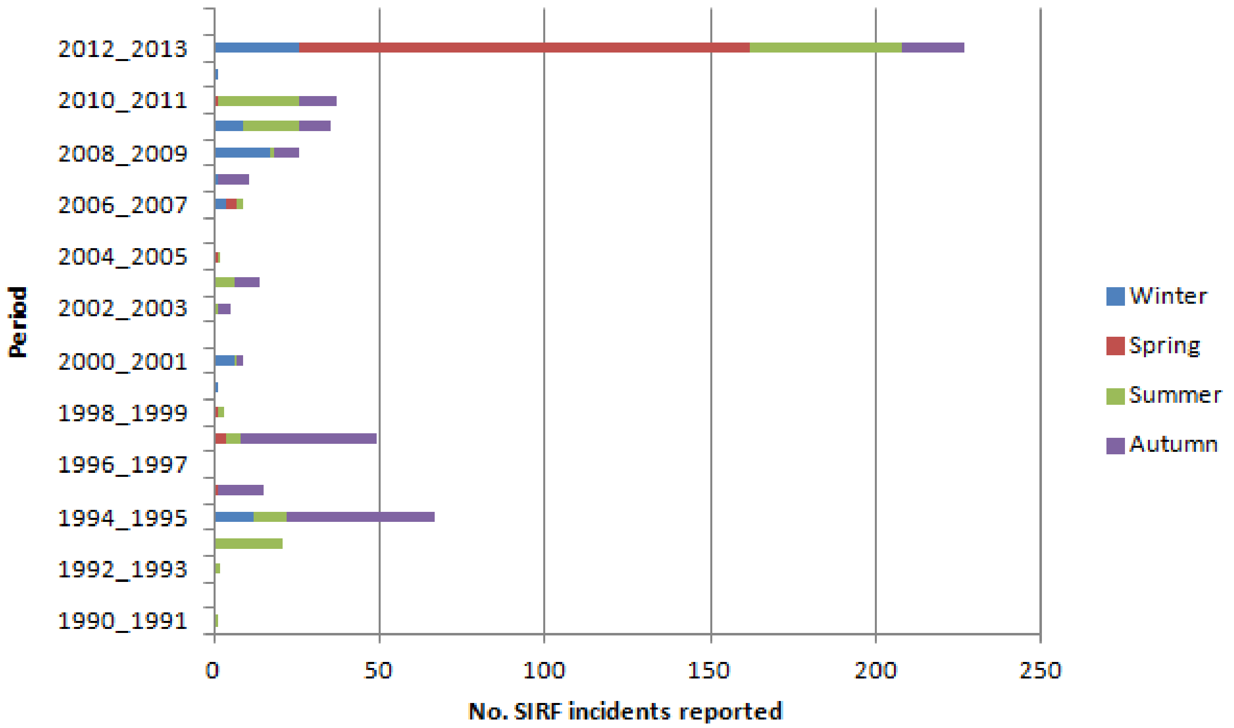
- The highest number of reported flood incidents relating to hydraulic overload was reported in 2012. In particular extensive flooding was reported in June, which coincided with an extreme 1 in 200 year (0.5% annual storm probability) storm event.

- The majority of the flooding, caused by hydraulic overload has been proven to occur in both summer and winter periods.

- Anecdotal information from SWS suggests that the worst flooding occurs following prolonged and sustained heavy rainfall when ground water levels are high and the catchment is particularly wet. This view is supported by the pumping station data which show that the pumps are running for long periods during sustained rainfall. In addition, the flow to full treatment data at Lidsey WTW shows greater volumes of flow entering the treatment works during wet conditions which indicates clear water flow is entering the public foul / combined sewer system from direct and indirect surface water connections and ground water. High ground water readings also correlate with significant flooding and surcharge from the public sewer system further demonstrating a linked relationship between sewer performance and ground water.

Discussions with both the residents and Partners has highlighted that flooding from the public sewer system has been a long standing issue which is considered to be a particular nuisance in confirmed specific locations around the catchment. Flooding from the public sewer system has historically impacted on residential and commercial properties both internally and externally. In addition flooding to both public and private land has and continues to occur. These flooding issues are recognised by SWS who have in the past and are continuing to investigate this matter. A summary of the SIRF data reported from 1990 to 2013 is shown in Figure 4.6. The location of sewer flooding due to hydraulic overload within the catchment.is shown in Appendix A – Plan 3.

Figure 4.6 - SIRF Flood Incidents



Note: Winter includes the months December, January, February; Spring includes March, April, May; Summer includes June, July, August; Autumn includes September, October and November.

It should be noted SWS tanker flows at strategic points during periods of prolonged wet weather / high groundwater to reduce risk of flooding.

4.7.3. Public Sewer System Performance

It is confirmed that flooding from the public sewer system occurs due to excessive inflows of clear water from ground water infiltration into manholes and sewers, direct surface water connections and indirect inundation. The photograph in Figure 4.7, taken during an Inflow and Infiltration (I&I) study in February 2014, demonstrates both the surcharge level and the clear water presence in a manhole SU94036201 located immediately upstream of the Lidsey sewerage treatment works.

Figure 4.7 - Surcharged manhole (SU94036201) upstream of the Lidsey STW Feb 2014

4.7.4. Inflow and Infiltration Investigations (2013 and 2014)

As part of the SWS AMP5 (Asset Management Plan) programme of works an Infiltration investigation was undertaken in May 2013. This study provided limited results given the dry catchment conditions and relatively little rainfall prior to and during the survey inspections. As such a further Inflow and Infiltration study was planned to take advantage of the wet catchment conditions between December 2013 and February 2014. During the I&I investigation flooding from the public foul / combined sewer system was confirmed at several locations previously known to be hydraulically overloaded.

The scope of the study included the following elements:

i. Procure and manage drainage surveys in the Lidsey catchment to assist with determining the origin of clear water inflows entering the foul drainage system. Given the scale of area requiring assessment a ‘Lift and Look’ inspection was proposed to provide an overview of the water levels and obtain visual evidence of clear flows being conveyed through the drainage system.
ii. Identify a long term strategy recommending further survey and investigations.
iii. If required, develop a long-term monitoring plan to assess the performance of the drainage system.

The work undertaken was documented in the Lidsey Infiltration and Inflow Investigation report (March, 2014). It included a schedule of improvement works and future investigations based on the survey and investigation findings.

Of the 80 manholes attempted for survey, 24 were found to be almost fully surcharged with clear water flows. High surcharge conditions were most evident in Walberton, Nyton, Westergate, Barnham and Yapton. Ground water was found to be entering a number of manhole chambers and surface water was also found to be entering manholes through inundation. Clear flow was also evident in many of the sewers inspected. Based on the findings from this study, the following recommendations were made:

1. Repair the defects at manholes SU93049703 (Elm Croft Place, Westergate), SU94053303 (Church Lane, Eastergate), SU96041506 (Barnham Lane, Barnham), SU97003104 (Denham Close, Middleton on Sea) and SZ94996401 (Upper Bognor Road, Bognor Regis) to prevent ground water intrusion into chamber.

2. Install water tight covers on manholes SU95047001 (Off Church Lane, Barnham), SU95067101 (Eastgate Lane, Eastergate), SU96040302 (Lake Lane, Barnham), SU96066006 (West Walberton Lane, Walberton), SU97003005 (Sea Close , Elmer), SU93058602 (Northfields Lane, Westergate), SU93058801 (Northfields Lane, Westergate), SU93058802 (Northfields Lane, Westergate), SU93059801 (Northfields Lane, Westergate), SU93058601 (Northfields Lane, Westergate), SU93058702 (Northfields Lane, Westergate),

3. Consider installation of water tight covers at 53 manholes considered 'at risk' of surface water inundation. These manholes and locations are specified in the Lidsey Inflow and Infiltration Investigation Report (March, 2014) Doc. Ref. 5123679 / 61 / DG / 002.

4. Consider undertaking 69.2 km of CCTV on the public foul sewer system to confirm source of clear water intrusion from infiltration. The selected CCTV survey lengths for consideration have been selected based on the following approach:

    a. Known locations where operational and structural defects are prevalent i.e. broken pipes, holes, deformation, fractures, infiltration, encrustations and root intrusion.
    b. Upstream of confirmed manholes / sewers where clear flow is evident.
    c. Where sewers are estimated to be surcharged based on the lift and look inspections.

    It should be noted that 69.2 km represents 34% of the 201.6 km of foul and combined public sewer contained within the SWMP study area. Historic data indicates that SWS has undertaken 80.4 km of CCTV in the study area since 1983.

5. Assess the operational performance and condition of Marshall Close CSO including a mechanical and electrical inspection to identify any potential faults and an inspection of the screens given that screen blinding has been suspected of inhibiting performance.

6. Consider additional long term management activities including:
    a. Continue to actively protect the foul sewer system from surface water inundation i.e. install water tight covers, raise surrounds around domestic open sink gullies etc.
    b. Promote the use of source control techniques i.e. water butts and rainwater harvesting.
    c. Reduce ground water and surface water entering new drainage. Ensure suitable standards are adopted to limit clear flow ingress into newly connected drainage systems.
    d. Maximise overflow output at Marshalls Close CSO to ensure the overflow operates as per its original design.
    e. Maximise available capacity in sewer system through regular proactive jetting in locations where siltation is known to be an issue.
    f. Ensure the Lidsey WTW passes forward its maximum consented flow to full treatment.
    g. Undertake long term flow monitoring of the system to assess its performance and benefits from interventions.
    h. Provide treatment at the source of spill in Tars Farm, using an ATAC Package Biological treatment Unit, as part of a medium term strategy.
    i. Boreholes

4.8. Effect of High Tidal Levels on Surface Water Flooding

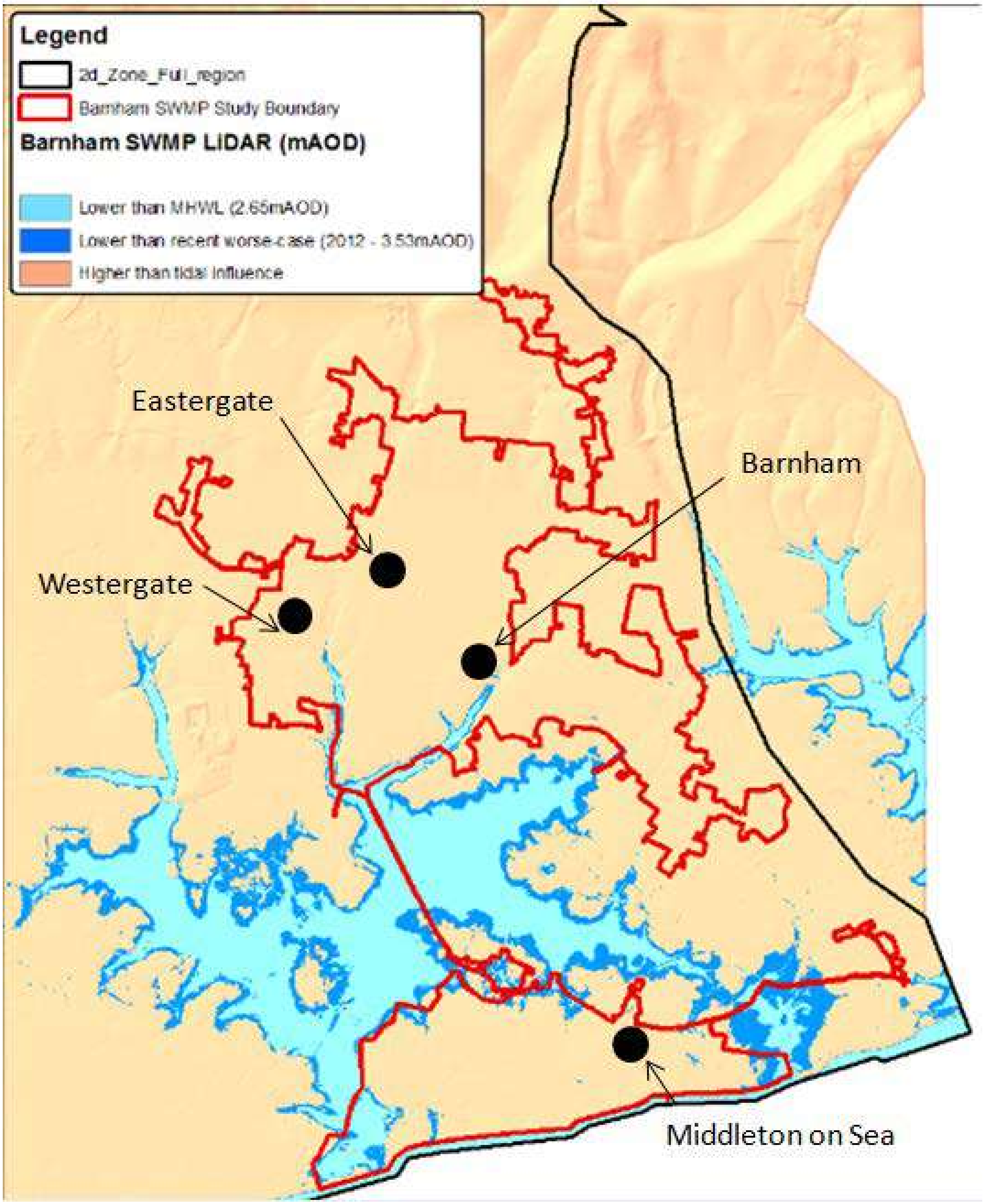
It is important to recognise the influence of the tide on the study area, as some areas are located directly on the south coast. Given the proximity of the study area to the coastline a Shoreline Management Plan and Coastal Defence Strategy has been prepared, as discussed in Sections 2.4.6 and 2.4.7, and is being utilised to effectively manage flood risk on the coastline.

Tide locking of surface water outfalls is known to occur. The effect of surface water drainage systems being locked during periods of high tide is a probability and has been allowed for within the study appraisal.

It is important to recognise that for tide locking to occur during a 1 in 100 year storm event is statistically more unlikely than the storm return period itself. But, given two high tides occur during the day there is a distinct risk this will occur. As such this scenario has been allowed for within the integrated model flood risk assessment.

Figure 4.8 shows the relative elevation of the study area against the Mean High Water Level (MHWL) (2.65m AOD). This highlights the relatively flat nature of the study area and demonstrates the potential tidal influence (light extent) with no fluvial defences in place. Middleton and Felpham would effectively be isolated from the mainland and the tidal influence on the Lidsey Rife would be observed up to Barnham.

Figure 4.8 - MHWL within the SWMP Study Area



5. Phase 2b – Intermediate Assessment of Local Flood Risk

5.1. Introduction

Phase 2 focuses on the Intermediate Assessment of Local Flood Risk. Given the size of the SWMP study area and the spread of flooding around the catchment, Local Flood Risk Zones (LFRZs) were created to demark specific areas for further analysis. This analysis initially identified 27 sites for review to enable more understanding as to the local flood risk from surface water, ground water, fluvial and sewer flooding.

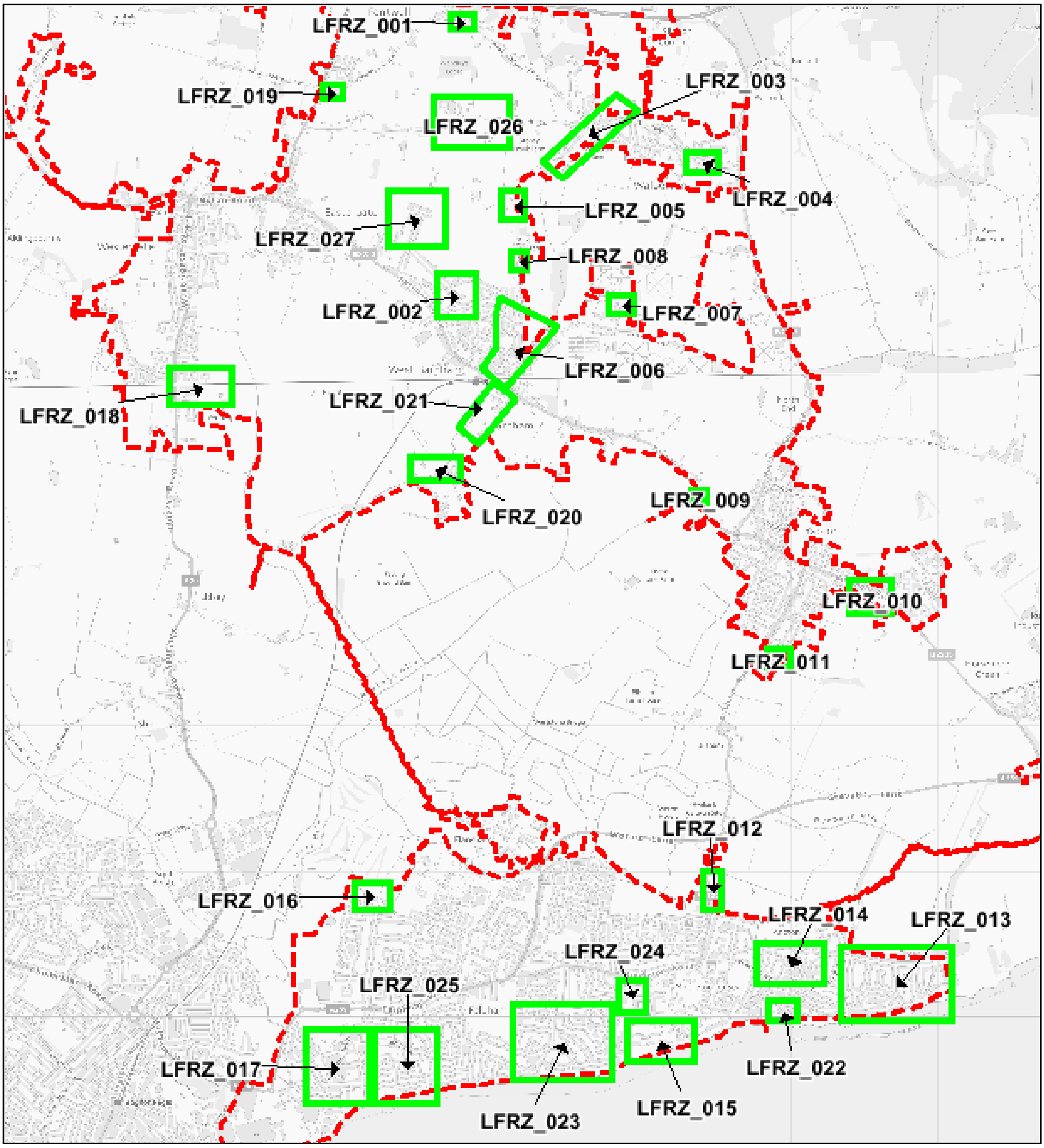
5.2. Selection and prioritisation of Local Flood Risk Zones

Using the information provided by the SWMP Partners, the reported flood history and available flood mapping records provided by the EA, the LFRZs were defined. These sites were shared and agreed by the Partners as areas which warranted further scrutiny and assessment. The LFRZs identified are listed in Table 5.1 and shown in Figure 5.1,

Table 5-1- Local Flood Risk Zones

LFRZ	Localised Place Name
LFRZ_001	West Walberton Lane, Walberton
LFRZ_002	Elm Grove, Barnham
LFRZ_003	Walberton Village (Barnham Lane (A))
LFRZ_004	Maple Road, Walberton
LFRZ_005	Barnham Lane, Barnham (B)
LFRZ_006	Lake Lane, Barnham
LFRZ_007	Park Road, Barnham
LFRZ_008	Barnham Lane, Barnham (C)
LFRZ_009	Yapton Road, Yapton
LFRZ_010	Burndell Road, Yapton
LFRZ_011	West View Drive, Yapton
LFRZ_012	Yapton Road, Middleton on Sea
LFRZ_013	Elmer Sands, Middleton on Sea
LFRZ_014	Lodge Close & Willow Brook, Middleton on Sea
LFRZ_015	Sea Way, Middleton on Sea
LFRZ_016	Golf Links Road, Felpham
LFRZ_017	Felpham Road, Felpham
LFRZ_018	Oak Tree Lane, Woodgate
LFRZ_019	Wandleys Lane, Eastergate
LFRZ_020	Highground Lane, Barnham
LFRZ_021	Marshalls Close / Church Lane, Barnham
LFRZ_022	Southdean Close, Middleton on Sea
LFRZ_023	Rudwicks Close, Broomcroft Road, The Loop, Jacken Close, Bramfield Road, Leverton Avenue, Limmer Lane (east end), Burley Road and Dryad Way in Felpham
LFRZ_024	West Close, Middleton on Sea
LFRZ_025	Limmer Lane, Felpham
LFRZ_026	Eastergate Lane, Eastergate
LFRZ_027	Downsview Road, Barnham

Figure 5.1 - LFRZ Location Plan



5.3. Adjacent flooding Needs Areas

An addition to the LFRZs identified in section 5.2 there are several other areas in the Lidsey SWMP catchment which warrant highlighting given historical flooding. These areas include the following:

1. **Hill Lane, Barnham** – Flooding in a private road. ADC report there is a lack of drainage infrastructure to drain roads and surrounding fields and there exists a query over Yapton Rife capacity.
2. **Maypole Lane, Yapton** – Property flooding. Pond is silted with no positive outlet and has defective culverts.
3. **North End Road/Lake Lane junction, Yapton** – Highway flooding. Culverts under road may potentially be silted and there exists a query over capacity of main river immediately downstream of this site.
4. **North End Road/Yapton Road junction (outside Olive Branch public house), Yapton** – highway flooding. There is a query whether this relates to a capacity or structural issue in existing highway drainage system.
5. **Northfields Lane, Aldingbourne** – property flooding. Historical issues surrounding the land drainage system but many improvements have now been carried out. Further investigation and works are considered likely. Problem exacerbated when main river in Northfields Lane overtops and overloads the adjacent land drainage system or when ground water flooding occurs.
6. **Ancton Lane, Middleton** – highway flooding. Issue with main river capacity, siltation of ditches and culverts restricting flow. Some desilting carried out by WSCC including removal of a culvert. EA has since removed a culvert.
7. **Southdean Drive, Middleton** – property and highway flooding. Infilled boundary ditch, ineffective private surface water drainage system and runoff from surrounding land/estates.

Albeit these sites have not been specifically assessed as part of the SWMP these location may warrant further assessment and monitoring to ensure suitable mitigation works and future hydraulic appraisal are undertaken based on available resources and prioritisation.

5.4. LFRZ Storyboards

To effectively assess the LFRZ sites and communicate the strategic flood risk storyboards were developed to present the risk of flooding from fluvial, ground water, surface water and public sewer sources. Where possible, the flood mechanism was determined through discussions with the Partners and Stakeholders and from available flood mapping. Where quick wins, typically relating to maintenance, were identified these were reported for Partners to consider intervention measures. The storyboards comprise of the information shown in Table 5.2.

Table 5-2- Storyboard Assessment

Item	Purpose
EA National Flood Zones (2 and 3)	Assess fluvial flood risk
EA ASTGWF	Assess ground water flood risk
EA FMfSWF (1 in 30 yr and 1 in 200 yr)	Assess surface water (pluvial) flood risk
Aerial Map	Assist with determine land use and also farming methods.
Receptor database	Determine properties and infrastructure at risk in each LFRZ
Mastermap plan of area showing major drainage infrastructure	Determine main drainage assets in area.
1870 and 1930 Mapping	Assess historic plans to determine if any major drainage channels have been removed. Reinstatement of these channels if possible may reduce flood risk.
Flooding Needs	Document historic flooding based on flood risk mapping
Site Visit Details	Document site visit notes / discussions with residents and general condition of drainage infrastructure.
Drainage condition	Identify any operational problems
Quick Wins	Determine any readily achievable quick win activities to improve drainage performance.
Conclusions and Recommendations	State conclusions / Recommendations from the intermediate assessment.

The LFRZ storyboards for 26 of the 27 sites are included in Appendix C. It should be noted that no storyboard has been prepared for LFRZ_13 Elmer Sands, Middleton on Sea given that a separate SWMP was completed for this area in 2011-2012.

5.5. Storyboard Summary

The assessment highlighted that flooding in the Lidsey SWMP study area is a widespread issue affecting multiple locations from all sources. A summary of the strategic flood risk based on the available EA flood mapping is shown in Table 5.3.

Table 5-3– Storyboard Assessment

LFRZ SWMP Ref.	LFRZ Name	LFRZ Area (ha)	Number of properties	Residential Properties in FMfSW	Commercial Properties in FMfSW	Residential Properties in Fluvial Zone 3	Commercial Properties in Fluvial Zone 3
LFRZ_001	West Walberton Lane, Walberton	2.0	14	1	0	0	0
LFRZ_002	Elm Grove, Barnham	8.8	136	29	0	15	0
LFRZ_003	Walberton Village (Barnham Lane (A))	12.6	114	50	1	44	0
LFRZ_004	Maple Road & The Street, Walberton	3.5	34	14	1	0	0
LFRZ_005	Barnham Lane (B), Barnham	3.5	2	2	0	0	0
LFRZ_006	Lake Lane, Barnham	11.1	242	48	4	73	4
LFRZ_007	Park Farm Road, Barnham	2.8	13	1	0	0	0
LFRZ_008	Barnham Lane (C), Barnham	1.8	1	0	0	0	0
LFRZ_009	Yapton Road, Yapton	1.2	7	0	0	0	0
LFRZ_010	Burndell Road, Yapton	7.1	51	4	0	0	0
LFRZ_011	West View Drive, Yapton	2.5	67	0	0	0	0
LFRZ_012	Yapton Road, Middleton on Sea	3.6	22	1	0	0	0
LFRZ_013	Elmer Sands, Middleton on Sea	40.0	548	7	0	263	2
LFRZ_014	Lodge Close & Willow Brook, Middleton on Sea	13.7	291	8	0	0	0
LFRZ_015	Sea Way Middleton on Sea	14.1	62	5	0	0	0
LFRZ_016	Golf Links Road, Felpham	5.0	45	4	1	7	1
LFRZ_017	Felpham Road, Felpham	22.8	617	13	4	173	33
LFRZ_018	Lidsey Road & Oak Tree Lane, Woodgate	11.6	101	2	0	0	0
LFRZ_019	Wandleys Lane, Eastergate, Eastergate	1.5	30	17	0	0	0
LFRZ_020	Highground Lane, Barnham	6.1	25	2	0	0	0
LFRZ_021	Marshalls Close / Church Lane, Banrham	7.4	43	0	0	3	0
LFRZ_022	Southdean Close, Middleton on Sea	3.0	55	2	0	0	0
LFRZ_023	Limmard Way / Hinde Road, Rudwick Close, Cross Bush Road & The Loop Felpham	36.6	448	10	0	0	0
LFRZ_024	West Close, Middleton on Sea	4.5	43	6	0	0	0
LFRZ_025	Limmer Lane, Felpham	22.8	261	7	0	66	0
LFRZ_026	Eastergate Lane, Eastergate	18.5	0	5	2	0	0
LFRZ_027	Downview Road, Barnham	15.7	0	17	0	14	0
		284	**3272**	**255**	**13**	**658**	**40**

This assessment provided a strategic view on the probable flood risk within the SWMP study areas LFRZs. The specific quantification of the number of residential properties and commercial properties (receptors) at risk has not been presented in the storyboards due to nature and limitations of the 1D wastewater models provided by SWS and the sensitive nature of model predictions. 1D wastewater models are capable of effectively assessing the performance of the public drainage system but are not able to fully predict the impact of overland flows once capacity in the public sewers is exceeded. As such, a general appreciation of flood risk from the public sewers has been allowed for in the LFRZ analysis.

The risk associated with ground water flooding was also not quantified against the number of receptors in each LFRZ given the location specific nature risk of flooding from ground water. Available mapping on ground water flood risk is widely accepted as being coarse and a numeric assessment would be misleading.

It worth highlighting that the fluvial Flood Zone 3 comprises land assessed as having a 1% (1 in 100) or greater annual probability of river flooding in any year. Most fluvial flood outlines are derived from the EA ‘JFlow’ generalised computer modelling, which is a ‘coarse’ modelling approach. It is well documented that caution must be exercised in interpreting JFlow derived flood outlines due to the large number of assumptions incorporated into the model. For instance, at some locations the river centreline incorporated into the model is identified to be erroneous with the result that the associated flood plains deviate from the natural valleys.

The FMfSW maps are suitable for high level risk assessments and are not recommended for individual property level flood risk appraisal. Given the scale of this national flood mapping broad assumptions have been used to allow its development. As such the FMfSW do not effectively allow for tide locking, high water levels in rivers and assumes uniform runoff rates from similar land surfaces. It is also documented that the FMfSW are more accurate at representing rural steep catchments as opposed to flat urban catchments such as Barnham and Middleton, where it has known limitations in its overall accuracy. These maps do not fully take into consideration of positive drainage i.e. highway drains and public sewers and as such have known limitations which need to be considered when interpreting flood risk.

6. Phase 2c - Detailed Assessment of Local Flood Risk

6.1. Introduction

Phase 2c focuses on the Detailed Assessment of Local Flood Risk. To facilitate the detailed assessment of the LFRZs an integrated model of the Lidsey SWMP study area was developed to assess interactions between above and below drainage assets and overland flow routing. Given the availability of SWS 1D InfoWorks CS models for Lidsey and Bognor Regis these were utilised in the construction of an Integrated Catchment Model in InfoWorks ICM software. Infoworks ICM was identified as the most suitable software tool given its ability to effectively represent all drainage system features required for assessment in the study. In addition, InfoWorks ICM is also being widely adopted by both the EA and SWS who will be responsible for the on-going ownership and maintenance of the models.

6.2. Integrated Model Build

The model was developed to include the public sewer system, main river system, selected highway drainage and ordinary watercourses. A 2D grid mesh was also incorporated to enable overland flow routing to be represented to enable surface water routing and ponding could be more accurately assessed. To facilitate the model build and verification a short term flow survey was also commissioned by the Partners to verify flow within the public sewer system in strategic locations.

Given the significant influence of ground water on the performance of the public sewer system allowances within the integrated model were incorporated to allow for elevated ground water conditions. The model build, verification and operation of the model are discussed further in Appendix D.

6.3. Integrated Model Build Future Management

Given the investment into the SWMP and the Infoworks ICM model development it is recommended that the Integrated Hydraulic Model is maintained to assist with future surface water management activities in the catchment. Given both the EA and SWS have the in-house expertise it is recommended these Partners take a lead on this activity.

It is recommended where further drainage surveys are completed in the study area and there will be a benefit from more detailed hydraulic appraisals this information should be integrated into the model. A good example of this would be the inclusion of the local drainage survey of existing assets in Middleton which has been commissioned by WSCC and is being currently completed by OPUS International. Such information will assist with future more detailed and local hydraulic appraisal.

It is recognised that the Aldingbourne Rife Integrated Flood Risk Management Plan & Works will seek to utilise the SWMP Infoworks ICM model and integrate the verified main river component which will be the main focus of the EA Study. Inclusion of the verified main rivers will further enhance the SWMP ICM model and improve the ability of the model to accurately predict local flood risk in the catchment.

WSCC will also be continuing to develop its flood asset register as part of its responsibilities under the Flood and Water Management Act 2010. Information collected as part of this process where appropriate should be used to update the SWMP ICM model where strategic benefits can be obtained.

Flood risk in the catchment has been assessed for a 1 in 30, 1 in 100 and 1 in 1000 years. In addition a sensitivity analysis of climate change has been allowed for in the analysis by allowing for a 20% increasing in peak intensities of rainfall. An assessment of RefH (Revitalised Flood Hydrograph) and local critical duration analysis has determined that the catchment critical duration is a 480 minute storm event.

7. Phase 2d - Map and Communicate Risk

7.1. Introduction

With the risk assessment completed, the final part of Phase 2, as outlined in Figure 4.1, is to map and communicate the risk. The integrated hydraulic model of the study area has been used to develop predicted flood mapping. The flood mapping produced by the model offers a broad understanding of the flood extents and flood hazards across the catchment. This information should be used by both urban and emergency planners to assist with reducing the impact of current and future flood risk within the catchment.

7.2. Flood Depth and Extents

The predicted flood extent for depths greater than 150mm has been developed to present the flood risk associated with the following storm event scenarios:

- 33.3% annual chance storm event (1 in 30 year return period)
- 1% annual chance storm event (1 in 100 year return period)
- 0.1% annual chance storm event (1 in 1000 year return period)

The predictive flood depth and extent outputs from the hydraulic model are discussed further in Section 7.4. These have been used to inform the economic flood damages assessment which is discussed in Section 7.5.

7.3. Flood Hazard Mapping

Flood hazard is a function of the flood depth, flow velocity and a debris factor. Flood risk mapping has been undertaken for the 1 in 100 chance storm event based on the SWMP Guidance Document. The Flood Risk is calculated using the following equation:

$$\text{Hazard rating} = d * (v + 0.5) + DF$$

Where: d = depth (m); v = velocity (m/s); and DF = debris factor (0, 0.5 or 1, depending on probability that debris will cause a hazard).

The flood hazard categories and their associated impact are shown in Table 7.1

Table 7-1 – Flood Hazard Categories

Degree of flood Hazard	Hazard Rating		Description
Low	<0.75	Caution	Flood zone with shallow water or deep standing water
Moderate	0.75 to 1.25	Dangerous for some i.e. children	Danger: Flood zone with deep or fast flowing water
Significant	1.25 to 2.5	Dangerous for most people	Danger: Flood zone with deep fast flowing water
Extreme	>2.5	Dangerous for all	Extreme danger: Flood zone with deep fast flowing water.

The relationship between Depth and Velocity and Hazard is shown in Figure 7.1.

Figure 7.1 - Flood Hazard Categorisation

HR	Debris Factor DF = 0.5				Debris Factor DF = 1									
	Depth of flooding D (m)													
Velocity V (m/s)	0.05	0.10	0.20	0.25	0.30	0.40	0.50	0.60	0.70	0.80	1.00	1.50	2.00	2.50
-	0.53	0.55	0.60	0.63	1.15	1.20	1.25	1.30	1.35	1.40	1.50	1.75	2.00	2.25
0.1	0.53	0.56	0.62	0.65	1.18	1.24	1.30	1.36	1.42	1.48	1.60	1.90	2.20	2.50
0.3	0.54	0.58	0.66	0.70	1.24	1.32	1.40	1.48	1.56	1.64	1.80	2.20	2.60	3.00
0.5	0.55	0.60	0.70	0.75	1.30	1.40	1.50	1.60	1.70	1.80	2.00	2.50	3.00	3.50
1.0	0.58	0.65	0.80	0.88	1.45	1.60	1.75	1.90	2.05	2.20	2.50	3.25	4.00	4.75
1.5	0.60	0.70	0.90	1.00	1.60	1.80	2.00	2.20	2.40	2.60	3.00	4.00	5.00	6.00
2.0	0.63	0.75	1.00	1.13	1.75	2.00	2.25	2.50	2.75	3.00	3.50	4.75	6.00	7.25
2.5	0.65	0.80	1.10	1.25	1.90	2.20	2.50	2.80	3.10	3.40	4.00	5.50	7.00	8.50
3.0	0.68	0.85	1.20	1.38	2.05	2.40	2.75	3.10	3.45	3.80	4.50	6.25	8.00	9.75
3.5	0.70	0.90	1.30	1.50	2.20	2.60	3.00	3.40	3.80	4.20	5.00	7.00	9.00	11.00
4.0	0.73	0.95	1.40	1.63	2.35	2.80	3.25	3.70	4.15	4.60	5.50	7.75	10.00	12.25
4.5	0.75	1.00	1.50	1.75	2.50	3.00	3.50	4.00	4.50	5.00	6.00	8.50	11.00	13.50
5.0	0.78	1.05	1.60	1.88	2.65	3.20	3.75	4.30	4.85	5.40	6.50	9.25	12.00	14.75

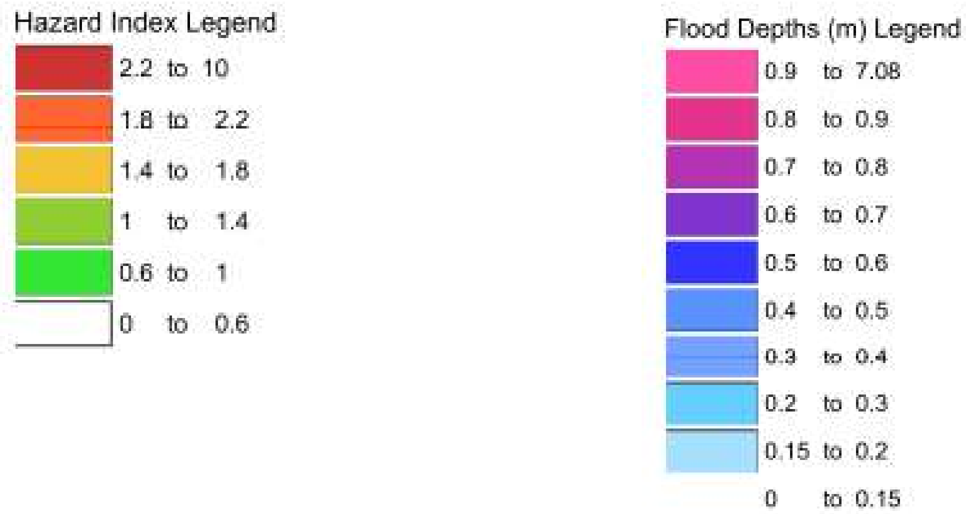
The flood hazard analysis and flood extent for a 1% annual chance storm event (1 in 100 year return period) event is shown in more detail in Section 7.4 for each LFRZ.

Predicted Flood Hazard Mapping for the catchment is included in Appendix A – Plan 7, 8 and 9 for a 1 in 30, 1 in 100 and 1 in 1000 return period. In addition, Appendix A – Plan 10, 11 and 12 provides plans of the predicted flood depths for a 1 in 30, 1 in 100 and 1 in 1000 return period.

7.4. LFRZ Flood Risk Assessment (LFRZ 1 to LFRZ 27)

A summary of the predicted flood risk and flood hazard for each of the Local Flood Risk Zones is shown in the following sections. The following legends apply to the flood Hazard and Flood Depth plans.

Figure 7.2 - Flood Hazard / Flood Depth Legends



LFRZ_001 - West Walberton Lane, Walberton

Figure 7.3 - Flood Risk LFRZ_001 (1 in 100 year storm event)

Figure 7.4 - Flood Hazard LFRZ_001 (1 in 100 year storm event)

Table 7-2 – Predicted Residential and Commercial Property Flood Impact LFRZ_001

Rainfall Return Period	Predicted number of properties at risk of flooding	
	Residential	Commercial
1 in 30 Year	2	0
1 in 100 Year	2	0
1 in 100 Year + (Climate Change (2080's)	2	1

Table 7-3 - Summary of local flood risk within the LFRZ_001

Flood Risk Source			
Pluvial Flood Risk	Fluvial Flood Risk	Ground Water Flood Risk	Public Sewer Flood Risk
Medium	Low	Medium	High
Flood Mechanism			
Public sewer flooding due to hydraulic overload in West Walberton Lane. Flooding of the public sewer system is primarily caused by clear water inflow into the public foul sewer system through infiltration of ground water and surface water inflows / inundation.			
Flood Risk Receptors			
Highway and residential properties			
Flood Hazard			
No specific flood hazard is predicted for 1% annual chance storm event (1 in 100 year return period)			
Validation			
Discussions with residents mainly concerned pluvial flooding and the state of the highway drainage in the area. Surface water runoff from the highway was the only known source of flooding. SWS confirm historic local flooding from the public sewer system.			

LFRZ_002 - Elm Grove, Barnham

Figure 7.5 - Flood Risk LFRZ_002 (1 in 100 year storm event)

Figure 7.6 - Flood Hazard LFRZ_002 (1 in 100 year storm event)

Table 7-4 - Predicted Residential and Commercial Property Flood Impact LFRZ_002

Rainfall Return Period	Predicted number of properties at risk of flooding	
	Residential	Commercial
1 in 30 Year	8	1
1 in 100 Year	15	1
1 in 100 Year + (Climate Change (2080's)	21	1

Table 7-5 - Summary of local flood risk within the LFRZ_002

Flood Risk Source			
Pluvial Flood Risk	Fluvial Flood Risk	Ground Water Flood Risk	Public Sewer Flood Risk
Medium	Low	High	High
Flood Mechanism			
Surface water and ground water flooding affecting properties internally and externally. Flooding from the public foul sewer system also occurs due to high inflows of surface water through inundation and ground water leading to hydraulic overload.			
Flood Risk Receptors			
Highway, school and residential properties			
Flood Hazard			
No specific flood hazard is predicted for 1% annual chance storm event (1 in 100 year return period)			
Validation			
Area experience severe flooding in Winter 1993, 1998 and Summer 2012 from surface water and sewer sources. Flooding of internal properties and property curtilage along south side of Elm Grove. Sewer capacities are exceeded after heavy prolonged rain. Combined flooding has been reported within Barnham Primary School grounds, after prolonged rainfall. Numerous properties affected. Low Lying property in Elm Grove suffers from ground water flooding of garden regularly. Primary school is also particularly low. SWS tankers regularly pump out foul sewers for days after heavy rainfall. Photographic evidence of flood extents has been provided by residents and SWMP Partners.			

LFRZ_003 – Walberton Village

Figure 7.7 - Flood Risk LFRZ_003 (1 in 100 year storm event)

Figure 7.8 - Flood Hazard LFRZ_003 (1 in 100 year storm event)

Table 7-6 - Predicted Residential and Commercial Property Flood Impact LFRZ_003

Rainfall Return Period	Predicted number of properties at risk of flooding	
	Residential	Commercial
1 in 30 Year	16	4
1 in 100 Year	27	4
1 in 100 Year + (Climate Change (2080's)	43	4

Table 7-7 - Summary of local flood risk within the LFRZ_003

Flood Risk Source			
Pluvial Flood Risk	Fluvial Flood Risk	Ground Water Flood Risk	Public Sewer Flood Risk
Medium	High	High	High
Flood Mechanism			
Surface water flooding occurs due to runoff from surrounding fields from the north and north-east of Walberton Village. Surface water flow is conveyed along The Street where it ponds around the junction of The Street and Eastergate Lane. Flooding in highway from public foul sewer system occurs within Walberton village. Main river capacity exceeded and floods rear gardens in Barnham Lane. Ordinary watercourses and pond capacity exceeded. The ditches in Eastergate Lane on both the north and south are exceeded.			
Flood Risk Receptors			
Residential and commercial properties			
Flood Hazard			
A 'moderate' flood hazard is predicted for 1% annual chance storm event (1 in 100 year return period) in The Street and in rear gardens of properties along Barnham Lane.			
Validation			
Flooding has been reported on a regular basis as sourcing from the fields to the north of the village, and the village pond. A report written by the Walberton Parish Council Flood Task Force indicates that flooding is largely winterbourne, with the exceptions of the June 2012 extreme event, resulting from prolonged rainfall. Key areas of identified risk are: Barrack Row, Eastergate Lane, The bungalows, Burch Grove, Walberton Green and West Walberton Lane.			

LFRZ_004 - Maple Road, Walberton

Figure 7.9 - Flood Risk LFRZ_004 (1 in 100 year storm event)

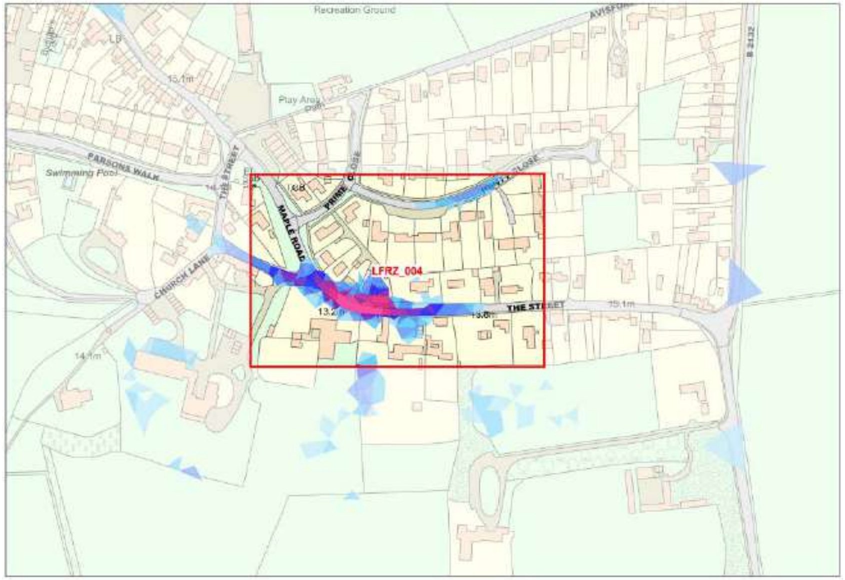


Figure 7.10 - Flood Hazard LFRZ_004 (1 in 100 year storm event)

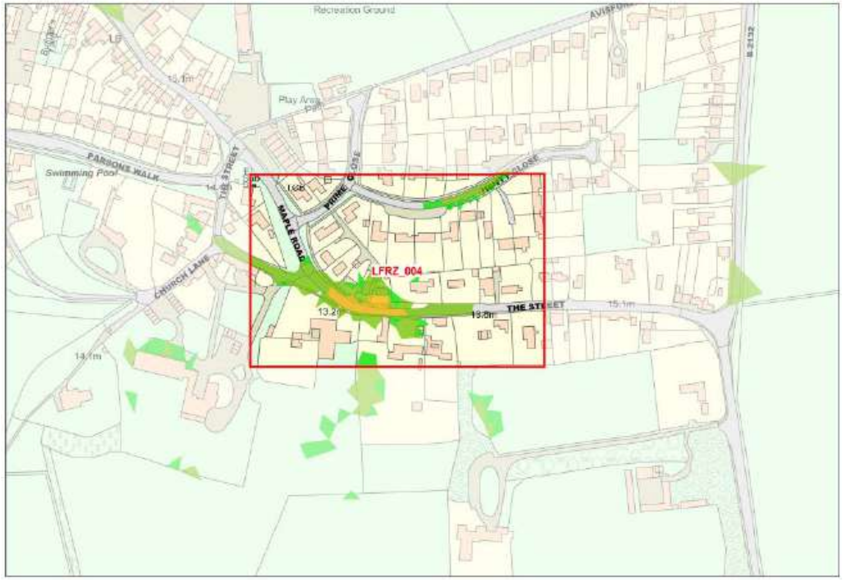


Table 7-8 - Predicted Residential and Commercial Property Flood Impact LFRZ_004

Rainfall Return Period	Predicted number of properties at risk of flooding	
	Residential	Commercial
1 in 30 Year	9	0
1 in 100 Year	10	0
1 in 100 Year + (Climate Change (2080's)	12	1

Table 7-9 - Summary of local flood risk within the LFRZ_004

Flood Risk Source			
Pluvial Flood Risk	Fluvial Flood Risk	Ground Water Flood Risk	Public Sewer Flood Risk
8. Medium	Low	Low	9. Medium
10. Flood Mechanism			
11. Surface water is being conveyed from the east on Maple Road where it attenuates at a low point in the highway. Flooding from foul manholes is reported in Maple Road downstream to the west of the highway flooding.			
Flood Risk Receptors			
Residential and commercial properties			
Flood Hazard			
A 'significant' flood hazard is predicted for 1% annual chance storm event (1 in 100 year return period) in The Street. However, it should be acknowledged that a flood relief scheme has been installed. WSCC confirmed their involvement in the scheme approx. 10 years ago. A new storm system taking highway surface water discharging to a pond to the south of the village was installed. This has reduced surface water flood risk in the area.			
Validation			
According to residents, the primary issue at present is flooding from foul / combined sewer along The Street. MH SU97053802 lifts and floods the road and adjacent properties. Sewer flooding has been reported in the area following heavy rainfall. Hydraulic overload of the public sewer system has been confirmed by Southern Waters SIRF data and hydraulic model of the wastewater sewer system. Anti-Flood Devices are in situ to mitigate sewer flooding at some properties in this LFRZ.			

LFRZ_005 - Barnham Lane, Barnham (B)

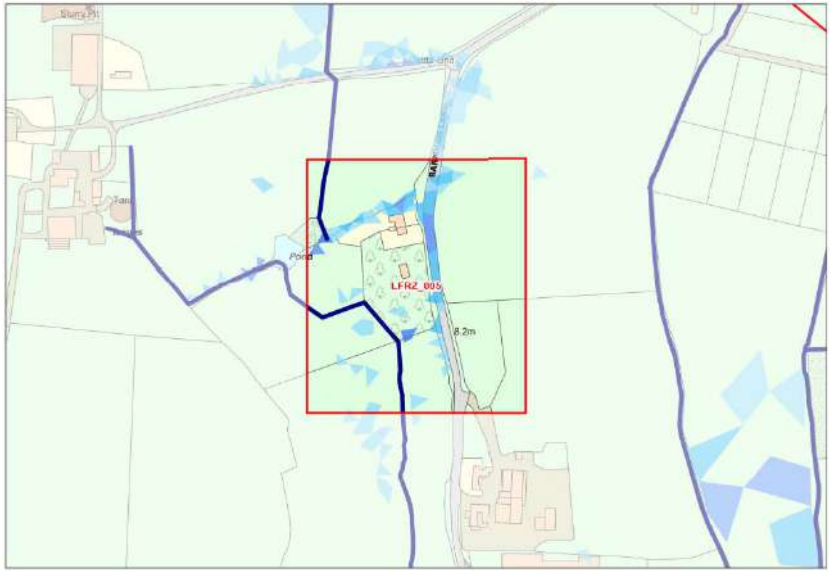


Figure 7.11 - Flood Risk LFRZ_005 (1 in 100 year storm event)

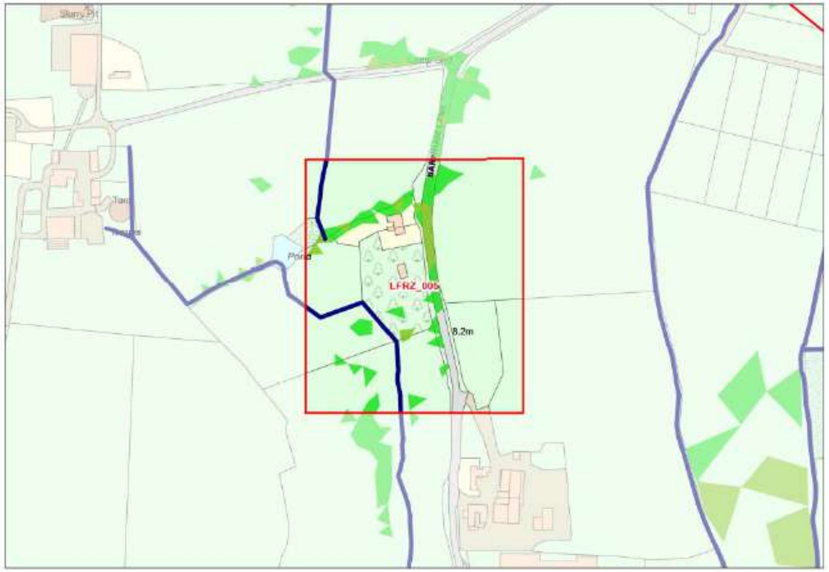


Figure 7.12 - Flood Hazard LFRZ_005 (1 in 100 year storm event)

Table 7-10 - Predicted Residential and Commercial Property Flood Impact LFRZ_005

Rainfall Return Period	Predicted number of properties at risk of flooding	
	Residential	Commercial
1 in 30 Year	1	0
1 in 100 Year	1	0
1 in 100 Year + (Climate Change (2080's)	1	0

Table 7-11 - Summary of local flood risk within the LFRZ_005

Flood Risk Source			
Pluvial Flood Risk	Fluvial Flood Risk	Ground Water Flood Risk	Public Sewer Flood Risk
12. Medium	Low	Medium	High
Flood Mechanism			
Highway flooding caused by ponding of surface water is unable to drain into overloaded ditch system. Surface water conveyed from the north to south along Barnham Lane. No spare capacity in Rife system to the west where ditch system and pond are connected. Foul flooding of highway from foul sewer system considered to be the main issue. Foul Sewer system is overloaded by clear water inflow through both ground water inflow and / or surface water inundation.			
Flood Risk Receptors			
Residential property and highway flooding.			
Flood Hazard			
A 'low' to moderate flood hazard is predicted for 1% annual chance storm event (1 in 100 year return period) in Barnham Lane. Velocity of the surface water is general low given the flat topography.			
Validation			
Discussions with residents along Barnham Lane indicate flooding from foul manholes in the highway after prolonged rainfall at winter time is their main concern. Floodwaters remain in the highway for up to four weeks after the storm event and do not drain away. Fields at back of properties also experience waterlogging and pluvial flooding. Worst recent storms: Winter 1999, Summer 2012			

LFRZ_006 - Lake Lane, Barnham

Figure 7.13 - Flood Risk LFRZ_006 (1 in 100 year storm event)

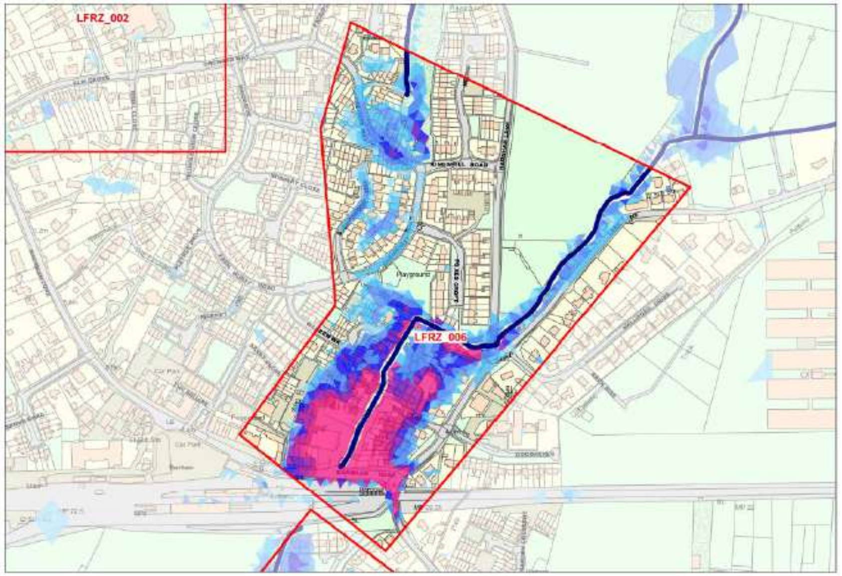


Figure 7.14 - Flood Hazard LFRZ_006 (1 in 100 year storm event)

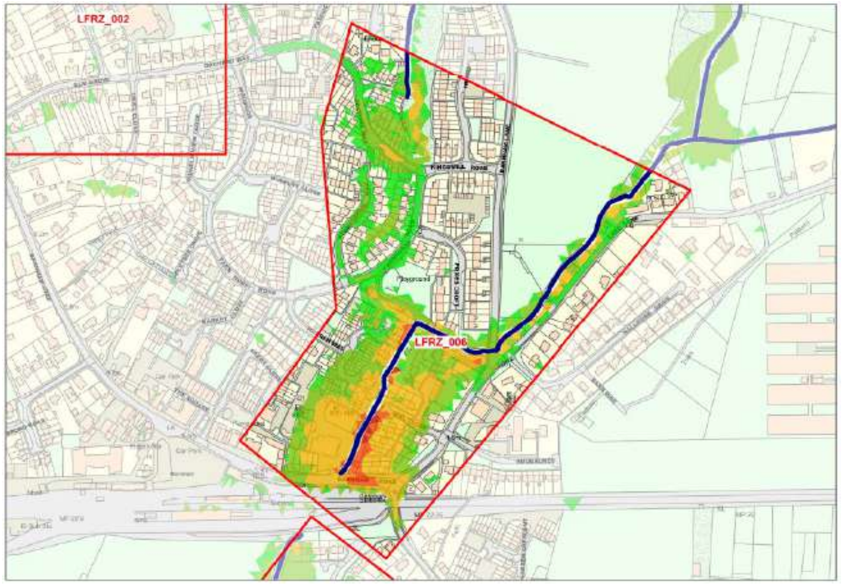


Table 7-12 - Predicted Residential and Commercial Property Flood Impact LFRZ_006

Rainfall Return Period	Predicted number of properties at risk of flooding	
	Residential	Commercial
1 in 30 Year	108	15
1 in 100 Year	147	16
1 in 100 Year + (Climate Change (2080's)	163	18

Table 7-13 - Summary of local flood risk within the LFRZ_006

Flood Risk Source			
Pluvial Flood Risk	Fluvial Flood Risk	Ground Water Flood Risk	Public Sewer Flood Risk
Medium	High	Medium	High
Flood Mechanism			
Reported flooding is influenced by 1) Culvert outlets for Surface Water drains becoming locked when the Rife is high. 2) Poor maintenance of ditched and culverts, reducing their capacity. 3) Capacity in the culverts under the railway line throttles the main river. 4) Public sewer flooding caused by excessive inflow of surface water and ground water.			
Flood Risk Receptors			
Residential and commercial properties and highway flooding.			
Flood Hazard			
A 'significant' flood hazard is predicted for 1% annual chance storm event (1 in 100 year return period) in Yapton Road due to out of bank flows from the Rife. Greatest flood hazard is the vicinity of the Rife immediately upstream of the culvert under the railway line.			
Validation			
Photographic, video and questionnaire responses validate flood history. Notable flood events experienced in Dec 1993 / Jan 1994, Summer 2012, Winter 2012 and Winter 2001 at Lake Lane, Warren Way, Dial Close, Yapton Road and Farnhurst Road. Warren Way: No flooding from river in 2012, though river was close to bursting. Flooding of roads. Fluvial flooding in 1993 as a result of blocked culvert inlet downstream. Outfall from SWS drains potentially blocked when rife is high. Dial Close: Flooding of Garages from Surface Water and River at times of heavy rain (including 2012). Little evidence to suggest flooding of properties as a result of these sources. Private drain discharge to Rife - no free outfall at times of high river level. Lake Lane: Flooding from Rife at Barnham Lane bridge (box culvert). Barnham Lane bridge throttles the main river and floods over the road into properties to south west. SWS manhole in Lake Lane lifts and floods properties to south possibly due to a blockage or restriction downstream (currently under investigation). SW drain leads south to Rife and received water from ditches to the north east. Yapton Road: No evidence of flooding properties in 2012. Main event cited is 1993. Farnhurst Road: Playground off Farnhurst Road has experienced flooding from foul manholes (MH Ref. SU96040507) located adjacent to surface water outfalls entering the rife. This has been expressed as a concern by residents and Partners.			

LFRZ_007 - Park Road, Barnham

Figure 7.15 - Flood Risk LFRZ_007 (1 in 100 year storm event)

Figure 7.16 - Flood Hazard LFRZ_007 (1 in 100 year storm event)

Table 7-14 - Predicted Residential and Commercial Property Flood Impact LFRZ_007

Rainfall Return Period	Predicted number of properties at risk of flooding	
	Residential	Commercial
1 in 30 Year	0	0
1 in 100 Year	0	0
1 in 100 Year + (Climate Change (2080's)	0	0

Table 7-15 - Summary of local flood risk within the LFRZ_007

Flood Risk Source			
Pluvial Flood Risk	Fluvial Flood Risk	Ground Water Flood Risk	Public Sewer Flood Risk
Medium	Low	Medium	Medium
Flood Mechanism			
SWS have reported incidents of sewer flooding in the area. ADC confirmed overflowing foul sewers due to infiltration/inundation/surface water connections. Surface water flooding due to capacity/unmaintained ditch network and ground water flooding due to spring behind properties on east side of Park Road. Ditch on northern boundary of Kilkenny has a trash screen. This is a poor arrangement and is considered to warrant improvement. This arrangement results in ditch backing up and overflowing. An assumed overflow from reservoir to N/E of Park Road is reported to flow continuously. It is understood that there is no surface water collection/storage by nursery at end of Park Road.			
Flood Risk Receptors			
Flooding in fields to the rear of properties.			
Flood Hazard			
No specific flood hazard is predicted for 1% annual chance storm event (1 in 100 year return period)			
Validation			
SWS have reported a single incident of hydraulic overload and flooding from the foul sewer system in the last 10 years, ADC confirmed overflowing foul sewers due to infiltration/inundation/surface water connections. Flooding to the east of the LFRZ has been identified to the EA due to exceedance from the main river.			

LFRZ_008 - Barnham Lane, Barnham (C)

Figure 7.17 - Flood Risk LFRZ_008 (1 in 100 year storm event)

Figure 7.18 - Flood Hazard LFRZ_008 (1 in 100 year storm event)

Table 7-16 - Predicted Residential and Commercial Property Flood Impact LFRZ_008

Rainfall Return Period	Predicted number of properties at risk of flooding	
	Residential	Commercial
1 in 30 Year	0	0
1 in 100 Year	1	0
1 in 100 Year + (Climate Change (2080's)	1	0

Table 7-17 - Summary of local flood risk within the LFRZ_008

Flood Risk Source			
Pluvial Flood Risk	Fluvial Flood Risk	Ground Water Flood Risk	Public Sewer Flood Risk
Low	Low	Medium	High
Flood Mechanism			
Highway flooding caused by ponding of surface water and flooding from foul manholes. Foul manholes covers are reported to lift along Barnham Lane.			
Flood Risk Receptors			
Flooding in field and curtilage of property.			
Flood Hazard			
No specific flood hazard is predicted for 1% annual chance storm event (1 in 100 year return period). Topography is fairly flat which dictates low velocity in surface water runoff.			
Validation			
Discussion with residents along Barnham Lane indicates flooding from foul manholes in the highway after prolonged rainfall at winter time. Floodwaters remain in the highway for up to four weeks after the storm event and do not drain away. Fields at back of properties also experience waterlogging and pluvial flooding. Worst recent storms: Winter 1999, Summer 2012			

LFRZ_009 - Yapton Road, Yapton

Figure 7.19 - Flood Risk LFRZ_009 (1 in 100 year storm event)

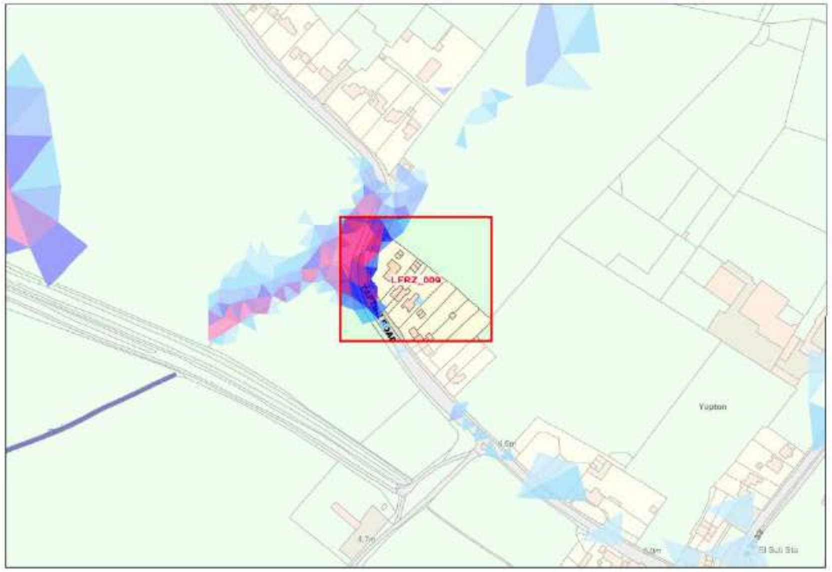


Figure 7.20 - Flood Hazard LFRZ_009 (1 in 100 year storm event)

Table 7-18 - Predicted Residential and Commercial Property Flood Impact LFRZ_009

Rainfall Return Period	Predicted number of properties at risk of flooding	
	Residential	Commercial
1 in 30 Year	0	0
1 in 100 Year	3	0
1 in 100 Year + (Climate Change (2080's)	3	0

Table 7-19 - Summary of local flood risk within the LFRZ_009

Flood Risk Source			
Pluvial Flood Risk	Fluvial Flood Risk	Ground Water Flood Risk	Public Sewer Flood Risk
High	Low	Medium	High
Flood Mechanism			
Highway flooding from surface water. An overland flow path from the fields to the east of Yapton Road conveying flow west across the highway and into a piped and ditched system is evident. Foul flooding upstream of the Yapton Road WPS due to hydraulic overload caused by excessive clear water inflows.			
Flood Risk Receptors			
Residential properties.			
Flood Hazard			
A 'significant' flood hazard is predicted for 1% annual chance storm event (1 in 100 year return period) in Yapton Road.			
Validation			
Two reported flooding incidents as a result of the June 2012 floods. Additional reported hydraulic sewer flooding as a result of overloading of Barnham Road Yapton pumping station in 2003. Yapton Road WPS has had its pumped upgraded in the recent past to convey greater combined flows forward. This is a known flooding problem to the SWMP Partners.			

LFRZ_0010 - Burndell Road, Yapton

Figure 7.21 - Flood Risk LFRZ_010 (1 in 100 year storm event)

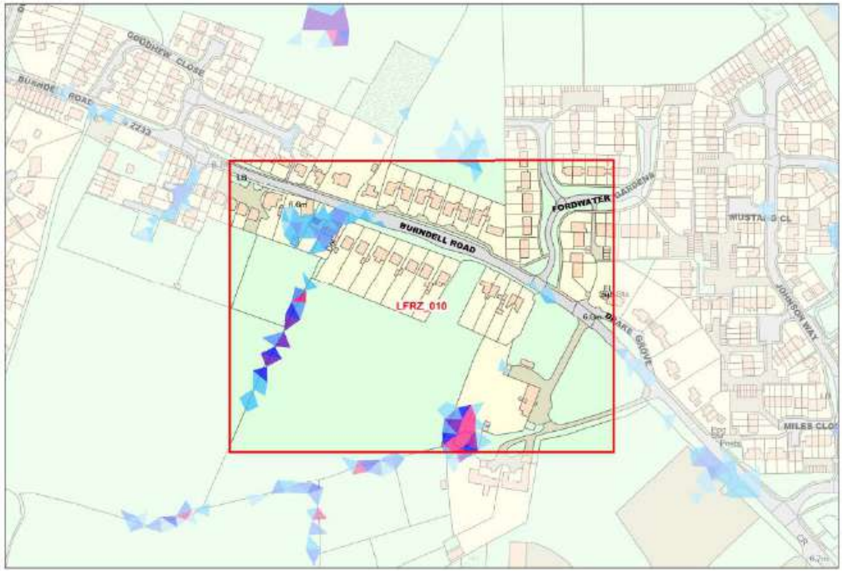


Figure 7.22 - Flood Hazard LFRZ_010 (1 in 100 year storm event)

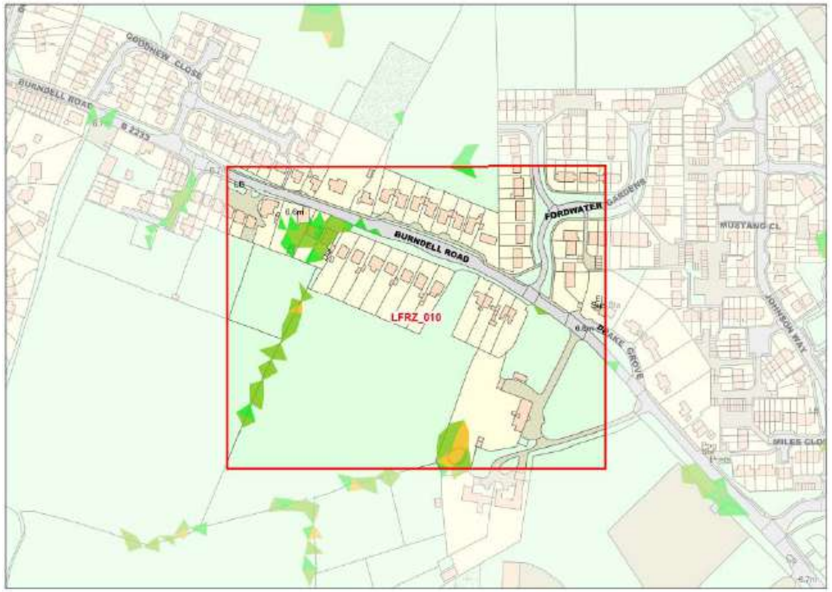


Table 7-20 - Predicted Residential and Commercial Property Flood Impact LFRZ_010

Rainfall Return Period	Predicted number of properties at risk of flooding	
	Residential	Commercial
1 in 30 Year	1	1
1 in 100 Year	3	2
1 in 100 Year + (Climate Change (2080's)	5	2

Table 7-21 - Summary of local flood risk within the LFRZ_010

Flood Risk Source			
Pluvial Flood Risk	Fluvial Flood Risk	Ground Water Flood Risk	Public Sewer Flood Risk
High	Low	High	Medium
Flood Mechanism			
Hydraulic overload and flooding of the foul sewer system due to excessive inflows from ground water and surface water. Highway drainage system unable to drain highway affectively. Flooding of basements due to high ground water is reported. Runoff from the fields to the south of the Burndell Road is contributing to the surface water flooding.			
Flood Risk Receptors			
Residential properties.			
Flood Hazard			
A 'low' flood hazard is predicted for 1% annual chance storm event (1 in 100 year return period) off Burndell Road			
Validation			
Residents reported bad flooding on properties in 1993, 2001 and 2012. All winter events with the exception of June 2012. Surrounding land is saturated easily after prolonged rainfall. Residents have reported extensive highway flooding and flooding of property. Extent of flooding has been provided by residents.			

LFRZ_0011 - West View Drive, Yapton

Figure 7.23 - Flood Risk LFRZ_011 (1 in 100 year storm event)

Figure 7.24 - Flood Hazard LFRZ_011 (1 in 100 year storm event)

Table 7-22 - Predicted Residential and Commercial Property Flood Impact LFRZ_011

Rainfall Return Period	Predicted number of properties at risk of flooding	
	Residential	Commercial
1 in 30 Year	2	1
1 in 100 Year	3	1
1 in 100 Year + (Climate Change (2080's)	3	1

Table 7-23 - Summary of local flood risk within the LFRZ_011

Flood Risk Source			
Pluvial Flood Risk	Fluvial Flood Risk	Ground Water Flood Risk	Public Sewer Flood Risk
Low	Low	Low	Low
Flood Mechanism			
Hydraulic overload of the foul sewer system is the main flood risk in this area. The flooding which occurred during an extreme event.			
Flood Risk Receptors			
Residential properties.			
Flood Hazard			
A 'low' flood hazard is predicted for 1% annual chance storm event (1 in 100 year return period).			
Validation			
SWS SIRF data reports two incidents of flooding during the June 2012 floods.			

LFRZ_0012 - Yapton Road, Middleton on Sea

Figure 7.25 - Flood Risk LFRZ_012 (1 in 100 year storm event)

Figure 7.26 - Flood Hazard LFRZ_012 (1 in 100 year storm event)

Table 7-24 - Predicted Residential and Commercial Property Flood Impact LFRZ_012

Rainfall Return Period	Predicted number of properties at risk of flooding	
	Residential	Commercial
1 in 30 Year	1	1
1 in 100 Year	1	4
1 in 100 Year + (Climate Change (2080's)	1	6

Table 7-25 - Summary of local flood risk within the LFRZ_012

Flood Risk Source			
Pluvial Flood Risk	Fluvial Flood Risk	Ground Water Flood Risk	Public Sewer Flood Risk
High	Low	Medium	Low
Flood Mechanism			
Flooding occurs in highway area caused by pluvial runoff from fields to the west of Yapton Road which inundates ditch system. Highway runoff also occurs from the south from Norton Road and Yapton Road roundabout north into the LFRZ. Flooding confirmed by ADC in June 2012 storm event. Surface water flooding – unmaintained ditches/culverts in the area have historically affected the performance. WSCC have undertaken ditch and culvert clearance in the area to improve drainage. Further work is currently being carried out by 'Opus' to better understand the flooding in this area. WSCC consider there to be large overland flows from fields to the east and west which overloads the existing surface water system in Yapton Road.			
Flood Risk Receptors			
Residential property and highway (Yapton Road).			
Flood Hazard			
A 'low' flood hazard is predicted for 1% annual chance storm event (1 in 100 year return period).			
Validation			
Yapton Road and properties curtilage flooded badly Summer 2012 and Winter 2012. Approximately 20-30 cm floodwater in road and property curtilage. Properties north of LFRZ also flooded badly during these events. No evidence given to suggest flooding from sewers. Residents have provided photographic evidence of flooding in the area showing flood extents.			

LFRZ_0013 - Elmer Sands, Middleton on Sea

Figure 7.27 - Flood Risk LFRZ_013 (1 in 100 year storm event)

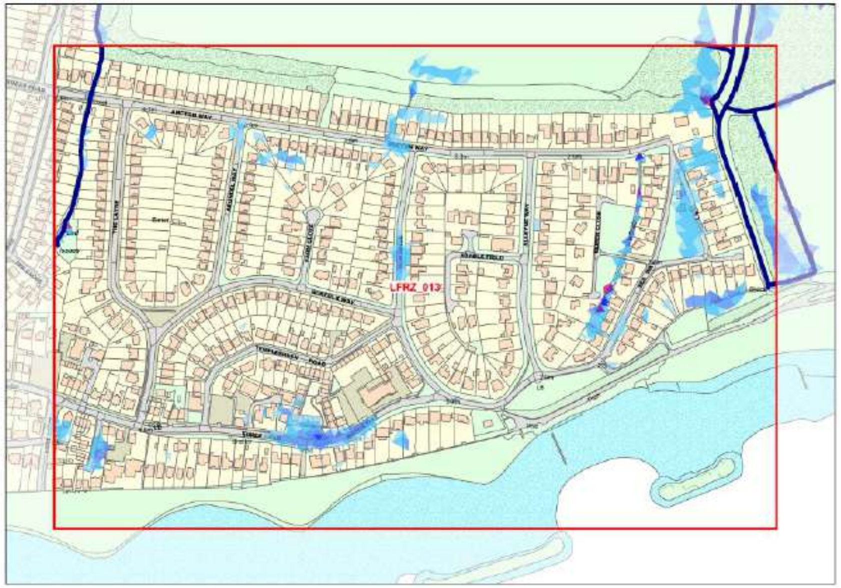


Figure 7.28 - Flood Hazard LFRZ_013 (1 in 100 year storm event)

Table 7-26 - Predicted Residential and Commercial Property Flood Impact LFRZ_013

Rainfall Return Period	Predicted number of properties at risk of flooding	
	Residential	Commercial
1 in 30 Year	35	4
1 in 100 Year	56	4
1 in 100 Year + (Climate Change (2080's)	68	4

Table 7-27 - Summary of local flood risk within the LFRZ_013

Flood Risk Source			
Pluvial Flood Risk	Fluvial Flood Risk	Ground Water Flood Risk	Public Sewer Flood Risk
High	Low	High	High
Flood Mechanism			
Hydraulic overload of the foul sewer system has been confirmed. Pluvial flooding is caused by ineffectual soakaways during high ground water conditions. At the lowest point in the LFRZ around The Hard ground water flooding is a probable risk based on ground water monitoring. Highway drainage system has been constructed at slack gradients to enable discharge to the Rife. This results in under capacity of the highway drainage network. The flood mechanism is discussed further in the Elmer SWMP reporting.			
Flood Risk Receptors			
Residential and commercial properties.			
Flood Hazard			
A 'low' flood hazard is predicted for 1% annual chance storm event (1 in 100 year return period).			
Validation			
Flooding has been confirmed by residents and SWMP Partners. Extensive supporting material has been collated under the Elmer SWMP.			

LFRZ_0014 - Lodge Close & Willow Brook, Middleton on Sea

Figure 7.29 - Flood Risk LFRZ_014 (1 in 100 year storm event)

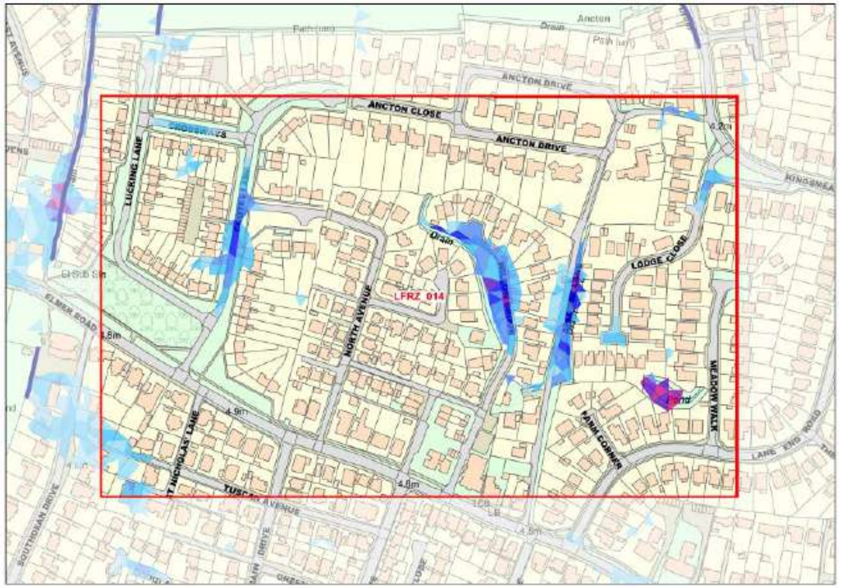


Figure 7.30 - Flood Hazard LFRZ_014 (1 in 100 year storm event)

Table 7-28 - Predicted Residential and Commercial Property Flood Impact LFRZ_014

Rainfall Return Period	Predicted number of properties at risk of flooding	
	Residential	Commercial
1 in 30 Year	13	2
1 in 100 Year	22	2
1 in 100 Year + (Climate Change (2080's)	36	2

Table 7-29 - Summary of local flood risk within the LFRZ_014

Flood Risk Source			
Pluvial Flood Risk	Fluvial Flood Risk	Ground Water Flood Risk	Public Sewer Flood Risk
High	Low	High	High
Flood Mechanism			
Surface water drainage systems are unable to effectively convey surface water north of the LFRZ. Soakaways are likely affected by high ground water conditions reducing affective disposal of surface water to ground. Flooding from the public foul sewer system due to hydraulic overload has been reported to SWS.			
Flood Risk Receptors			
Residential properties.			
Flood Hazard			
A 'low' flood hazard is predicted for 1% annual chance storm event (1 in 100 year return period).			
Validation			
Flooding has been confirmed by residents and the Middleton Strategic Flood Action Group, SWMP Partners, Middleton on Sea Parish Council and Middleton on Sea Association.			
General Notes			
WSCC are currently conducting an assessment of the drainage system in this area. Opus Consulting are completing condition surveys of key drainage assets to assess the condition. This assessment includes surveys of culverts and ponds. The information collected as part of the survey will be incorporated into future hydraulic assessments.			

LFRZ_0015 - Sea Way, Middleton on Sea

Figure 7.31 - Flood Risk LFRZ_015 (1 in 100 year storm event)

Figure 7.32 - Flood Hazard LFRZ_015 (1 in 100 year storm event)

Table 7-30 - Predicted Residential and Commercial Property Flood Impact LFRZ_015

Rainfall Return Period	Predicted number of properties at risk of flooding	
	Residential	Commercial
1 in 30 Year	7	1
1 in 100 Year	7	1
1 in 100 Year + (Climate Change (2080's)	7	1

Table 7-31 - Summary of local flood risk within the LFRZ_015

Flood Risk Source			
Pluvial Flood Risk	Fluvial Flood Risk	Ground Water Flood Risk	Public Sewer Flood Risk
High	Low	Medium	High
Flood Mechanism			
Pluvial flooding in highway area of Sea Way and cartilage flooding of properties. Surface water not able to effectively drain away. Internal property flooding reported in 2012 due to pluvial flooding. Flooding from the public foul sewer is reported and restricted toilet for prolonged periods is experienced. High ground water is reported by residents this is likely to compromise the effectiveness of soakaway systems.			
Flood Risk Receptors			
Residential properties.			
Flood Hazard			
A 'low' flood hazard is predicted for 1% annual chance storm event (1 in 100 year return period).			
Validation			
SWS SIRF data reports local flooding in the LFRZ. SWMP Partners, residents and the Middleton Strategic Action Group have all reported the flooding in this area. Completed questionnaires have been provided confirming local flood risk and flood extents.			
General Notes			
A new storm system has been installed by the residents to reduce surface water flood risk. It was reported that this provided hydraulic benefit in the December 2012 storm event. As well as the surface water ponding in Sea Way the new storm gully is reported to drain flooding from foul manholes. Problems associated with the foul flooding are of main local concern.			

LFRZ_0016 - Golf Links Road, Felpham

Figure 7.33 - Flood Risk LFRZ_016 (1 in 100 year storm event)

Figure 7.34 - Flood Hazard LFRZ_016 (1 in 100 year storm event)

Table 7-32 - Predicted Residential and Commercial Property Flood Impact LFRZ_016

Rainfall Return Period	Predicted number of properties at risk of flooding	
	Residential	Commercial
1 in 30 Year	0	1
1 in 100 Year	0	2
1 in 100 Year + (Climate Change (2080's)	1	2

Table 7-33 - Summary of local flood risk within the LFRZ_016

Flood Risk Source			
Pluvial Flood Risk	Fluvial Flood Risk	Ground Water Flood Risk	Public Sewer Flood Risk
Low	Medium	Low	Low
Flood Mechanism			
Fluvial flood and pluvial flood risk predicted. Issues with IDB ditches/main river capacity. EA replacing flap valve on IDB ditch outlet to main river. Ditch maintenance required and possible creation of additional flood storage on golf course			
Flood Risk Receptors			
Residential and commercial properties.			
Flood Hazard			
A 'low' flood hazard is predicted for 1% annual chance storm event (1 in 100 year return period) of Burndell Road			
Validation			
Residents in Golf Links Road indicate that the area has not flooded in the last 24 years. ADC confirm that surface water and foul water flooding of a local golf club has occurred previously. No foul flooding has been reported to SWS due to hydraulic overload.			

LFRZ_0017 - Felpham Road, Felpham

Figure 7.35 - Flood Risk LFRZ_017 (1 in 100 year storm event)

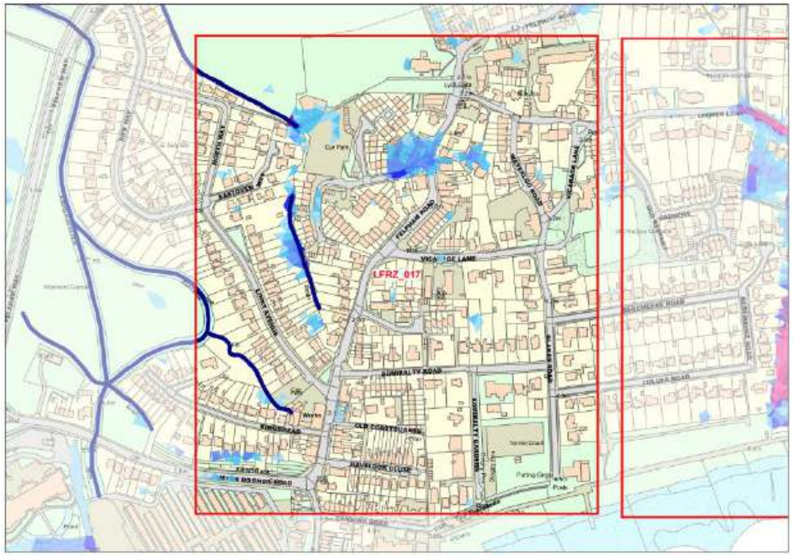


Figure 7.36 - Flood Hazard LFRZ_017 (1 in 100 year storm event)

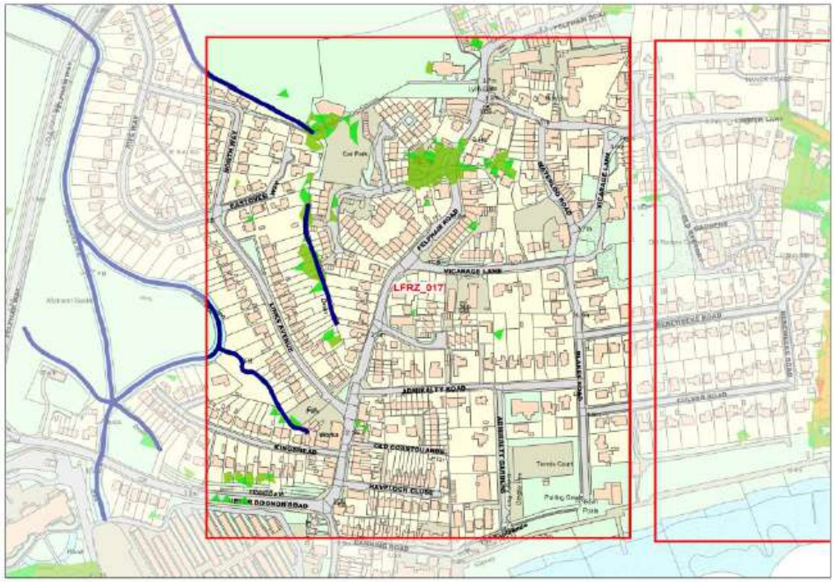


Table 7-34 - Predicted Residential and Commercial Property Flood Impact LFRZ_017

Rainfall Return Period	Predicted number of properties at risk of flooding	
	Residential	Commercial
1 in 30 Year	28	18
1 in 100 Year	37	19
1 in 100 Year + (Climate Change (2080's)	47	26

Table 7-35 - Summary of local flood risk within the LFRZ_017

Flood Risk Source			
Pluvial Flood Risk	Fluvial Flood Risk	Ground Water Flood Risk	Public Sewer Flood Risk
Medium	High	Medium	Medium
Flood Mechanism			
Pluvial flooding occurs due to limited capacity in surface water drainage system due to poor maintenance. Potentially of high impact from fluvial source.			
Flood Risk Receptors			
Residential and commercial properties.			
Flood Hazard			
A 'low' flood hazard is predicted for 1% annual chance storm event (1 in 100 year return period).			
Validation			
Kingsmead and Links Avenue: Regular flooding from Ground water and surface water. Hydraulic sewer flooding also reported at these locations. Floods occur after prolonged rainfall (usually winter) with the exception of the summer 2012 storm, during which the area flooded badly. Eastover Way: No history of flooding. Felpham Road: Flooded from surface water and sewers during the summer 2012 storm. Water sometimes pools in road but usually doesn't enter properties.			

LFRZ_0018 - Oak Tree Lane, Woodgate

Figure 7.37 - Flood Risk LFRZ_018 (1 in 100 year storm event)

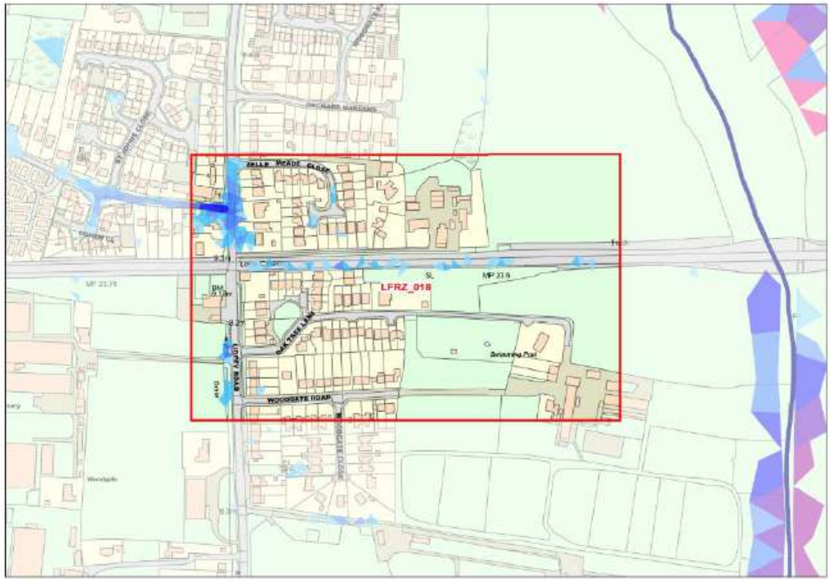


Figure 7.38 - Flood Hazard LFRZ_018 (1 in 100 year storm event)

Table 7-36 - Predicted Residential and Commercial Property Flood Impact LFRZ_018

Rainfall Return Period	Predicted number of properties at risk of flooding	
	Residential	Commercial
1 in 30 Year	8	0
1 in 100 Year	10	0
1 in 100 Year + (Climate Change (2080's)	16	1

Table 7-37 - Summary of local flood risk within the LFRZ_018

Flood Risk Source			
Pluvial Flood Risk	Fluvial Flood Risk	Ground Water Flood Risk	Public Sewer Flood Risk
Medium	Low	Low	High
Flood Mechanism			
Property flooding caused by pluvial runoff from highway. Flooding from foul manholes in highway due to hydraulic overload.			
Flood Risk Receptors			
Residential, commercial properties and highway.			
Flood Hazard			
A 'low' flood hazard is predicted for 1% annual chance storm event (1 in 100 year return period) of Burndell Road			
Validation			
Pluvial flooding experienced during the summer 2012 storm along Lidsey Road - otherwise flooding has not occurred here in recent history. Hydraulic overload of sewers reported in Oak Tree Lane on 02/01/2013 and on Westergate Street on 29/01/2013 and 09/11/2010.			

LFRZ_0019 - Wandleys Lane, Eastergate

Figure 7.39 - Flood Risk LFRZ_019 (1 in 100 year storm event)

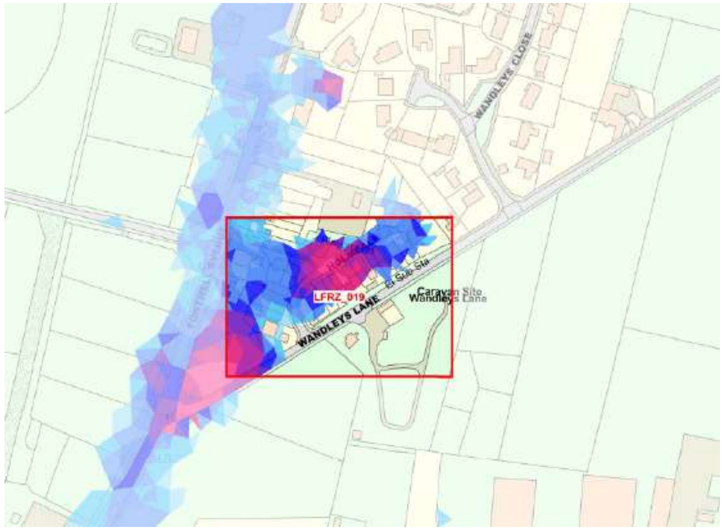


Figure 7.40 - Flood Hazard LFRZ_019 (1 in 100 year storm event)

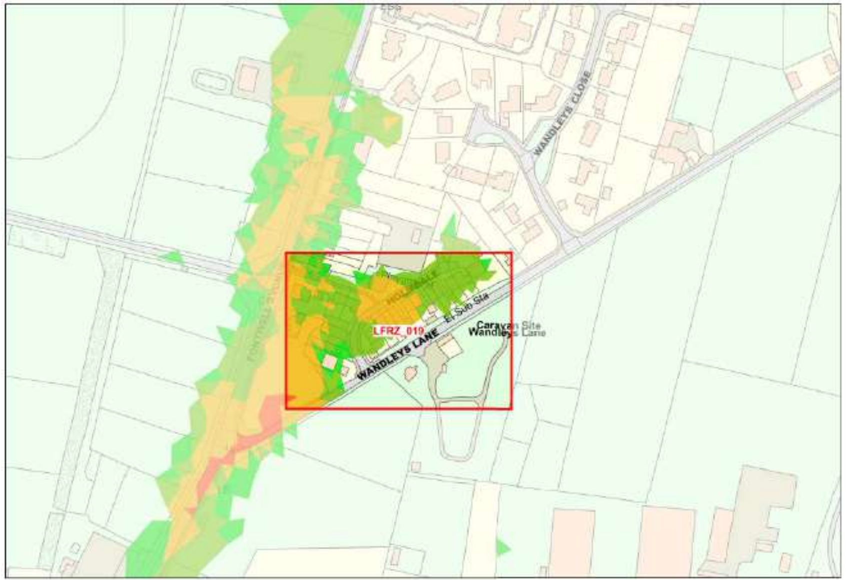


Table 7-38 - Predicted Residential and Commercial Property Flood Impact LFRZ_019

Rainfall Return Period	Predicted number of properties at risk of flooding	
	Residential	Commercial
1 in 30 Year	16	7
1 in 100 Year	20	8
1 in 100 Year + (Climate Change (2080's)	20	8

Table 7-39 - Summary of local flood risk within the LFRZ_019

Flood Risk Source			
Pluvial Flood Risk	Fluvial Flood Risk	Ground Water Flood Risk	Public Sewer Flood Risk
High	Low	High	Low
Flood Mechanism			
Portsmouth Water borehole has overflowed in the past and is thought to have contributed to the surface water flooding to highways and curtilage of properties in Fontwell Avenue, Wandleys Lane and Hunters Chase previously. Infilling of gravel pit at the junction of Wandleys Lane and Fontwell Avenue has probably compounded problems (i.e. loss of flood storage). Existing surface water drainage is exceeded during prolonged rainfall events.			
Flood Risk Receptors			
Residential and commercial properties.			
Flood Hazard			
A 'significant' and 'extreme' flood hazard is predicted for 1% annual chance storm event (1 in 100 year return period) in the junction of Wandleys Lane and Fontwell Avenue.			
Validation			
Verified by the SWMP Partners and local residents. Photographic evidence of flood extents has been provided through the questionnaire response.			

LFRZ_0020 - Highground Lane, Barnham

Figure 7.41 - Flood Risk LFRZ_020 (1 in 100 year storm event)

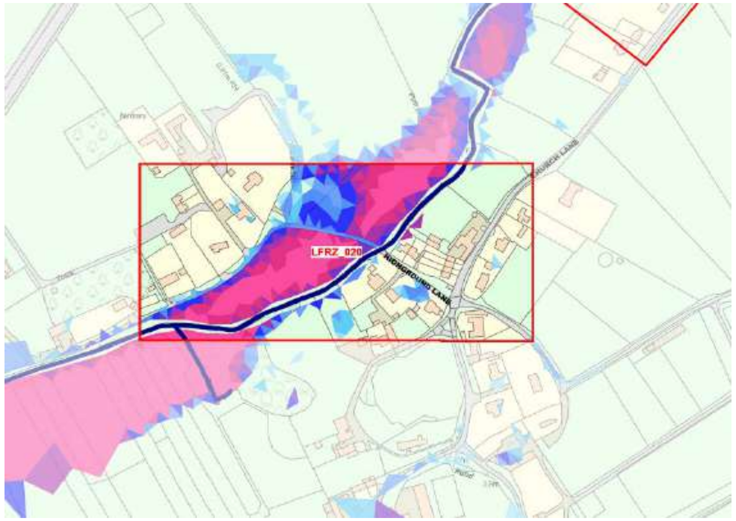


Figure 7.42 - Flood Hazard LFRZ_020 (1 in 100 year storm event)

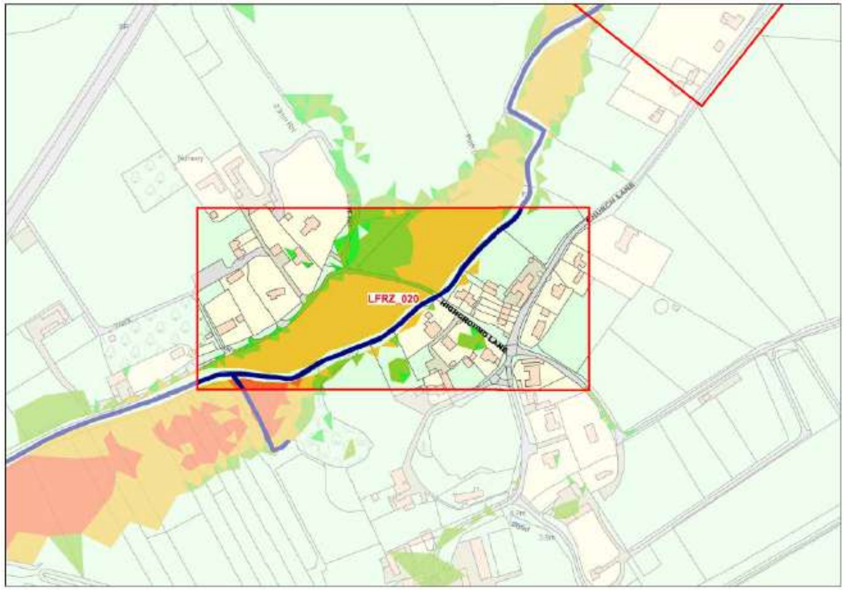


Table 7-40 - Predicted Residential and Commercial Property Flood Impact LFRZ_020

Rainfall Return Period	Predicted number of properties at risk of flooding	
	Residential	Commercial
1 in 30 Year	3	1
1 in 100 Year	4	1
1 in 100 Year + (Climate Change (2080's)	4	2

Table 7-41 - Summary of local flood risk within the LFRZ_020

Flood Risk Source			
Pluvial Flood Risk	Fluvial Flood Risk	Ground Water Flood Risk	Public Sewer Flood Risk
Medium	High	Medium	High
Flood Mechanism			
Hydraulic overload of the foul sewer system due to excessive inflows from ground water and surface water. This leads to flooding in fields and spill of foul flow into the Barnham Rife. Fluvial flooding of floodplain which affects fields and pluvial flooding of highway in Highground Lane.			
Flood Risk Receptors			
Primarily fields and highway flooding.			
Flood Hazard			
A 'significant' flood hazard is predicted for 1% annual chance storm event (1 in 100 year return period) in the Rifes flood plain.			
Validation			
Verified by the SWMP Partners and local residents. Hydraulic flooding from the foul sewer system is the main flooding concern for local residents consulted. This source of flooding is occurring on an almost annual basis.			

LFRZ_0021 - Marshalls Close / Church Lane, Barnham

Figure 7.43 - Flood Risk LFRZ_021 (1 in 100 year storm event)

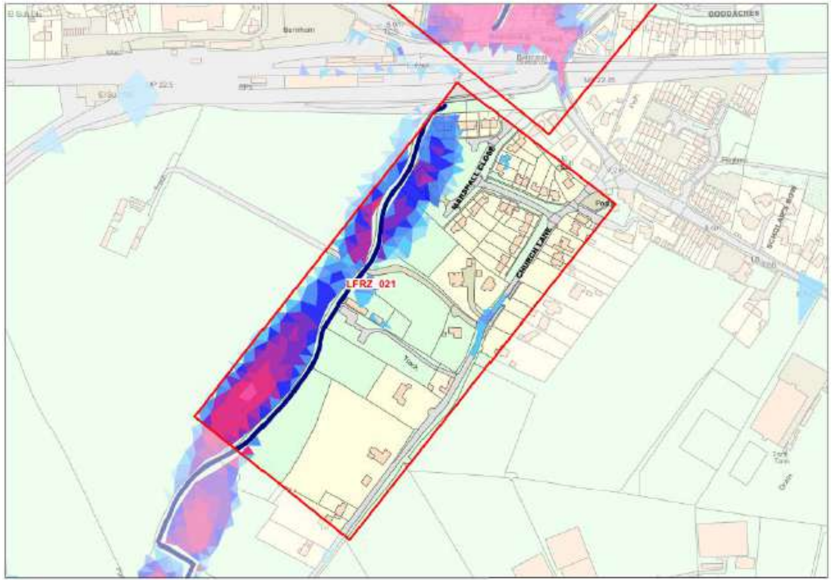


Figure 7.44 - Flood Hazard LFRZ_021 (1 in 100 year storm event)

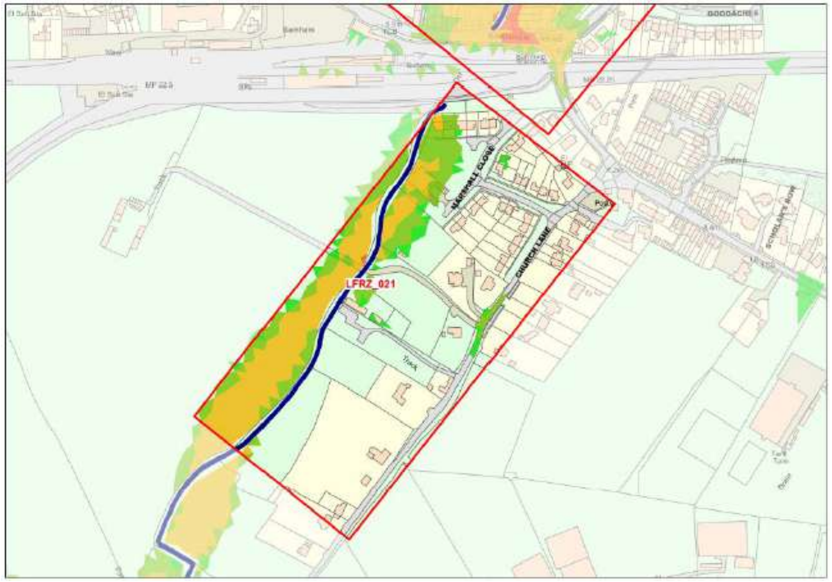


Table 7-42 - Predicted Residential and Commercial Property Flood Impact LFRZ_021

Rainfall Return Period	Predicted number of properties at risk of flooding	
	Residential	Commercial
1 in 30 Year	5	2
1 in 100 Year	5	2
1 in 100 Year + (Climate Change (2080's)	5	2

Table 7-43 - Summary of local flood risk within the LFRZ_021

Flood Risk Source			
Pluvial Flood Risk	Fluvial Flood Risk	Ground Water Flood Risk	Public Sewer Flood Risk
Low	High	High	High
Flood Mechanism			
Previous problem with locking of an overflow to the foul system into the rife. This is now replaced by a pumped overflow. Overloading of the pumped overflow has been reported since this installation. Investigations relating to the performance of the overflow are currently on-going by SWS. Fluvial flooding from the Barnham Rife (out of bank), and also prevents incoming highway drainage from discharging effectively. Overflowing foul sewers due to infiltration/inundation/surface water connections. Properties in Marshalls Close have been fitted with air brick covers/flood door protection, but water is also now known to come up through floors indicating a risk of ground water flooding.			
Flood Risk Receptors			
Residential, commercial properties and public space (park).			
Flood Hazard			
A 'significant' flood hazard is predicted for 1% annual chance storm event (1 in 100 year return period).			
Validation			
Residents confirmed extent of fluvial flooding in Marshalls Close. The extent of flooding is fairly well replicated by the EA flood Zone 1 and 2.			

LFRZ_022 - Southdean Close, Middleton on Sea

Figure 7.45 - Flood Risk LFRZ_022 (1 in 100 year storm event)

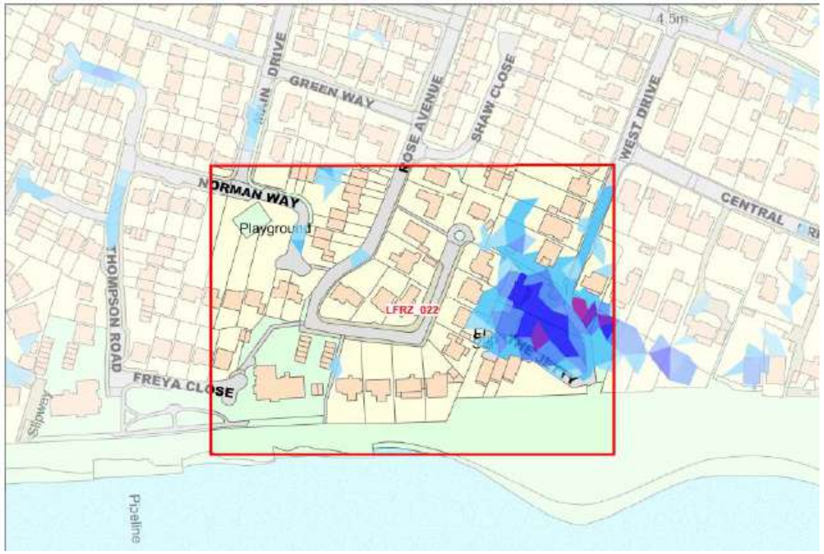


Figure 7.46 - Flood Hazard LFRZ_022 (1 in 100 year storm event)

Table 7-44 - Predicted Residential and Commercial Property Flood Impact LFRZ_022

Rainfall Return Period	Predicted number of properties at risk of flooding	
	Residential	Commercial
1 in 30 Year	8	1
1 in 100 Year	15	1
1 in 100 Year + (Climate Change (2080's)	21	1

Table 7-45 - Summary of local flood risk within the LFRZ_022

Flood Risk Source			
Pluvial Flood Risk	Fluvial Flood Risk	Ground Water Flood Risk	Public Sewer Flood Risk
Low	Low	Medium	Medium
Flood Mechanism			
Pluvial flooding caused by ponding of surface water. Surface water not being conveyed away.			
Flood Risk Receptors			
Residential and commercial properties.			
Flood Hazard			
A 'low' flood hazard is predicted for 1% annual chance storm event (1 in 100 year return period).			
Validation			
Few residents were available to discuss flooding problems. Surface water flooding is a regular problem affecting property curtilage, after prolonged rainfall. Two properties are affected. Two incidents of hydraulic overload of the foul sewer system have been reported in LFRZ_022.			

LFRZ_023 - Rudwicks Close, Broomcroft Road, The Loop, Jacken Close, Bramfield Road, Leverton Avenue, Limmer Lane (East End), Burley Road and Dryad Way

Figure 7.47 - Flood Risk LFRZ_023 (1 in 100 year storm event)

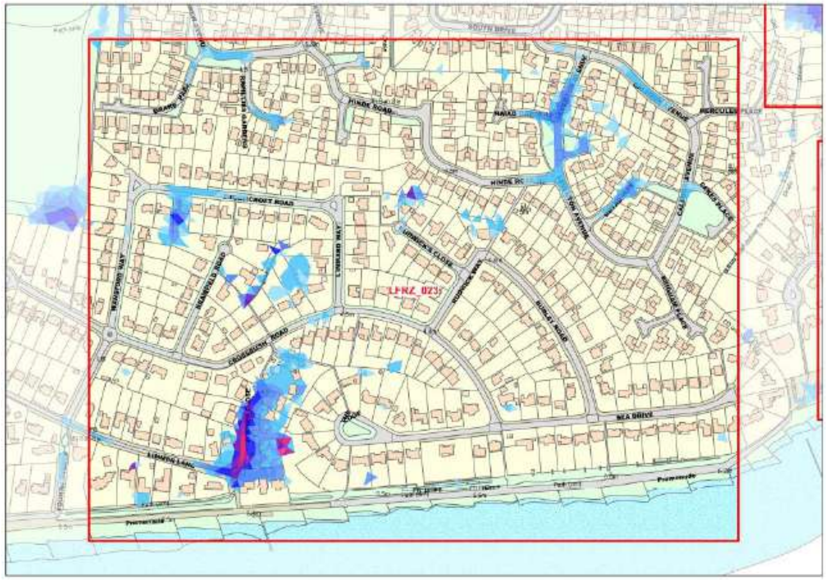


Figure 7.48 - Flood Hazard LFRZ_023 (1 in 100 year storm event)

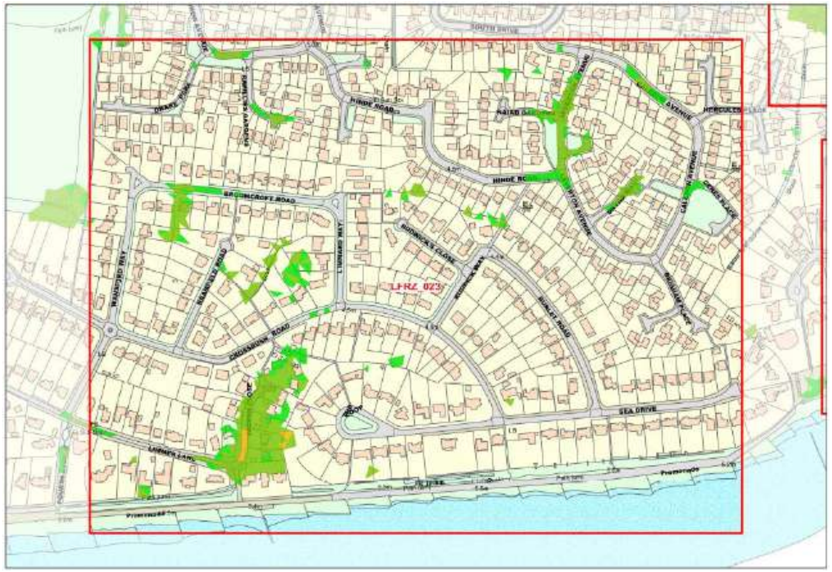


Table 7-46 - Predicted Residential and Commercial Property Flood Impact LFRZ_023

Rainfall Return Period	Predicted number of properties at risk of flooding	
	Residential	Commercial
1 in 30 Year	22	1
1 in 100 Year	40	5
1 in 100 Year + (Climate Change (2080's)	55	9

Table 7-47 - Summary of local flood risk within the LFRZ_023

Flood Risk Source			
Pluvial Flood Risk	Fluvial Flood Risk	Ground Water Flood Risk	Public Sewer Flood Risk
High	Low	Low	High
Flood Mechanism			
Leverton Avenue: Highway flooding at northern end of Leverton Avenue. Flooding from manholes in road & entering property curtilage. Dryad Way: Restricted Toilet Use (RTU) June 2012. Storm manhole SZ96996951 lifted and flooded highway. Residents report regular issues with the sewers in the area. Burley Road: Foul manhole in alleyway from Burley Road (MH SZ96995802) had lifted recently at time of site visit. Private manholes on properties frequently lift after prolonged rainfall and flood property curtilage. Old ditch used to run from behind properties to outfall at sea. Limmer Lane (East End) FWMH's overflow into road Broomcroft Road / Bramfield Road: Internal flooding experienced June 2012 from surface water. Bramfield Road: Restricted Toilet Use (RTU) experienced and foul sewer lifting manholes and floods highway which drains to ditch running from Bramfield Road to Crossbush Road (ditch discharges to sea). Ditch from Burley Road joins this ditch; however the connection from Burley Road is heavily blocked with stop logs and siltation. The Loop – garden flooding (fluvial) Jacken Close: Multiple hydraulic indicants reported in the area during prolonged rainfall			
Flood Risk Receptors			
Residential and commercial properties.			
Flood Hazard			
A 'significant' flood hazard is predicted in Jacken Close for 1% annual chance storm event (1 in 100 year return period).			
Validation			
Surface water and foul water flooding. Overflowing foul sewers in far eastern end of Limmer Lane due to infiltration/inundation/surface water connections. Fragmented land drainage system and ineffective private surface water drainage. Much more of the land drainage system needs to be investigated/re-instated. The private estate is proposing to carry out improvements to the highway drainage system. An active communities bid was submitted but has been unsuccessful. A much reduced bid has now been submitted. Numerous land drainage culverts/ditches have been investigated/re-instated/repaired (landowners/ADC)			

LFRZ_024 - West Close, Middleton on Sea

Figure 7.49 - Flood Risk LFRZ_024 (1 in 100 year storm event)

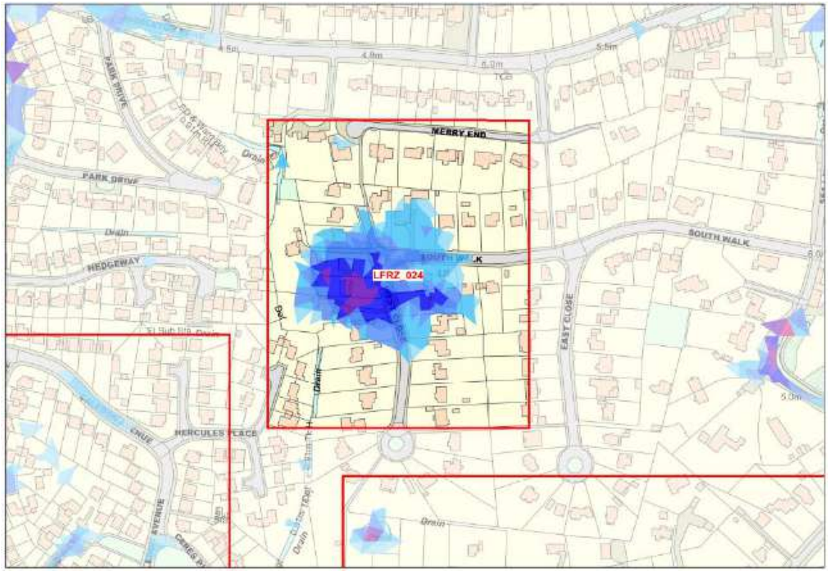


Figure 7.50 - Flood Hazard LFRZ_024 (1 in 100 year storm event)

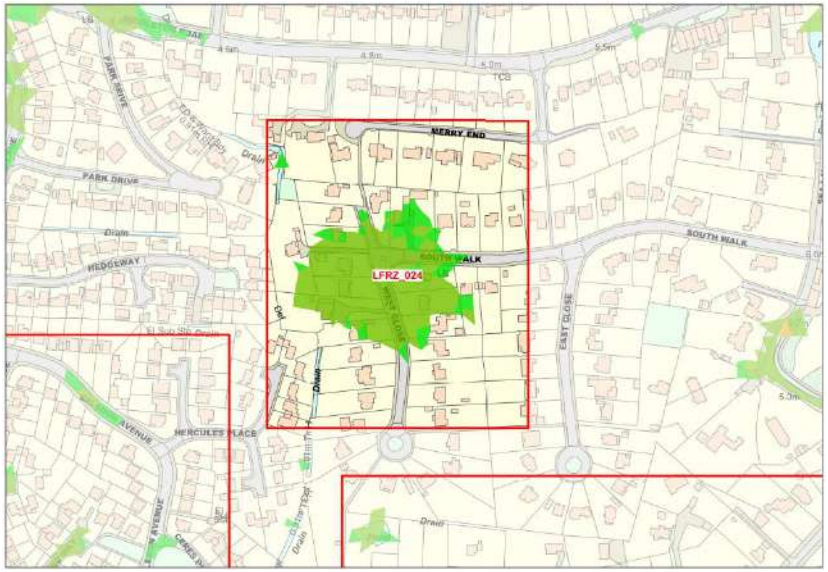


Table 7-48 - Predicted Residential and Commercial Property Flood Impact LFRZ_024

Rainfall Return Period	Predicted number of properties at risk of flooding	
	Residential	Commercial
1 in 30 Year	11	3
1 in 100 Year	14	3
1 in 100 Year + (Climate Change (2080's)	16	3

Table 7-49 - Summary of local flood risk within the LFRZ_024

Flood Risk Source			
Pluvial Flood Risk	Fluvial Flood Risk	Ground Water Flood Risk	Public Sewer Flood Risk
High	Low	Medium	High
Flood Mechanism			
Within a private estate inundation of the public foul system and pluvial flooding in the lowest point in West Close occurs. The existing surface water drainage is not capable of conveying surface water flow during heavy and prolonged rainfall. CCTV surveys have identified silting and roots causing major restrictions in the private storm sewer system. This is understood to have been rehabilitated by the estates management.			
Flood Risk Receptors			
Residential and commercial properties.			
Flood Hazard			
A 'low' flood hazard in West Close is predicted for 1% annual chance storm event (1 in 100 year return period).			
Validation			
Feedback from residents suggests that the summer 2012 storm event resulted in internal flooding of properties along West Close, with up to approximately 300 mm of floodwaters inside property buildings. Photographic evidence of the flood extents has been provided.			

LFRZ_025 - Limmer Lane, Felpham

Figure 7.51 - Flood Risk LFRZ_025 (1 in 100 year storm event)

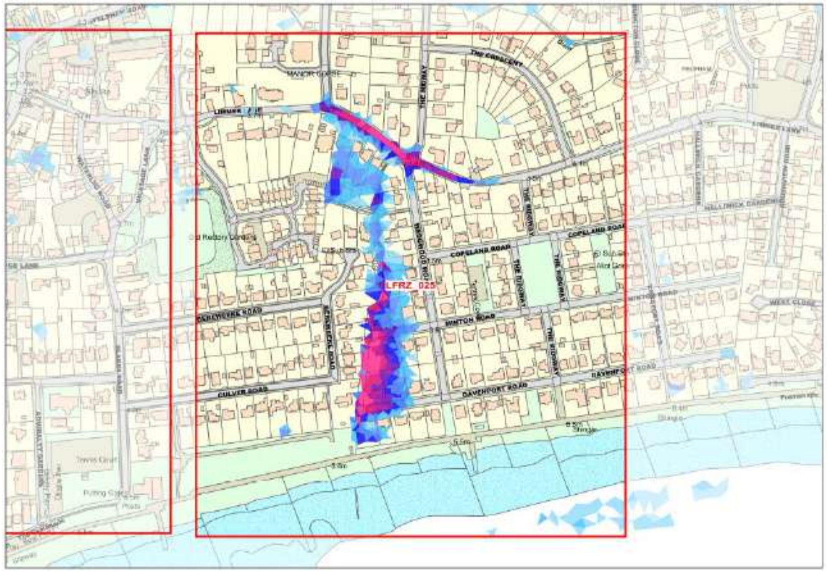


Figure 7.52 - Flood Hazard LFRZ_025 (1 in 100 year storm event)

Table 7-50 - Predicted Residential and Commercial Property Flood Impact LFRZ_025

Rainfall Return Period	Predicted number of properties at risk of flooding	
	Residential	Commercial
1 in 30 Year	6	1
1 in 100 Year	16	2
1 in 100 Year + (Climate Change (2080's)	27	2

Table 7-51 - Summary of local flood risk within the LFRZ_025

Flood Risk Source			
Pluvial Flood Risk	Fluvial Flood Risk	Ground Water Flood Risk	Public Sewer Flood Risk
High	Low	Medium	High
Flood Mechanism			
Surface water and foul water flooding occurs. Capacity of public surface water sewer system is the main issue (tide locking). Overflowing foul sewers due to infiltration/inundation/surface water connections. Also related flooding at junction of Summerley Lane/Limmer Lane and Felpham Way immediately north. Legal status of storage ditch above public surface water sewer is yet to be determined. SWS have improved valve arrangements in 'The Bunker' chamber, south of Davenport Road. Storage ditch above the public surface water sewer behind Wedgewood Road properties has been partially reinstated. (Active communities funding). Ditches and culverts in Ley Road have been reinstated (landowners/ADC). SWS have/or are proposing to undertake various improvements to the public surface water sewer in Hales footpath/The Grove. Root cutting has been undertaken as part of the works.			
Flood Risk Receptors			
Residential and commercial properties.			
Flood Hazard			
A 'significant' flood hazard is predicted for 1% annual chance storm event (1 in 100 year return period) has been identified in Limmer Lane, Davenport Road and Minton Road.			
Validation			
Historical flooding is confirmed by SWMP Partners and resident questionnaire.			

LFRZ_026 - Eastergate Lane, Eastergate

Figure 7.53 - Flood Risk LFRZ_026 (1 in 100 year storm event)

Figure 7.54 - Flood Hazard LFRZ_026 (1 in 100 year storm event)

Table 7-52 - Predicted Residential and Commercial Property Flood Impact LFRZ_026

Rainfall Return Period	Predicted number of properties at risk of flooding	
	Residential	Commercial
1 in 30 Year	4	2
1 in 100 Year	4	3
1 in 100 Year + (Climate Change (2080's)	4	3

Table 7-53 - Summary of local flood risk within the LFRZ_026

Flood Risk Source			
Pluvial Flood Risk	Fluvial Flood Risk	Ground water Flood Risk	Public Sewer Flood Risk
Medium	Low	Medium	Low
Flood Mechanism			
Surface water flooding from fields to the north. Flooding in the road near the junction of Freeman Close and Eastergate Lane.			
Flood Risk Receptors			
Residential and commercial properties.			
Flood Hazard			
A 'low' flood hazard is predicted for 1% annual chance storm event (1 in 100 year return period).			
Validation			
Residents in Freeman Close reported flooding in the road near the junction of Freeman Close and Eastergate Lane. It is reportedly a problem both in summer and winter after heavy rainfall. In winter the flooding on the road can last for several days. It is worth highlighting that a scheme is currently being considered by WSCC and ADC to the east of Freemans Close along Eastergate Lane to alleviate confirmed highway flooding.			

LFRZ_027 - Downsview Road, Barnham

Figure 7.55 - Flood Risk LFRZ_027 (1 in 100 year storm event)

Figure 7.56 - Flood Hazard LFRZ_027 (1 in 100 year storm event)

Table 7-54 - Predicted Residential and Commercial Property Flood Impact LFRZ_027

Rainfall Return Period	Predicted number of properties at risk of flooding	
	Residential	Commercial
1 in 30 Year	4	1
1 in 100 Year	4	1
1 in 100 Year + (Climate Change (2080's)	4	1

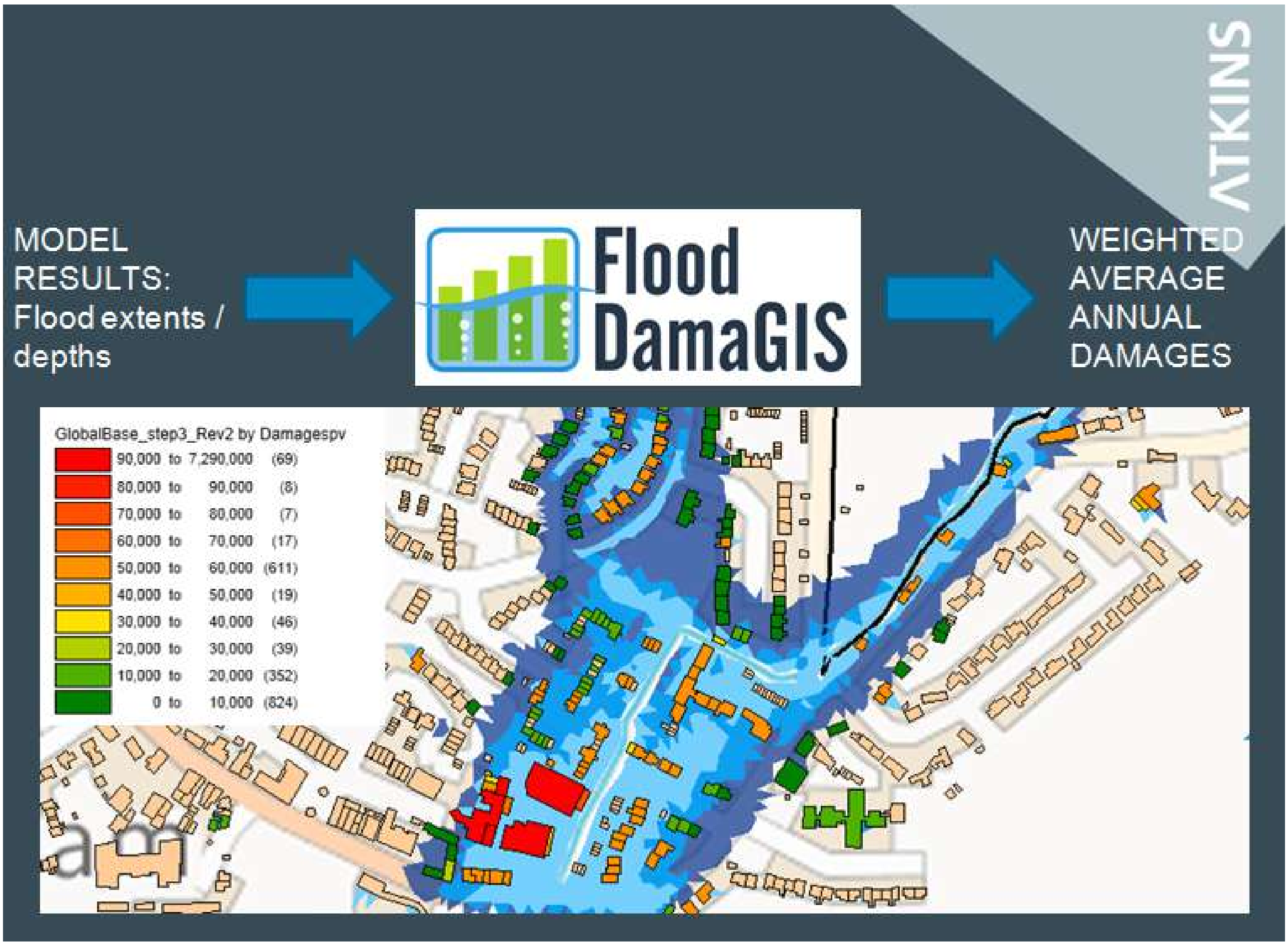
Table 7-55 - Summary of local flood risk within the LFRZ_027

Flood Risk Source			
Pluvial Flood Risk	Fluvial Flood Risk	Ground Water Flood Risk	Public Sewer Flood Risk
High	Low	Medium	Medium
Flood Mechanism			
Capacity in the drainage ditches to the west of Downsview Road is exceeded. Ground water flooding is also considered to be a possible source of flooding.			
Flood Risk Receptors			
Residential and commercial properties.			
Flood Hazard			
A 'low' flood hazard is predicted for 1% annual chance storm event (1 in 100 year return period).			
Validation			
The accounts of flooding in the vicinity differ greatly. While some residents reported flooding to the road and gardens, others reported that there were no issues at all. This is also reflected in the questionnaires that have been returned.			

7.5 Economic Assessment of Flood Damages (DamaGIS)

To enable a strategic assessment of the predicted damages associated to flooding, 'Flood DamaGIS', an Atkins developed Flood Benefits Tool, has been used to support the flood economic appraisal process. Flood DamaGIS is a GIS based tool which allows users to undertake high-level Weighted Annual Average Damage (WAAD) assessments in an efficient and consistent process. Figure 7.57 visualises the outputs from DamaGIS within an area of Barnham.

Figure 0.57 - Flood DamaGIS Economic Assessment



The tool uses the Multi Coloured Manual 2013 WAAD data and it only calculates flood damage to property (buildings). This approach is useful for high level appraisals, initial assessments, pre-feasibility studies and SWMPs. It is designed to work with the EAs National Receptor Database (England and Wales).

Flood DamaGIS has been used to calculate Annual Average Damages based on the Lidsey integrated models' predicted flood outlines for each of the LFRZs from a 480 minute 1 in 30 year (33.3% annual probability), 1 in 100 year (1% annual probability) and 1 in 1000 year (0.1% annual probability) storm events. A summary of the AADs, sorted by annual losses is detailed in Table 7.56. In addition, the annual average benefits have also been calculated to offer understanding as to the likely monetary benefit if the introduction of flood relief scheme designed to a 1 in 30 year level of protection was implemented.

The threshold level for flooding of properties was assumed to be a uniform 150mm. This assumes the flood water levels must reach 150 mm at a point around a building before it is considered to be at risk of internal flooding. This has been used as a broad assumption. Domestic properties maybe more elevated and as such may be less at risk than what has been considered. Some commercial properties may also have entrances at ground level with no definable elevated threshold and could be at higher risk than has been allowed in this assessment. When completing future applications for funding, i.e. FDGiA, it is recommended that a more detailed view of this economic assessment is considered. However, this SWMP can be used to support and inform FDGIA applications and future planning.

The weighted average annual damages for each LFRZ are shown in Table 7.56.

Table 0-1 - LFRZ Average Annual Damages

Local Flood Risk Zone	Location Name	Average Annual Damages (£)	Assuming a flood relief scheme was implemented providing 1 in 30 year level of flood protection	
			Predicted Residual Annual Average Damages (£)	Annual Average Damages Avoided (£)
LFRZ_006	Lake Lane, Barnham	£277,702	£76,471	£201,231
LFRZ_017	Felpham Road, Felpham	£74,582	£22,367	£52,215
LFRZ_013	Elmer Sands, Middleton on Sea	£70,270	£18,790	£51,481
LFRZ_019	Wandleys Lane, Eastergate	£42,018	£10,454	£31,564
LFRZ_023	Rudwicks Close, Broomcroft Road, The Loop, Jacken Close, Bramfield Road, Leverton Avenue, Limmer Lane (east end), Burley Road and Dryad Way in Felpham	£40,048	£17,538	£22,510
LFRZ_025	Limmer Lane, Felpham	£39,629	£13,084	£26,545
LFRZ_003	Walberton Village (Barnham Lane (A))	£36,918	£10,881	£26,037
LFRZ_002	Elm Grove, Barnham	£31,363	£11,984	£19,379
LFRZ_026	Eastergate Lane, Eastergate	£27,116	£15,545	£11,572
LFRZ_024	West Close, Middleton on Sea	£24,643	£5,608	£19,035
LFRZ_014	Lodge Close & Willow Brook, Middleton on Sea	£22,553	£9,285	£13,268
LFRZ_015	Sea Way, Middleton on Sea	£14,495	£2,965	£11,530
LFRZ_004	Maple Road, Walberton	£13,692	£3,298	£10,394
LFRZ_021	Marshalls Close / Church Lane, Barnham	£13,006	£3,839	£9,167
LFRZ_022	Southdean Close, Middleton on Sea	£9,816	£4,502	£5,313
LFRZ_018	Oak Tree Lane, Woodgate	£6,861	£2,406	£4,454
LFRZ_020	Highground Lane, Barnham	£5,916	£1,885	£4,030
LFRZ_012	Yapton Road, Middleton on Sea	£4,439	£2,197	£2,242
LFRZ_010	Burndell Road, Yapton	£4,065	£1,722	£2,343
LFRZ_027	Downsview Road, Barnham	£3,794	£825	£2,970
LFRZ_001	West Walberton Lane, Walberton	£3,693	£723	£2,970
LFRZ_016	Golf Links Road, Felpham	£524	£330	£194
LFRZ_009	Yapton Road, Yapton	£429	£429	£-
LFRZ_008	Barnham Lane, Barnham (C)	£362	£362	£-
LFRZ_005	Barnham Lane, Barnham (B)	£68	£68	£-
LFRZ_007	Park Road, Barnham	£-	£-	£-
LFRZ_011	West View Drive, Yapton	£-	£-	£-
Total		**£768,001**	**£237,559**	**£530,442**

Analysis from the integrated modelling predicts that there are 592 residential properties and 215 non-residential properties at risk across the catchment for a 3.33 probability storm event. This totals £2.7 million estimated Average Annual Damages (AAD), of which £0.77 million is within 27 LFRZs. As such, the LFRZs account for 28% of the Lidsey SWMP study areas AADs predicted to be incurred. If schemes were implemented in all of the LFRZs and continued for 100 years, then the Present Value benefits would be in the order of £15.8M based on the current Treasury variable discount rate which starts at 3.5%.

7.6 LFRZ Prioritisation

To assist with prioritising future works on all LFRZs a prioritisation methodology was applied. It is considered important to use a simple approach to ensure clear interpretation of the prioritisation process between one LFRZ over another. Given the economic AADs for the LFRZ incorporates the predicted number of properties flooded and accounts for apportioned damages to commercial properties it is considered appropriate that the following priority is given to each of the LFRZs as shown in Table 7.57.

Table 0-2 - LFRZ Prioritisation

Local Flood Risk Zone	Location Name	Priority
LFRZ_006	Lake Lane, Barnham	High
LFRZ_017	Felpham Road, Felpham	High
LFRZ_013	Elmer Sands, Middleton on Sea	High
LFRZ_019	Wandleys Lane, Eastergate	High
LFRZ_023	Rudwicks Close, Broomcroft Road, The Loop, Jacken Close, Bramfield Road, Leverton Avenue, Limmer Lane (East), Burley Road and Dryad Way in Felpham	High
LFRZ_025	Limmer Lane, Felpham	High
LFRZ_003	Walberton Village (Barnham Lane (A))	High
LFRZ_002	Elm Grove, Barnham	Medium
LFRZ_026	Eastergate Lane, Eastergate	Medium
LFRZ_024	West Close, Middleton on Sea	Medium
LFRZ_014	Lodge Close & Willow Brook, Middleton on Sea	Medium
LFRZ_015	Sea Way, Middleton on Sea	Medium
LFRZ_004	Maple Road, Walberton	Medium
LFRZ_021	Marshalls Close / Church Lane, Barnham	Medium
LFRZ_022	Southdean Close, Middleton on Sea	Medium
LFRZ_018	Oak Tree Lane, Woodgate	Medium
LFRZ_020	Highground Lane, Barnham	Medium
LFRZ_012	Yapton Road, Middleton on Sea	Medium
LFRZ_010	Burndell Road, Yapton	Medium
LFRZ_027	Downsview Road, Barnham	Medium
LFRZ_001	West Walberton Lane, Walberton	Medium
LFRZ_016	Golf Links Road, Felpham	Low
LFRZ_009	Yapton Road, Yapton	Low
LFRZ_008	Barnham Lane, Barnham (C)	Low
LFRZ_005	Barnham Lane, Barnham (B)	Low
LFRZ_007	Park Road, Barnham	Low
LFRZ_011	West View Drive, Yapton	Low

8. Phase 3a – Identify Measures

8.1. Introduction

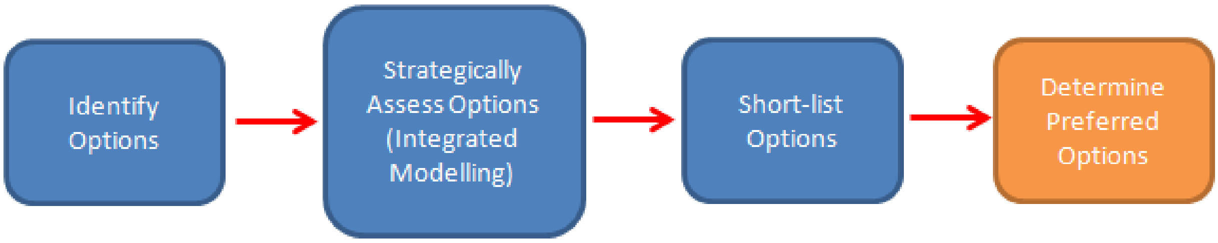
Phase 3 of the SWMP provides a methodology for the identification of options available to reduce flood risk within the study area as outlined in Figure 8.1.

Figure 8.1 - Phase 3 of the SWMP process

The option assessment has reviewed and shortlisted a range of options and interventions. This process has involved the identification of both structural and non-structural interventions targeted to provide benefit to flood risk areas. Options have been assessed relative to their likely effectiveness, benefits and cost. Measures which achieve multiple benefits such as water quality, amenity and biodiversity will be promoted.

For the purpose of assessment, a 1 in 30 year level of protection has been used where hydraulic interventions have been modelled using the Integrated Catchment Model. The approach adopted is shown in Figure 8.2. A catchment critical duration has been applied in the analysis (480 minutes) and no specific allowance has been made for climate change.

Figure 8.2 - Optioneering Process



8.2. Links to Funding Plans

There are a range of funding mechanisms which may be accessed to implement options and interventions identified. These are discussed below:

1. **Flood Defence Grant in Aid (FDGiA)**: As a risk management authority, WSCC can apply for an allocation of government funding annually from the EA. The flood and coastal erosion risk management grant in aid (FCERM GiA capital grants) can be used to contribute towards the costs of building new flood and coastal erosion defences. The amount of government funding the EA allocates to a project depends on the public benefit it provides. Benefits include reducing flood risk to households, businesses and infrastructure and creating habitat for wildlife. The amount of government funding available each year is limited. There are always more schemes proposed than there is government funding available. Contributions go to those projects that demonstrate most benefit and are proportionate to the benefits that they will deliver. Applications are made a year in advance. As such, to apply for an allocation for a project starting in April 2016, it would be required to submit the FCERM1 – MTP form in the 2015 submission period.

   An FDGiA application of Elmer Sands, Middleton-on-Sea was prepared by Atkins on behalf of SWS and WSCC for the 2014-2015 funding period and was entered to the Medium Term Plan. This application has since successfully secured funding to conduct further hydraulic investigation to allow for a detailed design of a permanent flood relief scheme.

2. **Major commercial and residential developments:** These should be seen as opportunities to retro-fit surface water management measures in Brownfield development sites. These benefits are typically funded by private developers and housing associations.

3. **West Sussex Transport Plan 2011-2026**: To deliver improvements set out in the plan, all potential funding mechanisms will be investigated as the opportunities arise. Funding routes may be made available through Department for Transport, Highways Agency, Network Rail and the District and Borough Council. Flooding of highways is one area of focus within the West Sussex Transportation Plan.

4. **West Sussex Active Community Fund:** Operation Watershed Active Communities Fund formed part of the County Council's initiative to tackle problems caused by severe weather. £1.25m of the fund was allocated to encourage communities to act against flooding in 2013/2014. It is reported that West Sussex County Council has approved further funding of at least £1m toward Active Communities projects in 2014/15.

5. **SWS Asset Management Plan (AMP) 2015-2020:** SWS prioritises funding across their service delivery region to meet with their stipulated targets. These targets for 2015-2020 include a 25 per cent reduction in sewer flooding inside homes and businesses by 2020 and the number of incidents brought down from 2,755 to 2,070 by 2020. In addition, there is to be no increase in the number of incidents of sewer flooding affecting outside areas.

   SWS have stated in their 2015-2020 Business Plan that they will *'carry out further detailed technical investigations to understand how we can tackle [flooding] problem(s) more widely. Investigating the local causes of infiltration will help us design the most cost-effective solutions to deal with it. This will help us keep our sewers working as they should. It will also reduce our reliance on tanker lorries to remove wastewater when our sewers are flooded, helping us save money'.* As such, problems associated with flooding and infiltration will be of focus between 2015 and 2020. Allocation of funds to target flooding and infiltration reduction will be conducted on a prioritised manner across their region to meet with their stipulated business plan targets.

8.3. Identification of Options

Methods of managing surface water can be divided into Source, Pathway or Receptor options as described below:

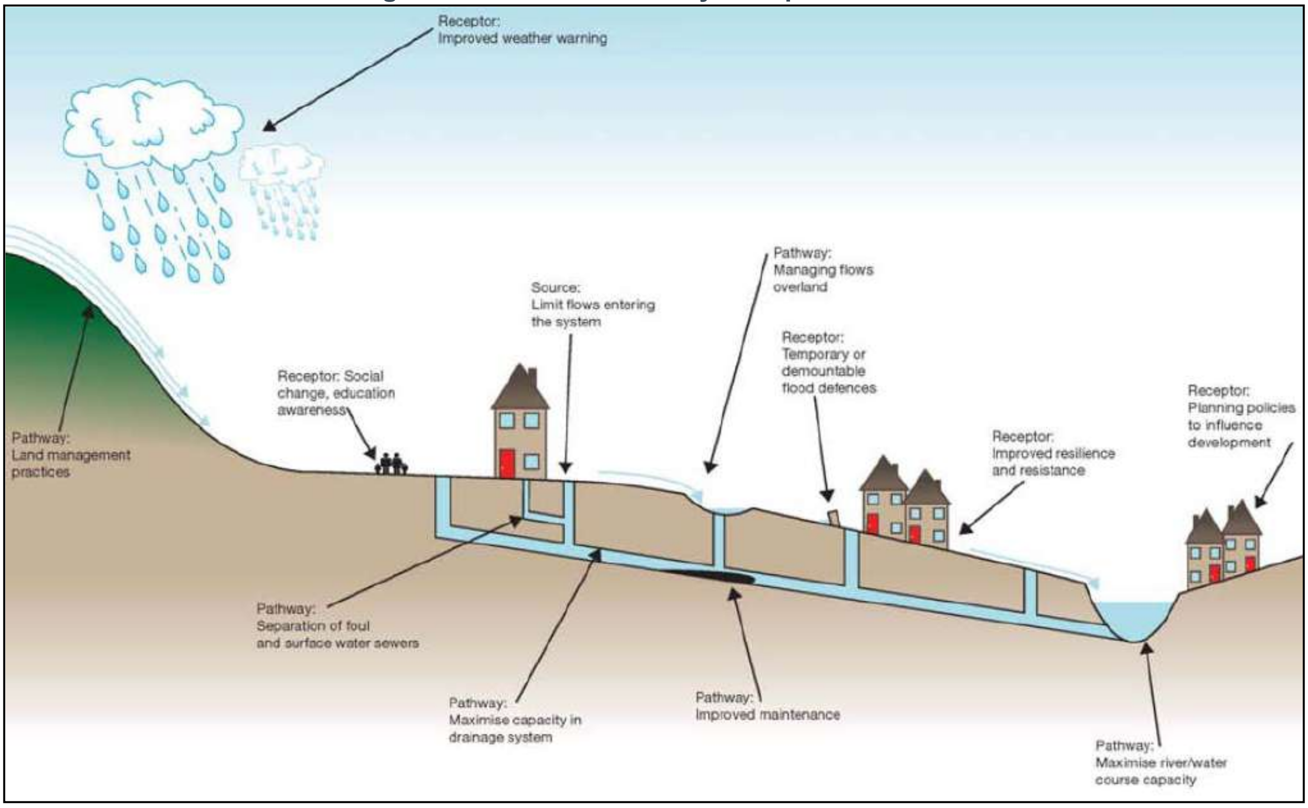
Source Control: Source controls look to reduce the volume of runoff and rate of flow from receiving surfaces, hence reduce the impact on receiving drainage systems.

Pathway Management: These measures aim to manage both overground and underground conveyance of water in the urban environment. Approaches to manage pathway may include sewer upsizing, sewer infiltration reduction, jetting of culverts to provide more capacity for surface water disposal.

Receptor Management: Is associated to changes in the community, property and the environment. This includes the use of flood mitigation measures, education and flood resilience measures to protect the impact of flooding i.e. flood gates.

The source pathway receptor model is shown in Figure 8.3. (Extracted from the Defra SWMP Technical Guidance Document).

Figure 8.3 - Source Pathway Receptor Model.



8.4. Source / Pathway / Receptor Options

As outlined in Section 8.3 options or interventions can be categorised under the three headings. The types of options available are detailed in Table 8.1.

Table 8-1 - Source / Pathway / Receptor Options

Option Ref.	Category	9. Option
1	Source	Green Roof
2	Source	Detention Basins (Attenuation / Retention)
3	Source	Permeable Paving
4	Source	Ponds and Wetlands
5	Source	Rainwater Harvesting
6	Source	Soakaways
7	Source	Swales
8	Source	Bioretention Basins
9	Source	Bioretention Street Planting
10	Source	Sealing of foul manhole covers and protecting open foul gullies
11	Source	Sealing Sewers (Reduce ground water / rainfall induced infiltration)
12	Pathway	Increasing Capacity in Drainage System (Storage, Upsize)
13	Pathway	Deculverting Watercourse(s)
14	Pathway	Improved maintenance regimes
15	Pathway	Increase Gully Assets
16	Pathway	Land management practices
17	Pathway	Managing overland flows (above ground storage)
18	Pathway	Managing overland flows (preferential flow paths during exceedance)
19	Pathway	Separation of foul and surface water
20	Receptor	Improve Weather Warning
21	Receptor	Improve resilience to flooding
22	Receptor	Social change, education and awareness
23	Receptor	Raising doorway / access threshold
24	Receptor	Planning policies to influence development (Development Control, SUDS Strategy, Blue Development Corridors, New Development).
25	Receptor	Temporary demountable flood defences
26	Strategy	Further Study / Investigations
27	Strategy	Survey, Advise & Monitoring
28	Strategy	Community Awareness

Examples of the Source Control options are shown in Figure 4.4. Figure 8.4 and Figure 8.5 show examples of Pathway and Receptor Options available to the drainage planners.

Figure 8.4 - Pathway Options

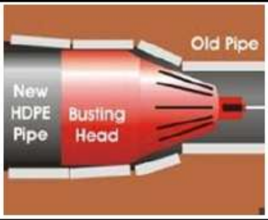
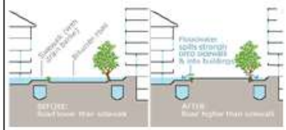
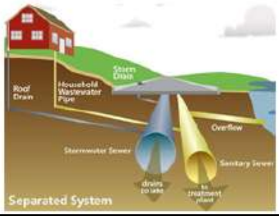
Pathway					
Increasing Capacity in Drainage System (Storage,Upsize)		Improved maintenance regimes (jetting / vegetation clearance / de-silting)		Land management practices - (rural zones)	
Deculverting Watercourse(s)		Increase Gully Assets		Managing overland flows (above ground storage)	
Managing overland flows (preferential flow paths during exceedance)		Separation of foul and surfacewater			

Figure 8.5 - Receptor Options

Receptor					
Improve resilience to flooding / flood mitigation	 See notes below.	Raising doorway / Access threshold		Temporary demountable flood defences	
Social change, education and awareness		Planning policies to influence development			

9.1. Option Constraints

There are several major constraints which influence the application of potential options due to the catchment characteristics and the general ability to currently fund interventions. Figure 8.6 highlights some of these specific constraints which affect the ability to implement interventions and these are discussed in more detail below.

Geology – Much of the catchment is located in clay soils this type of soil is generally performs poorly with respect to the use of soakaways. Conditions will vary across the catchment and may pose lesser problems than those areas identified as at risk of ground water flooding.

High Ground water – Based on localised borehole data high ground water in the catchment has been confirmed as being of particular issue and in some instances is contributing to the flood mechanism Again this reduced the practicalities of introducing infiltration SUDS.

Tidal Influence – The main rivers and coastal outfall are tidally affected. As a result surface water cannot always freely drain away. This needs to be considered when considering conveyance solutions to improve 'pathway' options. Space for attenuation areas would often be required.

Existing Infrastructure: Existing infrastructure including, buildings, bridges, embankments, railway lines offer engineering constraints which inhibit specific options being viable both from a technological and financial perspective.

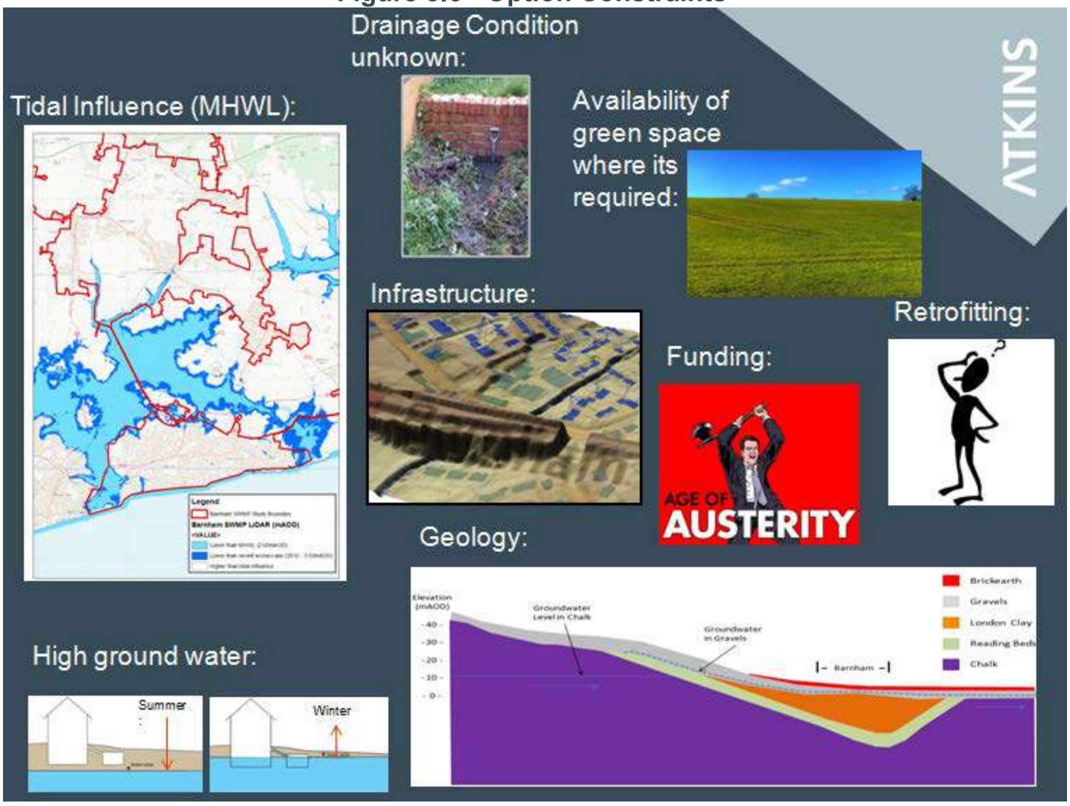
Retrofitting SUDs: Requires wide-scale Brownfield development to be implanted. Opportunities will be limited. Retro-fitting drainage is typically challenging due to existing infrastructure.

Drainage Asset Condition: The operational and structural condition of existing drainage infrastructure is not fully understood. As such, the performance of these assets cannot be fully established without investment in surveys and more detailed hydraulic analysis. Not all of the drainage assets are fully known.

Green Space: Limited availability of public green space limits where surface water could potentially be stored away from flood risk zones.

Funding ('Age of Austerity') – Funding schemes through public finance will typically be based on regional or national prioritisation. Funding is competitively sought.

Figure 8.6 - Option Constraints



9.2. Strategic Options (Integrated Modelling)

To assist with identifying suitable drainage solutions to resolve the flood risk in each of the LFRZs, conceptual scenario assessments were undertaken to evaluate the type of strategic improvements which would offer a net reduction in flooding. The strategic modelling considered the following scenarios which were assessed against the current base model predictions for a 1 in 30 year storm event (480 minutes). The following conceptual options were appraised:

Scenario 1 - Attenuation and retention.
Scenario 2 - SUDS (Water Butts and Permeable Paving).
Scenario 3 - Removal of impermeable area and infiltration entering the public foul sewers.
Scenario 4 - Increase surface water conveyance.
Scenario 5 – Reduce runoff from proposed development in Barnham.

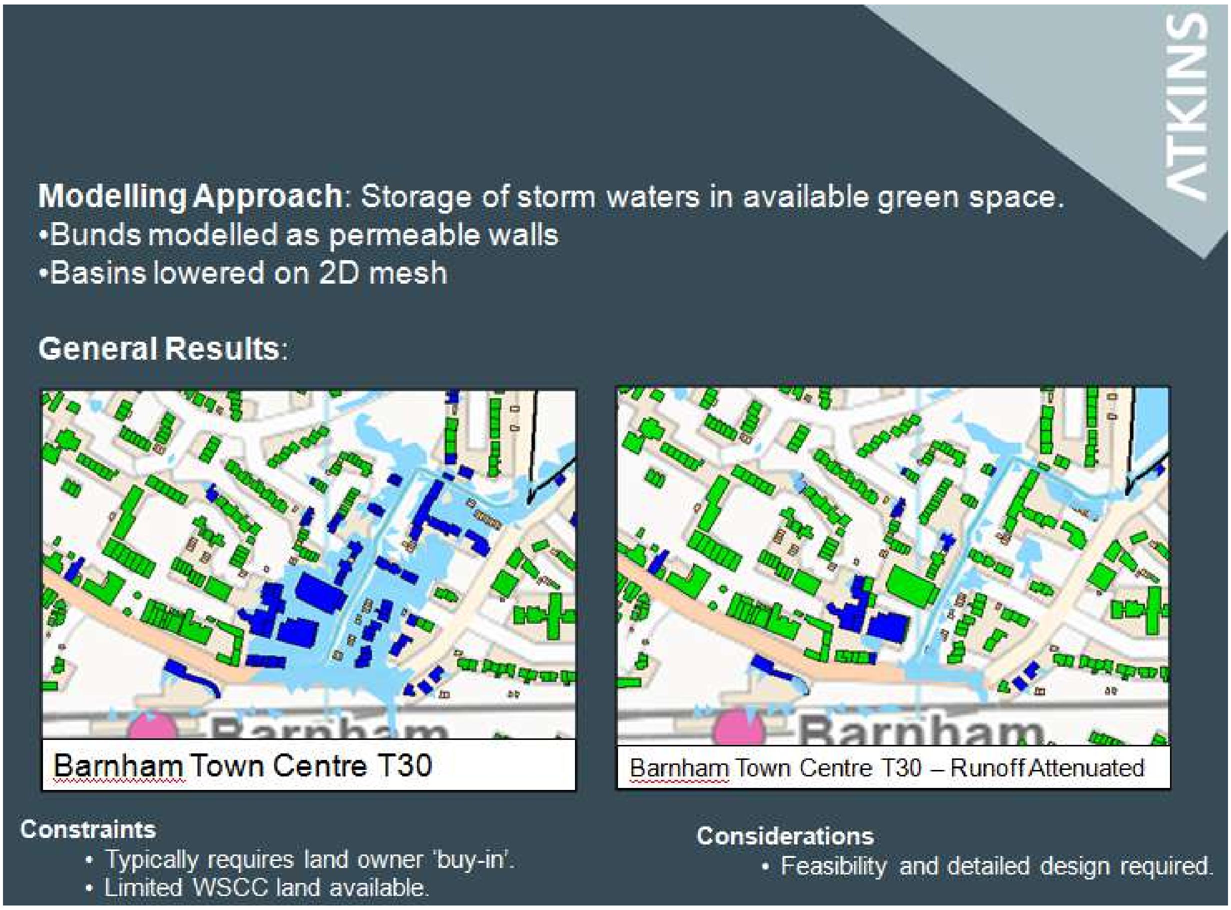
The result of the strategic filtering exercise is detailed in Section 8.6.7

9.2.1. Scenario 1 - Attenuation and Retention

This scenario comprised the following:

- Where available green space exists and is able to intercept and retain surface water these sites were selected as retention zones. Bunds were located north of The Street Walberton Village, Shrubs Field Middleton on Sea, Burndell Road Yapton, two in Eastergate Road Eastergate, Yapton Road Yapton, Downview Road Eastergate and Yapton Road Middleton on Sea, Lake Lane Barnham and Downsview Road Barnham.
- Generally the availability of green space is more readily available in Barnham and Walberton. Middleton has negligible available green space which could be used to attenuate surface water runoff. Figure 8.7 shows the reduction in flood risk with the installation of attenuation areas where they were proven to be effective in reducing flood risk.

Figure 8.7 - Flood Attenuation and Retention



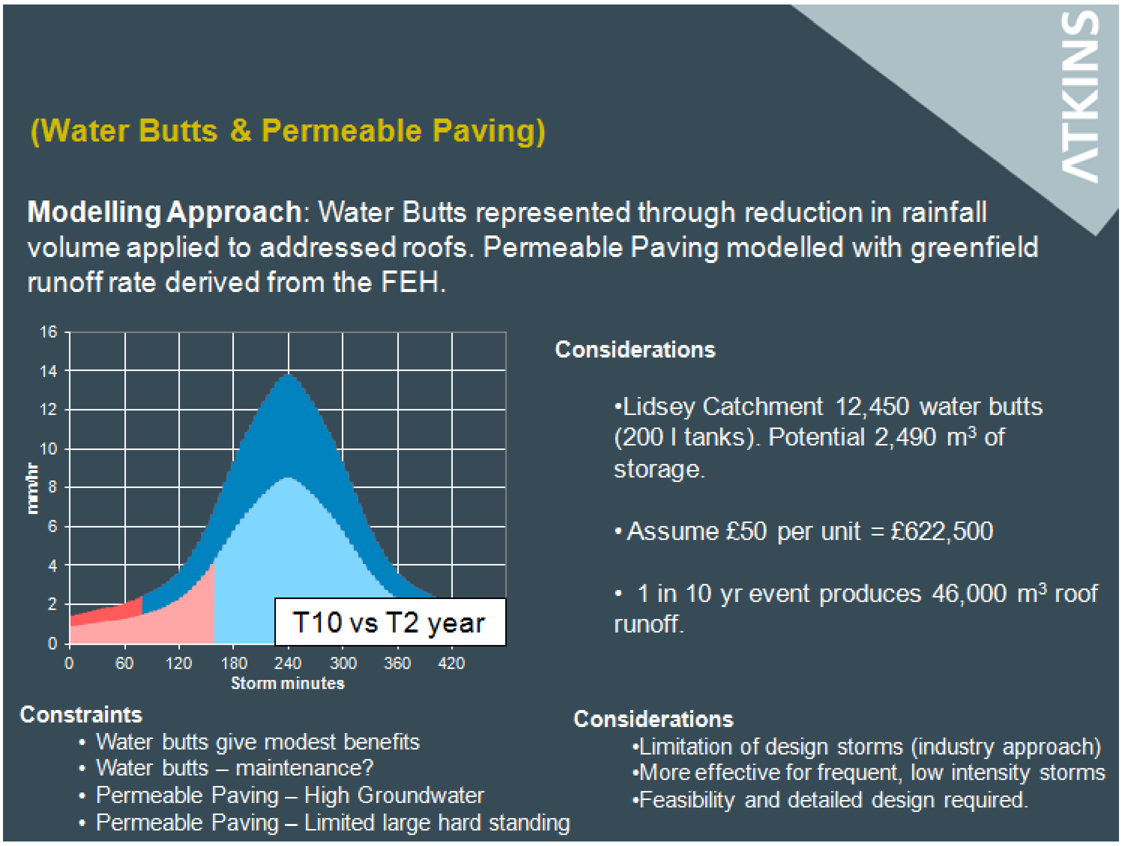
9.2.2. Scenario 2 - SUDS (Water Butts and Permeable Paving)

This scenario comprised the following:

- Water butts were represented through the volumetric truncation of the applied rainfall from the start of the design storm until the storage volume of a water butt had been reached. This element of the option represented the attenuation capacity of 12,450 water butts (200 l tanks) which offered a potential 2,490 m^3 of storage across the catchment. This analysis assumes all water butts are empty at the start of the storm event so represents a best case scenario. Prior to the uptake and distribution of water butts the public need to be made fully aware of the purpose of implementation and use of the water butts to reduce flood risk. This will ensure the water butts are used in a manner which ensures they are regularly emptied to allow for attenuation of roof runoff. Failure to empty the water butts will limit the purposefulness of a water butt for flood risk reduction.
- Adoption of Water Butts across the catchment would cost in the region of £622,500. The cost of converting all highways to permeable paving has not been formally assessed as this would not be considered feasible proposition. But the conversion of private roads, car parks and driveways could be viable and considered where appropriate in localised areas in order to reduce flood risk.
- All major hard standing surfaces i.e. car parks and road surfaces were converted to Greenfield runoff rates to replicate natural rates of runoff (30% fixed runoff).

- It should be realised that water butts do offer a benefit but do have limited capacity and will not be able to fully retain all of the surface water generated by more intense storm events. Water Butts would have a greater impact during lower intensity and more frequently occurring storm events. As an example for a 1 in 10 year 480 minute storm return period 46,000 m^3 of runoff would be generated from roof surfaces within the catchment area compared to 2,490 m^3 of storage capacity in the water butts. As such 43,510 m^3 runoff would still be conveyed into the drainage systems and only 5.4 % of the rainfall would be attenuated by the water butt. This is shown in Figure 8.8 pink and red areas of the graph represent the volume of runoff retained in a water butt for 1 in 10 year and 1 in 2 year return period storms. The respective blue areas demonstrates what would runoff into the drainage systems.

Figure 8.8 - Water Butts and Permeable Paving

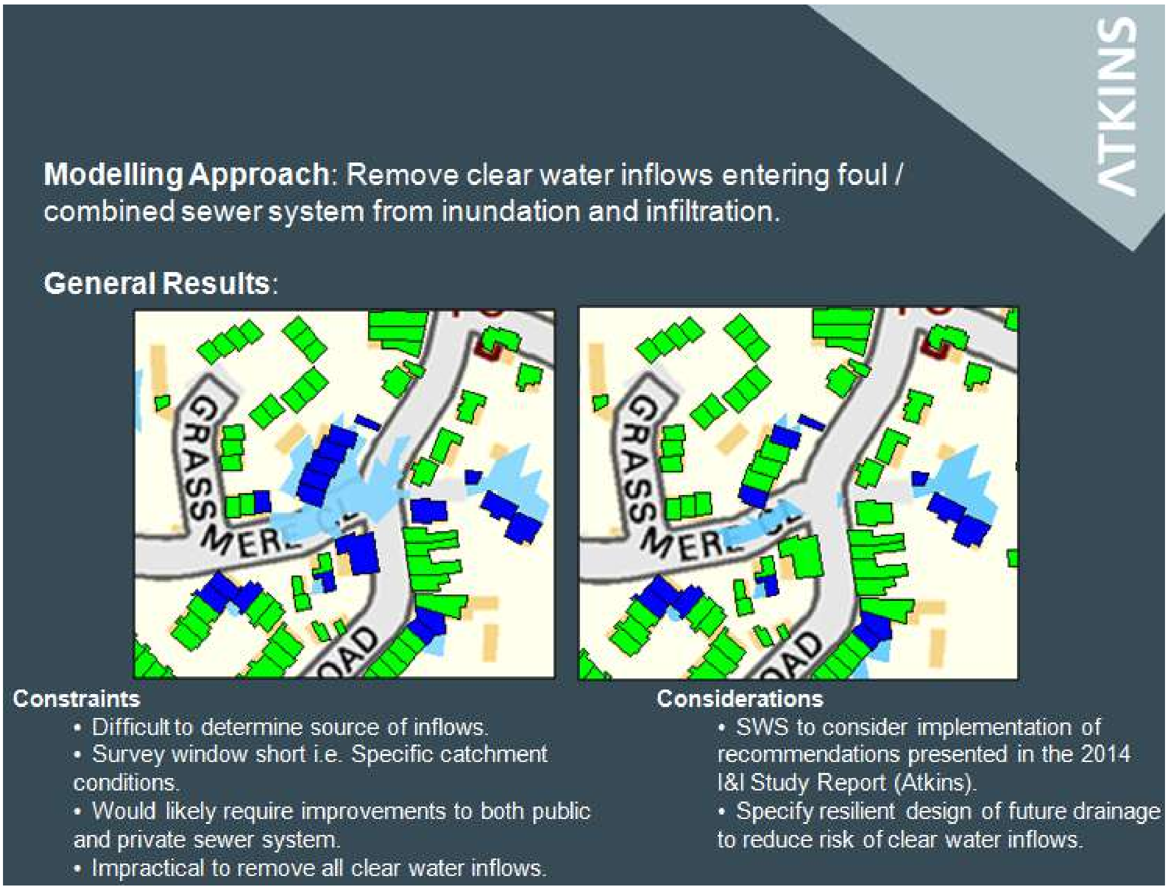


9.2.3. Scenario 3 – Remove connected contributing impermeable area and Ground water entering the public foul sewer system

This scenario comprised the following:

- Remove all impermeable area connected to the foul sewer system.
- Remove all inflows from connected surface water entering the foul sewer system. Significant inflow of groundwater has been confirmed during the I&I investigation.

Figure 8.9 - Remove connected contributing impermeable area and ground water entering the public foul sewer system



9.2.4. Scenario 4 – Increased Surface Water Conveyance

This scenario comprised the following:

- Construction of a new storm sewer system within the SWMP catchment area, comprising 65.6km of new sewer network simulated in the integrated model. The new conceptual surface water system was created through making a duplication of the existing public sewer drainage assets and upsizing the pipe diameters of the conceptual network. This scenario assumed a new surface water sewer system comprised of sewers ranging from 300mm to 1800mm diameter as detailed in Table 8.2.
- The discharge from the new conceptual storm sewer system has not been specifically assessed. Pumping or attenuation at specific outfall points may be required to ensure positive drainage is achievable.

Figure 8.9 shows the localised improvement and flood reduction from the implementation of the increased conveyance drainage assets in central Barnham.

Figure 8.10 - Increase Surface Water Conveyance

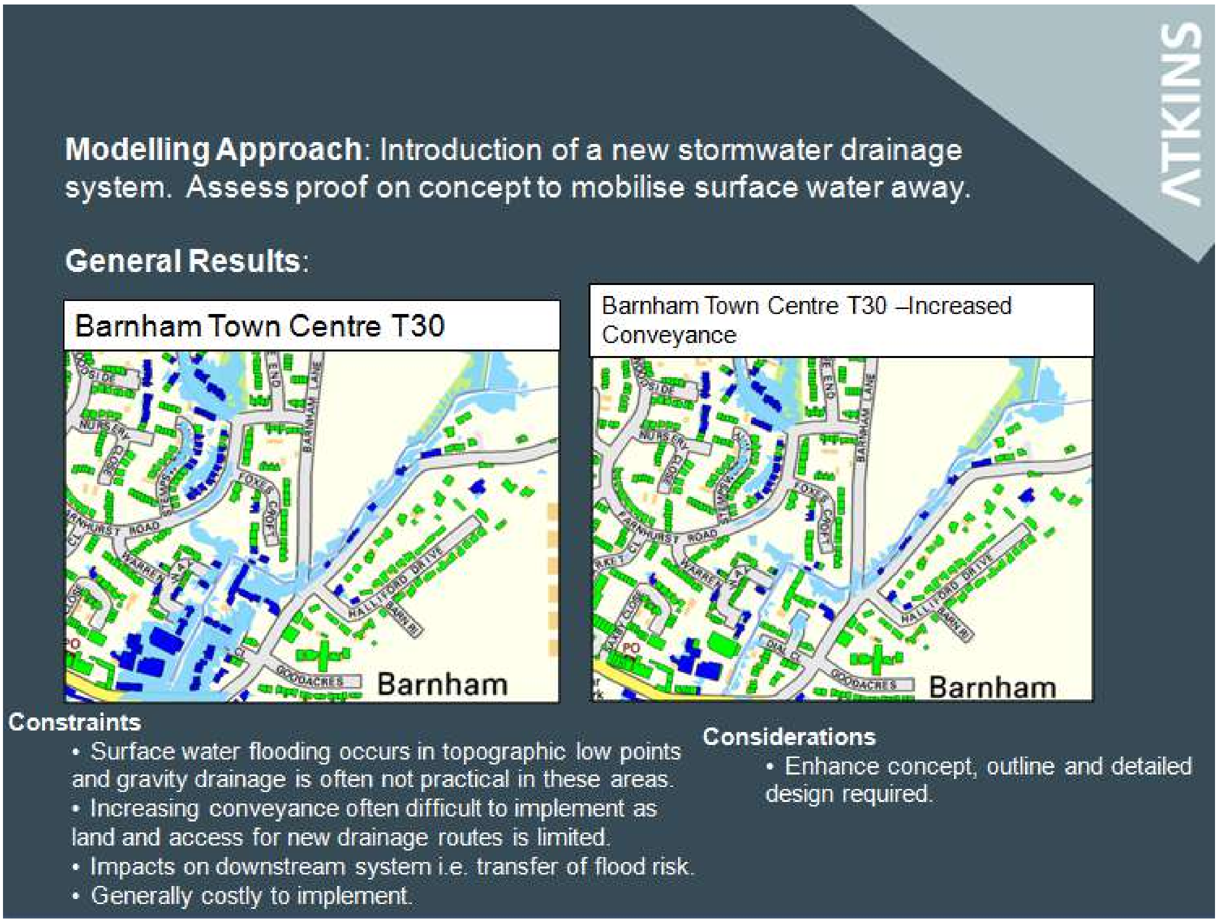


Table 8-2 - Conceptual Surface Water Network

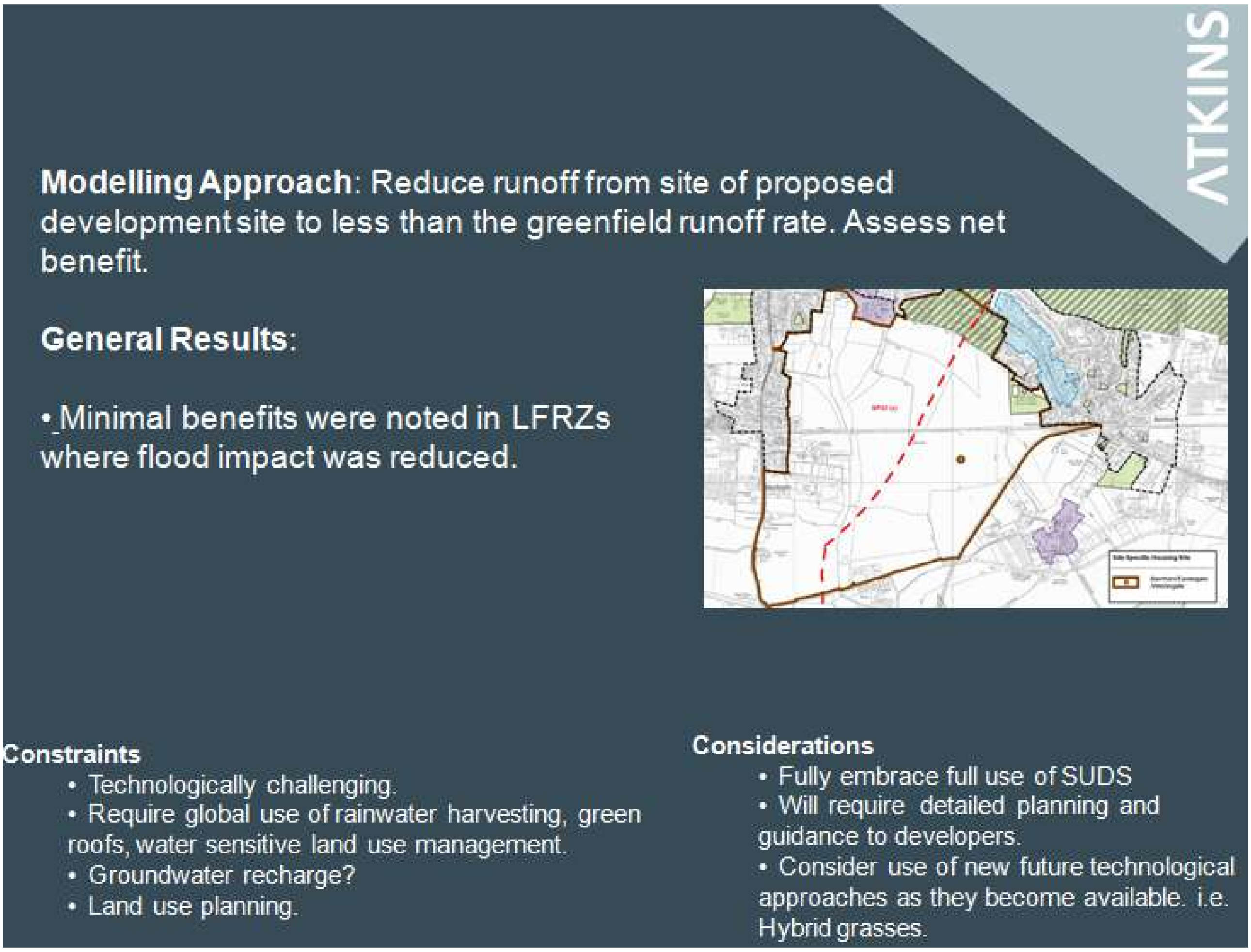
Sewer Diameter (mm)	Length (km)
300	0.05
450	21.78
525	23.54
600	0.05
675	11.75
750	0.91
900	6.26
1050	0.91
1350	0.05
1575	0.25
1800	0.05
Total	**65.6**

9.2.5. Scenario 5 – Reduce runoff from proposed development in Barnham

As detailed in Section 1.9 a sizable proposed development site (2,000 properties) has been identified in the west of Barnham, south of Eastergate and east of Westergate as shown in Figure 1.6. This site is a Greenfield site and as such if developed would be required to ensure that rates of runoff from surface water is limited to current Greenfield runoff rates as stipulated under the NPPF.

A scenario has been adopted to reduce the surface water runoff rate to zero runoff for a 1 in 30 year design event to assess how this may positively influence a reduction in current flood risk. It is appreciated that achieving such a target in runoff reduction would be technologically challenging and would require extensive and costly investment into rainwater harvesting and SUDS techniques but allows us to prove the concept and benefits.

Figure 8.11 - Reduce runoff from the proposed development



9.2.6. Scenario 6 – Impose a Greenfield runoff rate from Greenhouses in Barnham

Given the large area covered by the greenhouses in Barnham which equates to approximately 25 ha of impermeable roof area, it was considered valid to investigate the influence that these impermeable surfaces have on the surface water runoff and flooding in the catchment given their respective size.

The base model represented the greenhouses as impermeable surface features and assumed all runoff generated contributed to the surface water drainage systems. For the purpose of the sensitivity assessment these greenhouses were altered to recreate Greenfield permeable runoff surfaces which are in line with current recommended design guidance for new developments.

As shown in Table 8.3 the results of this analysis show no quantifiable benefit or reduction in flood risk from this type of intervention. This is considered to be due to the location of many of the greenhouses relative to the LFRZs.

9.2.7. Strategic Options (Integrated Modelling) Results

The results of the model scenario screening assessment, shown in Table 8.3, has shown the ‘type’ of solution which could contribute to provide a reduction of flood risk in each LFRZ. It is appreciated that this assessment has been completed at a coarse level but offers a good indication as to the most appropriate method of reducing flood risk.

Scenario 4 - Increased conveyance had the most improvement reducing properties predicted to flood from 386 to 274 across 15 of the 27 LFRZs

Scenario 1 – Retention and Attenuation showed the second best improvement with the number of properties predicted to flood reduce from 386 to 302. However, these benefits were only noted in just eight of the LFRZs where attenuation was a practical proposition were the presence of green space with potential to intercept and retain surface water runoff has the potential.

Table 8-3 - Strategic Option Results (1 in 30 year storm return period)

Scenario	Base Scenario	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
	Count of no. properties flooded						
	Base Model (No. of properties predicted to flood)	Runoff Retention	SUDs	Infiltration Reduction / Sewer Sealing	Increased Conveyance	Development Site Opportunity	Greenhouse Opportunity
LFRZ 01	2	2	2	2	2	2	2
LFRZ 02	9	9	9	9	6	9	9
LFRZ 03	20	7	20	20	11	20	20
LFRZ 04	9	8	9	9	6	9	9
LFRZ 05	1	1	1	1	1	1	1
LFRZ 06	123	64	121	123	74	123	123
LFRZ 07	0	0	0	0	0	0	0
LFRZ 08	0	0	0	0	0	0	0
LFRZ 09	0	0	0	0	0	0	0
LFRZ 10	2	2	1	2	2	1	2
LFRZ 11	3	3	3	3	3	3	3
LFRZ 12	2	2	2	2	0	2	2
LFRZ 13	39	38	39	39	28	39	39
LFRZ 14	15	13	13	15	10	15	15
LFRZ 15	8	8	8	8	5	8	8
LFRZ 16	1	1	1	1	1	1	1
LFRZ 17	46	46	42	36	39	45	46
LFRZ 18	8	8	7	8	6	8	8
LFRZ 19	23	19	23	23	20	19	23
LFRZ 20	4	4	4	4	4	4	4
LFRZ 21	7	6	6	6	6	6	7
LFRZ 22	9	9	7	9	4	9	9
LFRZ 23	23	23	23	23	20	23	23
LFRZ 24	14	14	14	14	11	14	14
LFRZ 25	7	7	6	6	4	7	7
LFRZ 26	6	6	6	6	6	6	6
LFRZ 27	5	2	5	5	5	5	5
Total	**386**	**302**	**372**	**374**	**274**	**379**	**386**

Key:

No. of properties predicted to flood in scenario (1 in 30 year) that provided a reduction in properties predicted at risk — 2 (green shading)

10. Phase 3b – Assess Options

10.1. Introduction

A high-level scoring system has been used to assess options available and short list preferred interventions. This approach aligns with the FCERM and Defra's SWMP Guidance. The scoring process is detailed in Table 9.1.

Table 10-1 - Options Assessment Short-Listing criteria

Assessment Criteria	Description
Technical	- Will the solution be robust and reliable?
	- Is the option buildable in the specific location?
	- Would the option require new technology or techniques?
	- Is the technology used proven?
Economic	- Will the benefits exceed the costs?
	- Is the option within available budgets and funding? (Alternative funding streams are available and may originate from alternative sources in the future. This shall be considered)?
Environmental	- Will the solution provide environmental benefits through improving water quality and biodiversity?
Objectiveness	- Does it serve a goal for the SWMP?
	- Does the option meet the objective of alleviating flood risk?
Social	- Would the option meet resistance from the local community?
	- does it improve local amenity?
	- Would the community benefit from the option?

Each of the assessment criteria has been scored based on the following values **-2** High Negative Outcomes, **-1** Moderate negative outcome, **0** Neutral, **+1** Moderate positive outcome and **+2**: High Positive Outcome.

An assessment of options and associated Partner Actions for each of the LFRZ has been prepared and is located in Appendix E. An example of the applied short listing criteria is shown in Table 9.2.

Table 10-2 - Options Assessment Short-Listing criteria (Example)

Option Ref.	Option Catagory (Source / Pathway / Receptor / Other)	Option	Potential	Considered	Scoring (-2 to +2) Options Assessment: Economic	Environmental	Objectiveness	Social	Technical	Total Score	Summary of scheme / General discussion
1	Do Nothing	Do Nothing	Yes	No	0	0	0	0	0	0	
2	Do minimum	Do minimum - continue current maintenance	Yes	Yes	2	2	0	2	1	7	
3	Source	Green Roof	Yes	No	0	0	0	0	0	0	
4	Source	Detention Basins (Attenuation / Retention)	No	No	0	0	0	0	0	0	
5	Source	Permeable Paving	No	No	0	0	0	0	0	0	
6	Source	Ponds and Wetlands	No	No	0	0	0	0	0	0	
7	Source	Rainwater Harvesting	Yes	Yes	2	2	1	2	2	9	
8	Source	Soakaways	No	No	0	0	0	0	0	0	
9	Source	Swales	No	No	0	0	0	0	0	0	
10	Source	Bioretention Basins	No	No	0	0	0	0	0	0	
11	Source	Bioretention Street Planting	Yes	No	0	0	0	0	0	0	
12	Source	Sealing of manhole covers and protecting gullies	Yes	Yes	1	2	2	2	1	8	
13	Source	Sealing Sewers (Reduce ground water / rainfall induced infiltration)	Yes	Yes	1	2	2	2	0	7	Infiltration maybe entering via private sewers
14	Source	Other Source Measures	No	No	0	0	0	0	0	0	
15	Pathway	Increasing Capacity in Drainage System (Storage,Upsize)	Yes	No	0	0	0	0	0	0	Increasing capacity in the public sewerage may reduce flood risk. However, reducing clearwater inflow would be preferable. Local sewer upsize not considered appropriate
16	Pathway	Deculverting Watercourse(s)	No	No	0	0	0	0	0	0	
17	Pathway	Improved maintenance regimes	Yes	Yes	-2	0	2	0	2	2	Optimise existing capacity.
18	Pathway	Increase Gully Assets	No	No	0	0	0	0	0	0	
19	Pathway	Land management practices	No	No	0	0	0	0	0	0	
20	Pathway	Managing overland flows (above ground storage)	No	No	0	0	0	0	0	0	
21	Pathway	Managing overland flows (preferential flow paths during exceedance)	No	No	0	0	0	0	0	0	
22	Pathway	Seperation of foul and surfacewater	Yes	Yes	0	2	2	0	0	4	Where practical remove surface water entering foul system. Target descrete surface water systems or large impermeable areas or roofs connecting storm flow into the foul system.
23	Receptor	Improve Weather Warning	No	No	0	0	0	0	0	0	
24	Receptor	Improve resilience to flooding	No	No	0	0	0	0	0	0	
25	Receptor	Social change, education and awareness	No	No	0	0	0	0	0	0	
26	Receptor	Raising doorway / access threshold	No	No	0	0	0	0	0	0	
27	Receptor	Planning policies to influence development (Development Control, SUDS Strategy, Blue Development Corridors, New Development).	Yes	Yes	2	2	2	2	1	9	Ensure sustainable building methods are adopted to reduce risk of surface water and ground water entering public sewer system.
28	Receptor	Temporary demountable flood defences	No	No	0	0	0	0	0	0	
29	Strategy	Further Study / Investigations	Yes	Yes	1	1	1	1	1	5	SWS recommended to conduct I&I investigations.
30	Strategy	Survey, Advise & Monitoring	No	No	0	0	0	0	0	0	
31	Strategy	Community Awareness	No	No	0	0	0	0	0	0	

10.2. LFRZs Options

Specific options for each of the LFRZs are discussed in this section.

01 - West Walberton Lane, Walberton

Preferred Interventions: Inflow and Infiltration reduction entering public foul sewers & SUDS

Table 10-3 - LFRZ_001 Options

Option Ref.	Option Category (Source / Pathway / Receptor / Other)	Option	Potential	Considered	Economic	Environmental	Objectiveness	Social	Technical	Total Score	Summary of scheme / General discussion
2	Do minimum	Do minimum - continue current maintenance	Yes	Yes	2	2	0	2	1	**7**	
7	Source	Rainwater harvesting	Yes	Yes	2	2	1	2	2	**9**	
12	Source	Sealing of manhole covers and protecting gullies	Yes	Yes	1	2	2	2	1	**8**	
13	Source	Sealing sewers (Reduce ground water / rainfall induced infiltration)	Yes	Yes	1	2	2	2	0	**7**	Infiltration maybe entering via private sewers upstream.
17	Pathway	Increasing capacity in drainage system (storage, upsize)	Yes	Yes	-2	0	2	0	2	**2**	Optimise existing capacity.
22	Pathway	Improve resilience to flooding	Yes	Yes	0	2	2	0	0	**4**	Where practical remove surface water entering foul system. Target discrete surface water systems or large impermeable areas or roofs connecting storm flow into the foul system.
27	Receptor	Planning policies to influence development (Development Control, SUDS Strategy, Blue Development Corridors, and New Development).	Yes	Yes	2	2	2	2	1	**9**	Ensure sustainable building methods are adopted to reduce risk of surface water and ground water entering public sewer system.
29	Strategy	Survey, advise & monitoring	Yes	Yes	1	1	1	1	1	**5**	SWS recommended to conduct targeted I&I investigations and develop a hydraulic scheme.

LFRZ_002 – Elm Grove, Barnham

Preferred Interventions: Planning activities, reduce surface water inflow and infiltration entering public foul sewers

Table 10-4 - LFRZ_002 Options

Option Ref.	Option Category (Source / Pathway / Receptor / Other)	Option	Potential	Considered	Economic	Environmental	Objectiveness	Social	Technical	Total Score	Summary of scheme / General discussion
2	**Do minimum**	Do minimum - continue current maintenance	Yes	Yes	2	2	0	2	1	**7**	
7	Source	Rainwater harvesting	Yes	Yes	2	2	1	2	2	**9**	Installation of water butts.
12	Source	Sealing of manhole covers and protecting gullies	Yes	Yes	1	2	2	2	1	**8**	Reduce surface water inflow.
13	Source	Sealing Sewers (Reduce ground water / rainfall induced infiltration)	Yes	Yes	1	2	2	2	0	**7**	Reduce ground water inflows entering the foul sewer system.
15	Pathway	Increasing capacity in drainage system (storage, upsize)	Yes	Yes	0	0	2	0	2	**4**	Consideration of opening the abandoned CSO in Elm Grove should be investigated further. This would require a local flow survey and model verification to confirm value of this option and its impact. This has the potential to increase conveyance of surface water away from the LFRZ.
24	Receptor	Improve resilience to flooding	Yes	Yes	2	2	2	2	1	**9**	Should be considered for susceptible properties affected by flood water entering properties.
27	Receptor	Planning policies to influence development (Development Control, SUDS Strategy, Blue Development Corridors, and New Development).	Yes	Yes	2	2	2	2	1	**9**	Ensure suitable development controls are placed on new developments in this LFRZ to reduce flood risk. New properties to utilise SUDS.
30	Strategy	Survey, advise & monitoring	Yes	Yes	0	1	1	1	2	**5**	Install permanent ground water telemetry in the existing borehole.

LFRZ_003 – Walberton Village

Preferred Interventions: Planning activities, land use management, attenuation & retention, surface water inflow and infiltration reduction entering public foul sewers

Table 10-5 - LFRZ_003 Options

Option Ref.	Option Category (Source / Pathway / Receptor / Other)	Option	Potential	Considered	Economic	Environmental	Objectiveness	Social	Technical	Total Score	Summary of scheme / General discussion
2	**Do minimum**	Do minimum - continue current maintenance	Yes	Yes	2	2	0	2	1	**7**	
4	Source	Detention basins (attenuation / retention)	Yes	Yes	0	1	2	0	2	**5**	Intercept runoff from the fields to north of village. See Attenuation / Retention Option.
7	Source	Rainwater harvesting	Yes	Yes	2	2	1	2	2	**9**	Installation of water butts.
12	Source	Sealing of manhole covers and protecting gullies	Yes	Yes	1	2	2	2	1	**8**	
13	Source	Sealing sewers (Reduce ground water / rainfall induced infiltration)	Yes	Yes	1	2	2	2	0	**7**	Infiltration maybe entering via private sewers
15	Pathway	Increasing capacity in drainage system (Storage, Upsize)	Yes	Yes	0	0	2	0	2	**4**	Increasing capacity in the main river system would likely reduce flood risk. See Figure 9.1 and 9.2. Remove weir on main river in Burch Grove.
17	Pathway	Improved maintenance regimes	Yes	Yes	-2	0	2	0	2	**2**	Optimise existing capacity. Desilt ditches and culverts at the east end of Eastergate Lane.
19	Pathway	Land management practices	Yes	Yes	0	1	1	1	1	**4**	Ensuring land is managed affectively. Ploughing fields east to west is recommended in the fields to the north of the village to reduce runoff. See Figure 9.3.
24	Receptor	Improve resilience to flooding	Yes	Yes	2	2	2	2	1	**9**	Flood mitigation to be considered in the area at those properties at risk of surface water flooding.
26	Receptor	Raising doorway / access threshold	Yes	Yes	2	2	2	2	1	**9**	Should be considered for susceptible properties affected by overland flows entering properties.
27	Receptor	Planning policies to influence development (Development Control, SUDS Strategy, Blue Development Corridors, and New Development).	Yes	Yes	2	2	2	2	1	**9**	Ensure sustainable building methods are adopted to reduce risk of surface water and ground water entering public sewer system. Ensure suitable development controls are in place.
29	Strategy	Further study / investigations	Yes	Yes	1	1	1	1	1	**5**	Assess hydraulic schemes in more detail using the integrated model containing the verified fluvial network. Fluvial assessment of the main river systems should be undertaken as part of

											the current EA Rife study (2014). To accurately assess the performance of the existing pond and consider desilting if necessary.

LFRZ_003 – Walberton Village (cont.)

Attenuation and Retention Option (Element 1)

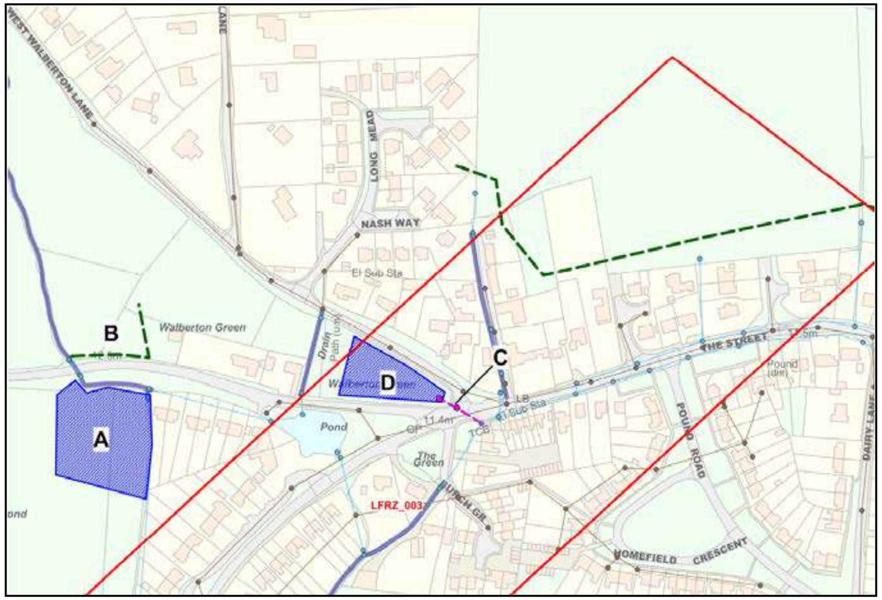
A: Construct a new storage area to store high flows from Rife. Lower south bank of the Rife by approximately 400 mm to allow high flows to spill.

B: 700 mm high, 34m long bund to store spill from Rife and prevent water flowing onto road and towards properties

C: New storm drain arrangement connecting to the existing highway drainage network. Spilling to new Storage area in Walberton Green

D: New 900 m^3 storage area in Walberton Green receiving flows from highway.

Figure 10.1 - Walberton Village (Element 1)



Attenuation and Retention Option (Element 2)

A: Construct a new 380 m long, 1.2 m high bund

B: Construct a new 500 m long, 1.2 m high bund

Figure 10.2 - Walberton Village (Element 2)

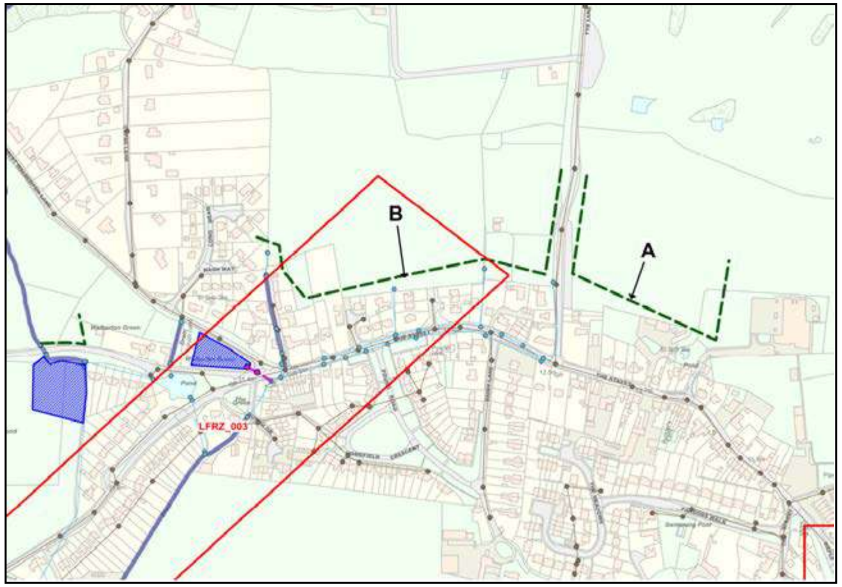


Figure 10.3 - Land Use Management

LFRZ_004 – Maple Road, Walberton

Preferred Interventions: Surface water and infiltration reduction entering public foul sewers

Table 10-6 - LFRZ_004 Options

Option Ref.	Option Category (Source / Pathway / Receptor / Other)	Option	Potential	Considered	Economic	Environmental	Objectiveness	Social	Technical	Total Score	Summary of scheme / General discussion
2	**Do minimum**	Do minimum - continue current maintenance	Yes	Yes	2	2	0	2	1	**7**	
7	Source	Rainwater harvesting	Yes	Yes	2	2	1	2	2	**9**	
12	Source	Sealing of manhole covers and protecting gullies	Yes	Yes	1	2	2	2	1	**8**	
13	Source	Sealing sewers (Reduce ground water / rainfall induced infiltration)	Yes	Yes	1	2	2	2	0	**7**	Infiltration reduction required
15	Pathway	Increasing capacity in drainage system (Storage, Upsize)	Yes	Yes	0	0	2	0	2	**4**	Increasing capacity in the public sewerage may reduce flood risk. However, reducing clear water inflow would be preferable.
27	Receptor	Planning policies to influence development (Development Control, SUDS Strategy, Blue Development Corridors, and New Development).	Yes	Yes	2	2	2	2	1	**9**	Ensure sustainable building methods are adopted to reduce risk of surface water and ground water entering public sewer system.
29	Strategy	Further study / investigations	Yes	Yes	1	1	1	1	1	**5**	SWS to investigate source of Fat, Oil, Grease which has been reported by residents. Develop hydraulic solution for the localised foul sewer flooding.

LFRZ_005 – Barnham Lane, Barnham (B)

Preferred Interventions: Reduce surface water and infiltration entering public foul sewers, asset management.

Table 10-7 - LFRZ_005 Options

Option Ref.	Option Category (Source / Pathway / Receptor / Other)	Option	Potential	Considered	Economic	Environmental	Objectiveness	Social	Technical	Total Score	Summary of scheme / General discussion
2	**Do minimum**	Do minimum - continue current maintenance	Yes	Yes	2	2	0	2	1	**7**	
12	Source	Sealing of manhole covers and protecting gullies	Yes	Yes	1	2	2	2	1	**8**	To be considered in local area and in the upstream network.
13	Source	Sealing Sewers (Reduce ground water / rainfall induced infiltration)	Yes	Yes	1	2	2	2	0	**7**	Infiltration maybe entering via private sewers. Conduct I&I study investigations on system upstream.
17	Pathway	Improved maintenance regimes	Yes	Yes	-2	0	2	0	2	**2**	Clear drainage ditches. Investigate potential restrictions in the ditch systems.
27	Receptor	Planning policies to influence development (Development Control, SUDS Strategy, Blue Development Corridors, and New Development).	Yes	Yes	2	2	2	2	1	**9**	Ensure sustainable building methods are adopted to reduce risk of surface water and ground water entering public sewer system.
29	Strategy	Further Study / Investigations	Yes	Yes	1	1	1	1	1	**5**	Investigate ditch on northern side of track to North Choller Farm has potentially been filled (vehicular crossing). Some of the highway drainage system in Barnham Lane may discharge into this ditch. The outfall is assumed buried. Investigate the ditch that flows from the highway toward the rife adjacent to the property and establish the reason for the pooling of water off the Highway. Identify if there is a hydraulic restriction.

LFRZ_006 - Lake Lane, Barnham

Preferred Interventions: Planning activities, asset management, potential for attenuation and retention (EA river modelling study to assess opportunities)

Table 10-8 - LFRZ_006 Options

Option Ref.	Option Category (Source / Pathway / Receptor / Other)	Option	Potential	Considered	Economic	Environmental	Objectiveness	Social	Technical	Total Score	Summary of scheme / General discussion
2	**Do minimum**	Do minimum - continue current maintenance	Yes	Yes	2	2	0	2	1	7	
4	Source	Detention Basins (Attenuation / Retention)	Yes	Yes	0	1	2	0	2	5	Utilise available land upstream of Barnham to attenuate flows from main river. This should be investigated further within the EA River Modelling study. See figure 9.4. Determine if site A is planned for development.
7	Source	Rainwater Harvesting	Yes	Yes	2	2	1	2	2	9	Installation of water butts in upstream catchment.
12	Source	Sealing of manhole covers and protecting gullies	Yes	Yes	1	2	2	2	1	8	Reduce surface water inflow.
13	Source	Sealing Sewers (Reduce ground water / rainfall induced infiltration)	Yes	Yes	1	2	2	2	0	7	Reduce ground water inflows.
22	Pathway	Separation of foul and surface water	Yes	Yes	0	2	2	0	0	4	Control at source see activities 12 & 13
27	Receptor	Planning policies to influence development (Development Control, SUDS Strategy, Blue Development Corridors, and New Development).	Yes	Yes	2	2	2	2	1	9	Ensure suitable development controls are placed on new developments in this LFRZ to reduce flood risk.

LFRZ_006 – Lake Lane, Barnham (cont.)

Attenuation and Retention Option

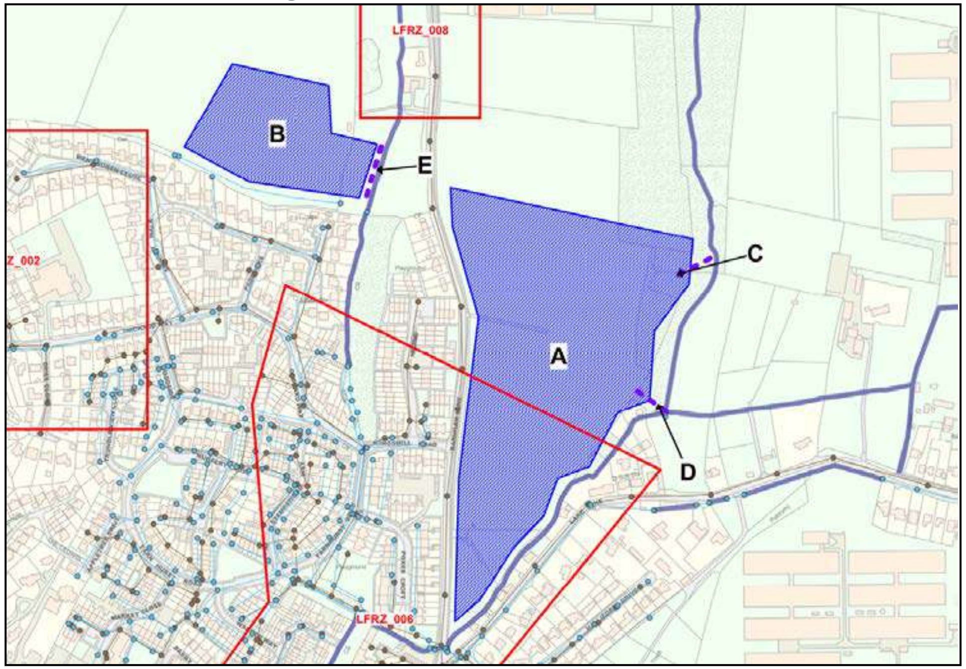
A: Provide storage for 8,000 m^3 of flow from Rife during storm events (1 in 30 year standard of protection)

B: Provide storage for 3,500 m^3 of flow from the Rife during storm events (1 in 30 year standard of protection)

C & D: Landscape (Ditch / bund) so that bank-spilled flows from rife are conveyed into storage area

E: Landscape Rife western bank so that high flows spill into storage area.

Figure 10.4 – Lake Lane, Barnham



LFRZ_007 – Park Road, Barnham

Preferred Interventions: Asset management, reduce surface water and infiltration entering public foul sewers.

Table 10-9 - LFRZ_007 Options

Option Ref.	Option Category (Source / Pathway / Receptor / Other)	Option	Potential	Considered	Economic	Environmental	Objectiveness	Social	Technical	Total Score	Summary of scheme / General discussion
2	**Do minimum**	Do minimum - continue current maintenance	Yes	Yes	2	2	0	2	1	7	
7	Source	Rainwater Harvesting	Yes	Yes	2	2	1	2	2	9	Installation of water butts.
12	Source	Sealing of manhole covers and protecting gullies	Yes	Yes	1	2	2	2	1	8	Reduce surface water inflow.
13	Source	Sealing Sewers (Reduce ground water / rainfall induced infiltration)	Yes	Yes	1	2	2	2	0	7	Reduce ground water inflows.
27	Receptor	Planning policies to influence development (Development Control, SUDS Strategy, Blue Development Corridors, and New Development).	Yes	Yes	2	2	2	2	1	9	Ensure suitable development controls are placed on new developments in this LFRZ to reduce flood risk.
29	Strategy	Further Study / Investigations	Yes	Yes	1	1	1	1	1	5	Investigate current surface water drainage from local nurseries. Investigate the screen arrangement in the ditch on northern boundary of Kilkenny in order to evaluate performance. Investigation the surface water disposal from the greenhouses to assess if improvements can be made to reduce peak flows entering main river. This may reduce flood risk at Meadow Farm. Also consider the affect of the attenuation ponds further in the EA River Modelling Study.

LFRZ_008 – Barnham Lane, Barnham (C)

Preferred Interventions: Asset Management, reduce surface water and infiltration entering public foul sewers

Table 10-10 - LFRZ_008 Options

Option Ref.	Option Category (Source / Pathway / Receptor / Other)	Option	Potential	Considered	Economic	Environmental	Objectiveness	Social	Technical	Total Score	Summary of scheme / General discussion
2	**Do minimum**	Do minimum - continue current maintenance	Yes	Yes	2	2	0	2	1	7	
12	Source	Sealing of manhole covers and protecting gullies	Yes	Yes	1	2	2	2	1	8	To be considered in local area and in the upstream network.
13	Source	Sealing Sewers (Reduce ground water / rainfall induced infiltration)	Yes	Yes	1	2	2	2	0	7	Infiltration maybe entering via private sewers. Conduct I&I study investigations on system upstream.
17	Pathway	Improved maintenance regimes	Yes	Yes	-2	0	2	0	2	2	Clear drainage ditches. Investigate potential restrictions in the ditch systems.
27	Receptor	Planning policies to influence development (Development Control, SUDS Strategy, Blue Development Corridors, and New Development).	Yes	Yes	2	2	2	2	1	9	Ensure sustainable building methods are adopted to reduce risk of surface water and ground water entering public sewer system.
29	Strategy	Further Study / Investigations	Yes	Yes	1	1	1	1	1	5	Ditch clearance in Barnham Lane Implement I&I interventions to reduce Inflow and Infiltration entering public foul sewers.

LFRZ_009 – Yapton Road, Yapton

Preferred Interventions: Asset Management, Reduce surface water and infiltration entering public foul sewers

Table 10-11 - LFRZ_009 Options

Option Ref.	Option Category (Source / Pathway / Receptor / Other)	Option	Potential	Considered	Economic	Environmental	Objectiveness	Social	Technical	Total Score	Summary of scheme / General discussion
2	**Do minimum**	Do minimum - continue current maintenance	Yes	Yes	2	2	0	2	1	**7**	
4	Source	Detention Basins (Attenuation / Retention)	Yes	Yes	0	1	2	0	2	**5**	Investigate opportunity to attenuate surface water in the north-eastern field off of Yapton Road. This will require more detailed investigation. See figure 9.5.
7	Source	Rainwater Harvesting	Yes	Yes	2	2	1	2	2	**9**	Installation of water butts in upstream catchment.
12	Source	Sealing of manhole covers and protecting gullies	Yes	Yes	1	2	2	2	1	**8**	Reduce surface water inflow.
13	Source	Sealing Sewers (Reduce ground water / rainfall induced infiltration)	Yes	Yes	1	2	2	2	0	**7**	Reduce ground water inflows.
17	Pathway	Improved maintenance regimes	Yes	Yes	-2	0	2	0	2	**2**	CCTV inspection of the last leg of the 150 mm land drain to confirm if there is a blockage / partial collapse which is currently suspected.
22	Pathway	Separation of foul and surface water	Yes	Yes	0	2	2	0	0	**4**	Control at source see activities 12 & 13
27	Receptor	Planning policies to influence development (Development Control, SUDS Strategy, Blue Development Corridors, and New Development).	Yes	Yes	2	2	2	2	1	**9**	Ensure suitable development controls are placed on new developments in this LFRZ to reduce flood risk.
29	Strategy	Further Study / Investigations	Yes	Yes	1	1	1	1	1	5	Investigate opportunity to attenuate surface water in the north-eastern field off of Yapton Road. This will require more detailed investigation.

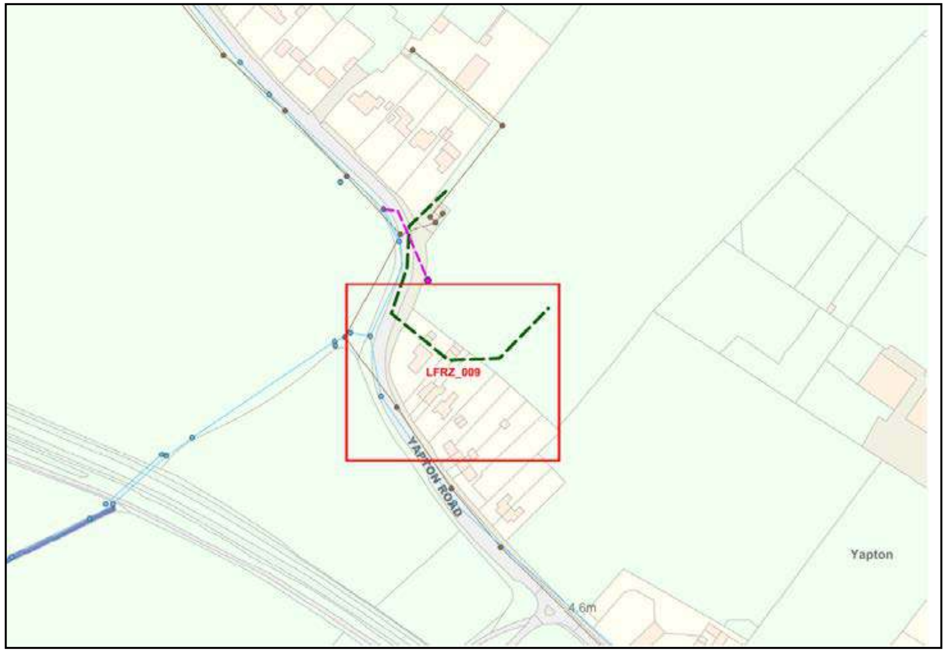
LFRZ_009 – Yapton Road, Yapton (Cont.)

Attenuation and Retention Option

Install storage for 3,500 m^3 water, to provide a 1 in 30 year level of protection, in field north-east of Yapton Road. Install 60 m of sewer at high level connecting the existing surface water network to the new storage area.

Note: This option has not been hydraulically modelled.

Figure 10.5 - Yapton Road, Yapton



LFRZ_010 – - Burndell Road, Yapton

Preferred Interventions: Asset management, Reduce surface water and infiltration entering public foul sewers. Planning Activities

Table 10-12 - LFRZ_010 Options

Option Ref.	Option Category (Source / Pathway / Receptor / Other)	Option	Potential	Considered	Economic	Environmental	Objectiveness	Social	Technical	Total Score	Summary of scheme / General discussion
2	**Do minimum**	Do minimum - continue current maintenance	Yes	Yes	2	2	0	2	1	7	
7	Source	Rainwater Harvesting	Yes	Yes	2	2	1	2	2	9	Installation of water butts in upstream catchment.
12	Source	Sealing of manhole covers and protecting gullies	Yes	Yes	1	2	2	2	1	8	Reduce surface water inflow.
13	Source	Sealing Sewers (Reduce ground water / rainfall induced infiltration)	Yes	Yes	1	2	2	2	0	7	Reduce ground water inflows.
15	Pathway	Increasing Capacity in Drainage System (Storage, Upsize)	Yes	Yes	0	0	2	0	2	4	Investigate conveying surface water away from properties. See figure 9.6.
17	Pathway	Improved maintenance regimes	Yes	Yes	-2	0	2	0	2	2	Continue to maintain existing drainage assets to optimise existing capacity.
18	Pathway	Increase Gully Assets	Yes	Yes	0	0	2	1	2	5	This should be investigated to remove highway flooding.
22	Pathway	Separation of foul and surface water	Yes	Yes	0	2	2	0	0	4	Control at source see activities 12 & 13
27	Receptor	Planning policies to influence development (Development Control, SUDS Strategy, Blue Development Corridors, and New Development).	Yes	Yes	2	2	2	2	1	9	Obtain drainage benefits from local development.
29	Strategy	Further Study / Investigations	Yes	Yes	1	1	1	1	1	5	Investigate conveying surface water away from properties through the introduction of new land drainage channels and increased capacity in highway drainage. It is considered likely that this intervention would need to fully replace the current highway drainage system. However, utilisation of existing assets / capacity should be considered when this is being assessed in more detail.

LFRZ_010 – Burndell Road, Yapton (Cont.)

Increased Surface Water Conveyance

A: Install new highway pipe and gullies to improve drainage in highway

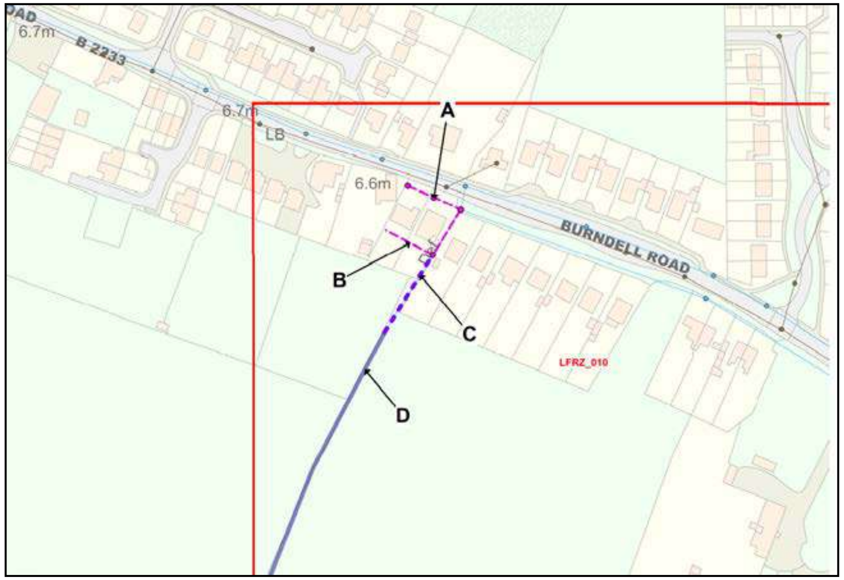
B: Install French drain to the rear of properties in Burndell Road

C: Extend existing ditch north to property boundary to receive highway runoff

D: Ensure ditch is maintained

Note: This option has not been hydraulically modelled. There is a need to fully understand the existing highway drainage system and outlet as part of this assessment.

Figure 10.6 - Burndell Road, Yapton



LFRZ_011 – West View Drive, Yapton

Preferred Interventions: Asset Management (Monitor performance).

Table 10-13 - LFRZ_011 Options

Option Ref.	Option Category (Source / Pathway / Receptor / Other)	Option	Potential	Considered	Economic	Environmental	Objectiveness	Social	Technical	Total Score	Summary of scheme / General discussion
30	Strategy	Survey, Advise & Monitoring	Yes	Yes	0	1	1	1	2	5	SWS to monitor public sewer performance using their Area Asset Plan prioritisation system to identify emerging issues and priorities future hydraulic investigations.

LFRZ_012 – Yapton Road, Middleton on Sea

Preferred Interventions: Asset Management, Flood Resilience, conveyance and attenuation.

Table 10-14 - LFRZ_012 Options

Option Ref.	Option Category (Source / Pathway / Receptor / Other)	Option	Potential	Considered	Economic	Environmental	Objectiveness	Social	Technical	Total Score	Summary of scheme / General discussion
2	**Do minimum**	Do minimum - continue current maintenance	Yes	Yes	2	2	0	2	1	7	
4	Source	Detention Basins (Attenuation / Retention)	Yes	Yes	0	1	2	0	2	5	Investigate conveying surface water away from affected area and attenuate flows. This should be completed after survey of existing drainage assets.
7	Source	Rainwater Harvesting	Yes	Yes	2	2	1	2	2	9	Installation of water butts in upstream catchment to reduce surface water runoff.
12	Source	Sealing of manhole covers and protecting gullies	Yes	Yes	1	2	2	2	1	8	Reduce surface water inflow.
15	Pathway	Increasing Capacity in Drainage System (Storage, Upsize)	Yes	Yes	0	0	2	0	2	4	Investigate conveying surface water away from affected area and attenuate flows. This should be completed after survey of existing drainage assets. See figure 9.7.
17	Pathway	Improved maintenance regimes	Yes	Yes	-2	0	2	0	2	2	optimisation of existing assets
18	Pathway	Increase Gully Assets	Yes	Yes	0	0	2	1	2	5	This should be investigated to intercept and remove highway flooding and runoff.
24	Receptor	Improve resilience to flooding	Yes	Yes	2	2	2	2	1	9	To be considered in a hydraulic investigation
26	Receptor	Raising doorway / access threshold	Yes	Yes	2	2	2	2	1	9	To be considered in a hydraulic investigation
27	Receptor	Planning policies to influence development (Development Control, SUDS Strategy, Blue Development Corridors, and New Development).	Yes	Yes	2	2	2	2	1	9	Implement SUDS on new brownfield developments
28	Receptor	Temporary demountable flood defences	Yes	Yes	1	0	2	0	2	5	Potentially applicable.
29	Strategy	Further Study / Investigations	Yes	Yes	1	1	1	1	1	5	Detailed hydraulic investigation is required to confirm appropriate actions. Update ICM model to assist the investigation.

LFRZ_012 – Yapton Road, Middleton on Sea (Cont.)

Increased Surface Water Conveyance and Attenuation

A: Install Strip drain to capture highway runoff.

B: New Highway pipe connecting into an attenuation basin.

C: Install a 1,800 m^3 attenuation basin capacity to provide a 1 in 30 year level of protection

Note: This option has not been hydraulically modelled.

Figure 10.7 - Yapton Road, Middleton on Sea

LFRZ_013 – Elmer Sands, Middleton on Sea

Preferred Interventions: Progress with the FDGIA funded investigation to complete further optioneering, selection and development of a detailed design scheme.

Please refer to the Elmer SWMP report (Doc ref. 5090247 / 61 / DG / 010).

LFRZ_014 – Lodge Close & Willow Brook, Middleton on Sea

Preferred Interventions: Asset management, planning activities, further hydraulic investigation

Table 10-15 - LFRZ_014 Options

Option Ref.	Option Category (Source / Pathway / Receptor / Other)	Option	Potential	Considered	Economic	Environmental	Objectiveness	Social	Technical	Total Score	Summary of scheme / General discussion
2	**Do minimum**	Do minimum - continue current maintenance	Yes	Yes	2	2	0	2	1	7	
7	Source	Rainwater Harvesting	Yes	Yes	2	2	1	2	2	9	Installation of water butts in upstream catchment to reduce surface water runoff.
12	Source	Sealing of manhole covers and protecting gullies	Yes	Yes	1	2	2	2	1	8	Reduce surface water inflow.
15	Pathway	Increasing Capacity in Drainage System (Storage, Upsize)	Yes	Yes	0	0	2	0	2	4	Investigate conveying surface water away from affected area. This should be completed after survey of existing drainage assets which is currently being undertaken during the development of the SWMP.
17	Pathway	Improved maintenance regimes	Yes	Yes	-2	0	2	0	2	2	optimisation of existing assets
18	Pathway	Increase Gully Assets	Yes	Yes	0	0	2	1	2	5	This should be investigated to remove highway flooding As part of the Opus study.
24	Receptor	Improve resilience to flooding	Yes	Yes	2	2	2	2	1	9	To be considered in a hydraulic investigation
26	Receptor	Raising doorway / access threshold	Yes	Yes	2	2	2	2	1	9	To be considered in a hydraulic investigation
27	Receptor	Planning policies to influence development (Development Control, SUDS Strategy, Blue Development Corridors, and New Development).	Yes	Yes	2	2	2	2	1	9	Implement SUDS on new Brownfield developments
28	Receptor	Temporary demountable flood defences	Yes	Yes	1	0	2	0	2	5	Potentially applicable.
29	Strategy	Further Study / Investigations	Yes	Yes	1	1	1	1	1	5	Detailed hydraulic investigation is required. Update ICM model to assist the investigation. Improved conveyance of surface water is the preferred conceptual option at this initial stage. Investigate culverts under Ancton Lodge Lane. It is considered these are currently at incorrect levels which is causing the siltation and surcharging upstream in the Lodge Close drainage system.

LFRZ_015 – Sea Way Middleton on Sea

Preferred Interventions: Asset Management, reduce surface water and infiltration entering public foul sewers, monitor performance.

Table 10-16 - LFRZ_015 Options

Option Ref.	Option Category (Source / Pathway / Receptor / Other)	Option	Potential	Considered	Economic	Environmental	Objectiveness	Social	Technical	Total Score	Summary of scheme / General discussion
2	**Do minimum**	Do minimum - continue current maintenance	Yes	Yes	2	2	0	2	1	7	
7	Source	Rainwater Harvesting	Yes	Yes	2	2	1	2	2	9	Installation of water butts in upstream catchment to reduce surface water runoff.
12	Source	Sealing of manhole covers and protecting gullies	Yes	Yes	1	2	2	2	1	8	Reduce surface water inflow.
13	Source	Sealing Sewers (Reduce ground water / rainfall induced infiltration)	Yes	Yes	1	2	2	2	0	7	
17	Pathway	Improved maintenance regimes	Yes	Yes	-2	0	2	0	2	2	Optimisation of existing assets
27	Receptor	Planning policies to influence development (Development Control, SUDS Strategy, Blue Development Corridors, and New Development).	Yes	Yes	2	2	2	2	1	9	Implement SUDS on new Brownfield developments
29	Strategy	Further Study / Investigations	Yes	Yes	1	1	1	1	1	5	Recommend a detailed hydraulic investigation is required to confirm appropriate actions. Update ICM model to assist the investigation. This will require the introduction of the recent improvement scheme implemented by residents.
30	Strategy	Survey, Advise & Monitoring	Yes	Yes	0	1	1	1	2	5	Monitor performance of the drainage to confirm success of recently installed hydraulic scheme.

LFRZ_016 – Golf Links Road, Felpham

Preferred Interventions: Asset Management.

Table 10-17 - LFRZ_016 Options

Option Ref.	Option Category (Source / Pathway / Receptor / Other)	Option	Potential	Considered	Economic	Environmental	Objectiveness	Social	Technical	Total Score	Summary of scheme / General discussion
2	**Do minimum**	Do minimum - continue current maintenance	Yes	Yes	2	2	0	2	1	7	
7	Source	Rainwater Harvesting	Yes	Yes	2	2	1	2	2	9	Installation of water butts in upstream catchment to reduce surface water runoff.
17	Pathway	Improved maintenance regimes	Yes	Yes	-2	0	2	0	2	2	optimisation of existing assets
27	Receptor	Planning policies to influence development (Development Control, SUDS Strategy, Blue Development Corridors, and New Development).	Yes	Yes	2	2	2	2	1	9	Implement SUDS on new brownfield developments
29	Strategy	Further Study / Investigations	Yes	Yes	1	1	1	1	1	5	Consider increased flood storage in golf course. Sizing of storage would require an independent analysis. Also consider desilting of existing ditches. EA main river study to consider this flood risk.

LFRZ_017 – Felpham Road, Felpham

Preferred Interventions: Asset management and increase surface water conveyance.

Table 10-18 - LFRZ_017 Options

Option Ref.	Option Category (Source / Pathway / Receptor / Other)	Option	Potential	Considered	Economic	Environmental	Objectiveness	Social	Technical	Total Score	Summary of scheme / General discussion
2	**Do minimum**	Do minimum - continue current maintenance	Yes	Yes	2	2	0	2	1	7	
7	Source	Rainwater Harvesting	Yes	Yes	2	2	1	2	2	9	Installation of water butts in upstream catchment to reduce surface water runoff.
15	Pathway	Increasing Capacity in Drainage System (Storage, Upsize)	Yes	Yes	0	0	2	0	2	4	Improve local conveyance of surface water. Investigate conveying surface water west through the upgrade of existing drainage assets. See figure 9.8.
17	Pathway	Improved maintenance regimes	Yes	Yes	-2	0	2	0	2	2	optimisation of existing assets
27	Receptor	Planning policies to influence development (Development Control, SUDS Strategy, Blue Development Corridors, and New Development).	Yes	Yes	2	2	2	2	1	9	Implement SUDS on new brownfield developments
29	Strategy	Further Study / Investigations	Yes	Yes	1	1	1	1	1	5	As per option 15. EA main river study to consider this flood risk.

LFRZ_017 – Felpham Road, Felpham (Cont.)

Increased Surface Water Conveyance

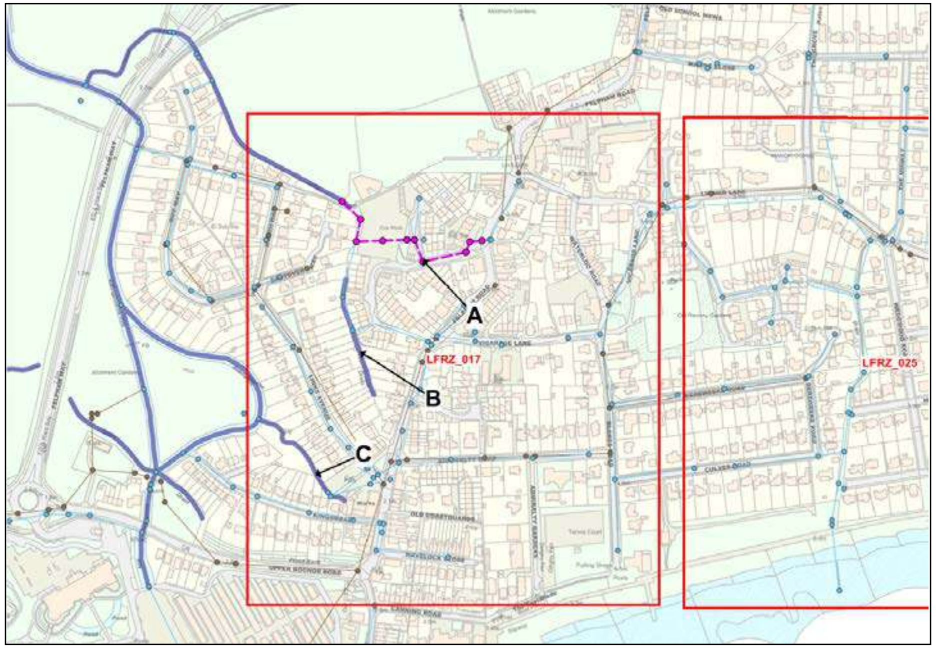
A: Upsize surface water drainage to the Rife

B: Clear and maintenance on ditch behind properties in Links Avenue

C: Clear and maintenance on ditch behind properties in Kingsmead

Note: This option has not been hydraulically modelled.

Figure 10.8 - Felpham Road, Felpham



LFRZ_018 – Oak Tree Lane, Woodgate

Preferred Interventions: Asset Management. Reduce surface water and infiltration entering public foul sewers. Improve surface water conveyance.

Table 10-19 - LFRZ_018 Options

Option Ref.	Option Category (Source / Pathway / Receptor / Other)	Option	Potential	Considered	Economic	Environmental	Objectiveness	Social	Technical	Total Score	Summary of scheme / General discussion
2	**Do minimum**	Do minimum - continue current maintenance	Yes	Yes	2	2	0	2	1	7	
7	Source	Rainwater Harvesting	Yes	Yes	2	2	1	2	2	9	Installation of water butts in upstream catchment.
12	Source	Sealing of manhole covers and protecting gullies	Yes	Yes	1	2	2	2	1	8	Reduce surface water inflow.
13	Source	Sealing Sewers (Reduce ground water / rainfall induced infiltration)	Yes	Yes	1	2	2	2	0	7	Reduce ground water inflows.
15	Pathway	Increasing Capacity in Drainage System (Storage, Upsize)	Yes	Yes	0	0	2	0	2	4	Investigate conveying surface water away from properties. This should be completed after survey of existing drainage assets. See figure 9.9.
17	Pathway	Improved maintenance regimes	Yes	Yes	-2	0	2	0	2	2	Optimisation of existing assets. WSCC and ADC are planning to clear the ditch on the west side of Lidsey Road
18	Pathway	Increase Gully Assets	Yes	Yes	0	0	2	1	2	5	This should be investigated to remove highway flooding.
22	Pathway	Separation of foul and surface water	Yes	Yes	0	2	2	0	0	4	Control at source see activities 12 & 13
24	Receptor	Improve resilience to flooding	Yes	Yes	2	2	2	2	1	9	To be considered in a hydraulic investigation.
26	Receptor	Raising doorway / access threshold	Yes	Yes	2	2	2	2	1	9	To be considered in a hydraulic investigation.
28	Receptor	Temporary demountable flood defences	Yes	Yes	1	0	2	0	2	5	Potentially applicable.
29	Strategy	Further Study / Investigations	Yes	Yes	1	1	1	1	1	5	Detailed hydraulic investigation is required. As detailed in Option 15.

LFRZ_018 – Oak Tree Lane, Woodgate (Cont.)

Increased Surface Water Conveyance

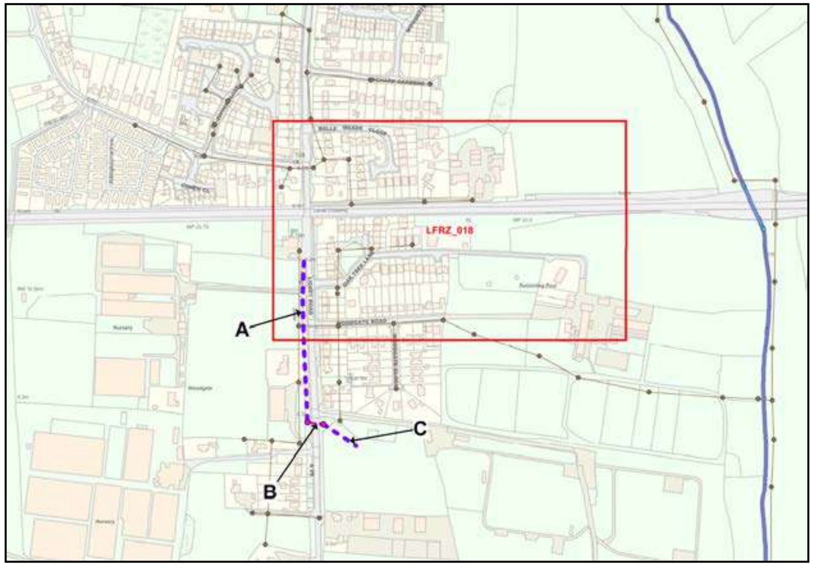
A: Improve / maintain existing ditch. The conveyance system upgrade may also need to extend further north to the level crossing as the hydraulic model indicates that surface water runoff is predicted to occur north of the railway line. Conveying surface water from Lidsey Road (north of railway crossing) to the south would require construction of a culvert. If practical this would be costly element of works.

B: New Culvert

C: Install new ditch to convey water to open green space

Note: This option has not been hydraulically modelled.

Figure 10.9 - Oak Tree Lane, Woodgate



WSCC and ADC are planning to clear the ditch on the west side of Lidsey Road and are investigating liaising with land owners to ensure capacity is available downstream of the highway ditch.

LFRZ_019 – Wandleys Lane, Eastergate

Preferred Interventions: Resilience and increase surface water conveyance

Table 10-20 - LFRZ_019 Options

Option Ref.	Option Category (Source / Pathway / Receptor / Other)	Option	Potential	Considered	Economic	Environmental	Objectiveness	Social	Technical	Total Score	Summary of scheme / General discussion
2	**Do minimum**	Do minimum - continue current maintenance	Yes	Yes	2	2	0	2	1	7	
4	Source	Detention Basins (Attenuation / Retention)	Yes	Yes	0	1	2	0	2	5	Consider with Option 15. See figure 9.10.
7	Source	Rainwater Harvesting	Yes	Yes	2	2	1	2	2	9	Installation of water butts in upstream catchment.
12	Source	Sealing of manhole covers and protecting gullies	Yes	Yes	1	2	2	2	1	8	Reduce surface water inflow. Improve performance downstream.
13	Source	Sealing Sewers (Reduce ground water / rainfall induced infiltration)	Yes	Yes	1	2	2	2	0	7	Reduce ground water inflows.
15	Pathway	Increasing Capacity in Drainage System (Storage, Upsize)	Yes	Yes	0	0	2	0	2	4	Investigate conveying and retaining surface water away from properties. This should be completed after survey of existing drainage assets. See figure 9.10.
17	Pathway	Improved maintenance regimes	Yes	Yes	-2	0	2	0	2	2	Optimisation of existing assets
18	Pathway	Increase Gully Assets	Yes	Yes	0	0	2	1	2	5	This should be investigated to remove highway flooding.
24	Receptor	Improve resilience to flooding	Yes	Yes	2	2	2	2	1	9	To be considered in a hydraulic investigation.
26	Receptor	Raising doorway / access threshold	Yes	Yes	2	2	2	2	1	9	To be considered in a hydraulic investigation.
28	Receptor	Temporary demountable flood defences	Yes	Yes	1	0	2	0	2	5	Potentially applicable.
29	Strategy	Further Study / Investigations	Yes	Yes	1	1	1	1	1	5	Detailed hydraulic investigation is required.

LFRZ_019 – Wandleys Lane, Eastergate (Cont.)

Increased Surface Water Conveyance and Retention

A: Install new ditch, lower road kerb to ditch. This ditch will either replace existing highway drainage pipe or will run onto of the existing pipe.

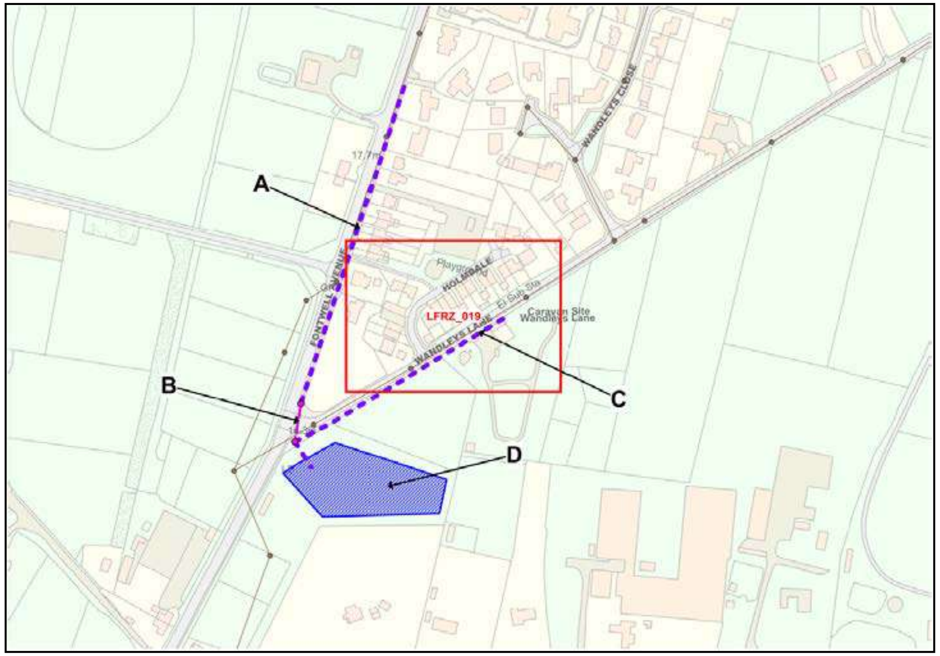
B: Install a new Culvert

C: Maintain existing ditches and install new ditch

D: Attenuation basin (Unsubstantiated volume).

Note: This option has not been hydraulically modelled.

Figure 10.10 - Wandleys Lane, Eastergate



LFRZ_020 – LFRZ_0020 - Highground Lane, Barnham

Preferred Interventions: Reduce surface water and infiltration entering public foul sewers.

Table 10-21 - LFRZ_020 Options

Option Ref.	Option Category (Source / Pathway / Receptor / Other)	Option	Potential	Considered	Economic	Environmental	Objectiveness	Social	Technical	Total Score	Summary of scheme / General discussion
2	**Do minimum**	Do minimum - continue current maintenance	Yes	Yes	2	2	0	2	1	7	
7	Source	Rainwater Harvesting	Yes	Yes	2	2	1	2	2	9	Installation of water butts in upstream catchment.
12	Source	Sealing of manhole covers and protecting gullies	Yes	Yes	1	2	2	2	1	8	Reduce surface water inflow.
13	Source	Sealing Sewers (Reduce ground water / rainfall induced infiltration)	Yes	Yes	1	2	2	2	0	7	Reduce ground water inflows.
22	Pathway	Separation of foul and surface water	Yes	Yes	0	2	2	0	0	4	Control at source; see activities 12 & 13.
27	Receptor	Planning policies to influence development (Development Control, SUDS Strategy, Blue Development Corridors, and New Development).	Yes	Yes	2	2	2	2	1	9	Ensure suitable development controls are placed on new developments in this LFRZ to reduce flood risk.
29	Strategy	Further Study / Investigations	Yes	Yes	1	1	1	1	1	5	As Option ref. 29 in Marshalls Close (LFRZ_021). Investigate the performance of the Marshalls Close overflow to improve its performance and capacity in foul sewer system.

LFRZ_021 – Marshalls Close / Church Lane, Barnham

Preferred Interventions: Planning activities; reduce surface water and infiltration entering public foul sewers.

Table 10-22 - LFRZ_021 Options

Option Ref.	Option Category (Source / Pathway / Receptor / Other)	Option	Potential	Considered	Economic	Environmental	Objectiveness	Social	Technical	Total Score	Summary of scheme / General discussion
2	**Do minimum**	Do minimum - continue current maintenance	Yes	Yes	2	2	0	2	1	7	
7	Source	Rainwater Harvesting	Yes	Yes	2	2	1	2	2	9	Installation of water butts in upstream catchment.
12	Source	Sealing of manhole covers and protecting gullies	Yes	Yes	1	2	2	2	1	8	Reduce surface water inflow.
13	Source	Sealing Sewers (Reduce ground water / rainfall induced infiltration)	Yes	Yes	1	2	2	2	0	7	Reduce ground water inflows.
22	Pathway	Separation of foul and surface water	Yes	Yes	0	2	2	0	0	4	Control at source; see activities 12 & 13.
27	Receptor	Planning policies to influence development (Development Control, SUDS Strategy, Blue Development Corridors, and New Development).	Yes	Yes	2	2	2	2	1	9	Ensure suitable development controls are placed on new developments in this LFRZ to reduce flood risk.
29	Strategy	Further Study / Investigations	Yes	Yes	1	1	1	1	1	5	Utilise available land upstream of Barnham to attenuate flows from main river. This should be investigated further within the EA River Modelling study. Investigate additional flood protection measures in Marshalls Close i.e. sealing floors and walls. Investigate maintenance / design improvements to the Marshalls Close CSO to improve its performance.

LFRZ_022 – Southdean Close, Middleton on Sea

Preferred Interventions: Asset management and flood Resilience.

Table 10-23 - LFRZ_022 Options

Option Ref.	Option Category (Source / Pathway / Receptor / Other)	Option	Potential	Considered	Economic	Environmental	Objectiveness	Social	Technical	Total Score	Summary of scheme / General discussion
2	**Do minimum**	Do minimum - continue current maintenance	Yes	Yes	2	2	0	2	1	7	
7	Source	Rainwater Harvesting	Yes	Yes	2	2	1	2	2	9	Installation of water butts in upstream catchment to reduce surface water runoff.
12	Source	Sealing of manhole covers and protecting gullies	Yes	Yes	1	2	2	2	1	8	Reduce surface water inflow.
15	Pathway	Increasing Capacity in Drainage System (Storage, Upsize)	Yes	Yes	0	0	2	0	2	4	Investigate conveying surface water away from affected area. This should be completed after survey of existing drainage assets. Consider connecting existing or new highway drainage system into the Rose Avenue storm system. The storm system may require upgrade to accommodate increased inflows.
17	Pathway	Improved maintenance regimes	Yes	Yes	-2	0	2	0	2	2	Optimisation of existing assets.
18	Pathway	Increase Gully Assets	Yes	Yes	0	0	2	1	2	5	This should be investigated to remove highway flooding.
24	Receptor	Improve resilience to flooding	Yes	Yes	2	2	2	2	1	9	To be considered in a hydraulic investigation.
26	Receptor	Raising doorway / access threshold	Yes	Yes	2	2	2	2	1	9	To be considered in a hydraulic investigation.
27	Receptor	Planning policies to influence development (Development Control, SUDS Strategy, Blue Development Corridors, and New Development).	Yes	Yes	2	2	2	2	1	9	Implement SUDS on new Brownfield developments.
28	Receptor	Temporary demountable flood defences	Yes	Yes	1	0	2	0	2	5	Potentially applicable.
29	Strategy	Further Study / Investigations	Yes	Yes	1	1	1	1	1	5	Detailed hydraulic investigation is required to confirm appropriate actions. Update ICM model to assist the investigation.

LFRZ_023 – Rudwicks Close, Broomcroft Road, The Loop, Jacken Close, Bramfield Road, Leverton Avenue, Limmer Lane (East End) Burley Road and Dryad Way in Felpham

Preferred Interventions: Asset Management and reduce surface water and infiltration entering public foul sewers.

Table 10-24 - LFRZ_023 Options

Option Ref.	Option Category (Source / Pathway / Receptor / Other)	Option	Potential	Considered	Economic	Environmental	Objectiveness	Social	Technical	Total Score	Summary of scheme / General discussion
2	**Do minimum**	Do minimum - continue current maintenance	Yes	Yes	2	2	0	2	1	7	
5	Source	Permeable Paving	Yes	Yes	0	1	1	0	2	4	High ground water, but considered to be worth investigating.
7	Source	Rainwater Harvesting	Yes	Yes	2	2	1	2	2	9	Installation of water butts in upstream catchment to reduce surface water runoff.
12	Source	Sealing of manhole covers and protecting gullies	Yes	Yes	1	2	2	2	1	8	Reduce surface water inflow.
15	Pathway	Increasing Capacity in Drainage System (Storage, Upsize)	Yes	Yes	0	0	2	0	2	4	Consider increasing capacity if optimisation of existing assets fails to reduce flood risk. See figure 9.11.
17	Pathway	Improved maintenance regimes	Yes	Yes	-2	0	2	0	2	2	Optimisation of existing assets.
27	Receptor	Planning policies to influence development (Development Control, SUDS Strategy, Blue Development Corridors, and New Development).	Yes	Yes	2	2	2	2	1	9	Implement SUDS on new Brownfield developments.
29	Strategy	Further Study / Investigations	Yes	Yes	1	1	1	1	1	5	Detailed hydraulic investigation is required to evaluate need for increased conveyance using the ICM model to assist the investigation.

LFRZ_023 – Rudwicks Close, Broomcroft Road, The Loop, Jacken Close, Bramfield Road, Leverton Avenue, Limmer Lane (East End) Burley Road and Dryad Way in Felpham

(Cont.)

Increased Surface Water Conveyance

(This area is subject to a separate investigation which will determine a hydraulic scheme)

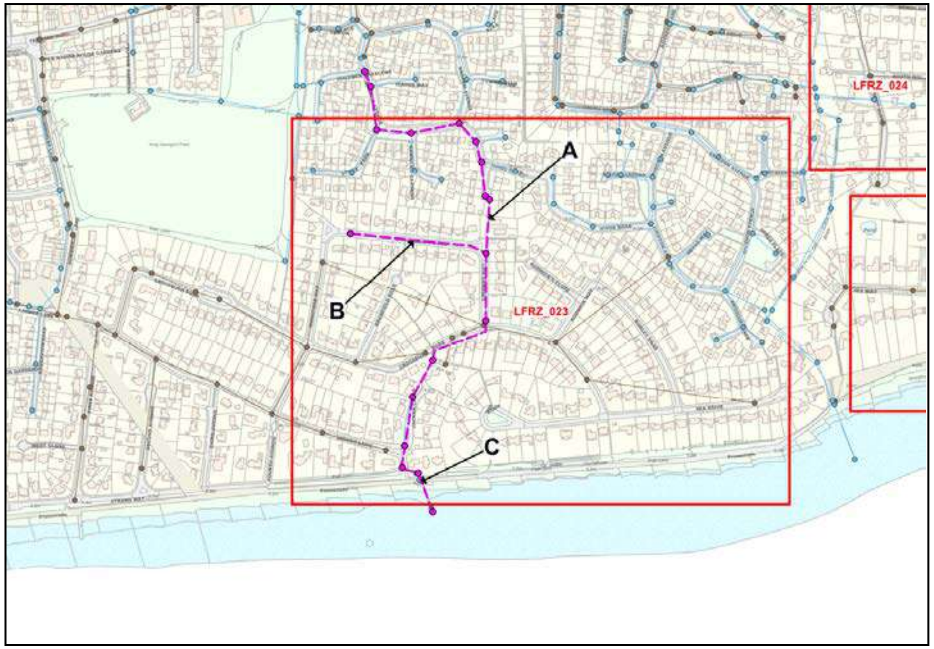
A: Upsize or reinforce surface water network.

B: Install new pipe. (size to be determined)

C: Provide ~ storage at downstream of network to protect against tidal locking or provide a pumped outfall

Note: This option has not been hydraulically modelled. There is potential to consider connecting the severed land drainage system from King Georges Field to pipe B. However, routing flows to this point would likely be prohibitive given the proximity of local properties. Consideration of connecting severed land drainage system in the loop to section A or C.

Figure 10.11 - Rudwicks Close, Broomcroft Road, The Loop, Jacken Close, Bramfield Road, Leverton Avenue, Limmer Lane (East End), Burley Road and Dryad Way in Felpham



LFRZ_024 – - West Close, Middleton on Sea

Preferred Interventions: Asset management and reduce surface water and infiltration entering public foul sewers.

Table 10-25 - LFRZ_024 Options

Option Ref.	Option Category (Source / Pathway / Receptor / Other)	Option	Potential	Considered	Economic	Environmental	Objectiveness	Social	Technical	Total Score	Summary of scheme / General discussion
2	**Do minimum**	Do minimum - continue current maintenance	Yes	Yes	2	2	0	2	1	7	
5	Source	Permeable Paving	Yes	Yes	0	1	1	0	2	4	High ground water, but considered to be worth investigating.
7	Source	Rainwater Harvesting	Yes	Yes	2	2	1	2	2	9	Installation of water butts in upstream catchment to reduce surface water runoff.
12	Source	Sealing of manhole covers and protecting gullies	Yes	Yes	1	2	2	2	1	8	Reduce surface water inflow.
13	Source	Sealing Sewers (Reduce ground water / rainfall induced infiltration)	Yes	Yes	1	2	2	2	0	7	
15	Pathway	Increasing Capacity in Drainage System (Storage, Upsize)	Yes	Yes	0	0	2	0	2	4	Consider increasing capacity if optimisation of existing assets fails to reduce flood risk. See figure 9.12.
17	Pathway	Improved maintenance regimes	Yes	Yes	-2	0	2	0	2	2	Optimisation of existing assets
24	Receptor	Improve resilience to flooding	Yes	Yes	2	2	2	2	1	9	This should be considered.
26	Receptor	Raising doorway / access threshold	Yes	Yes	2	2	2	2	1	9	This should be considered.
27	Receptor	Planning policies to influence development (Development Control, SUDS Strategy, Blue Development Corridors, and New Development).	Yes	Yes	2	2	2	2	1	9	Implement SUDS on new Brownfield developments
29	Strategy	Further Study / Investigations	Yes	Yes	1	1	1	1	1	5	Detailed hydraulic investigation is required to evaluate need for increased conveyance using the ICM model to assist the investigation.
30	Strategy	Survey, Advise & Monitoring	Yes	Yes	0	1	1	1	2	5	Survey surface water drainage assets.

LFRZ_024 – West Close, Middleton on Sea (Cont.)

Increased Surface Water Conveyance

A: Install new surface water collection system

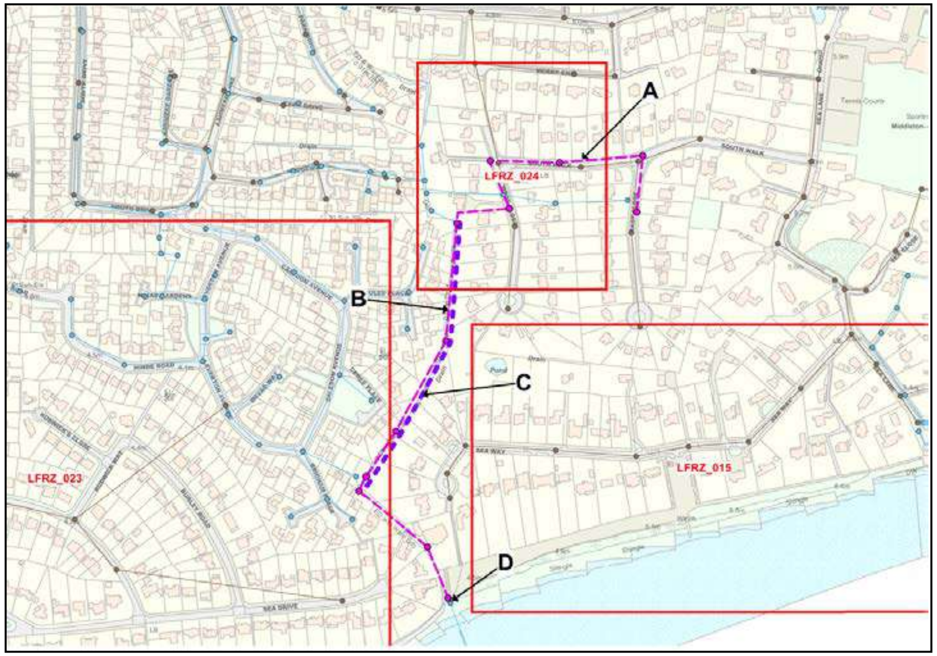
B: Upgrade existing surface water network to the coast

C: Clear / maintain ditch system

D: Pumped outfall during tidal locking

Note: This option has not been hydraulically modelled.

Figure 10.12 - West Close, Middleton on Sea



LFRZ_025 – Limmer Lane, Felpham

Preferred Interventions: Asset Management. Reduce surface water and infiltration entering public foul sewers. Increase surface water conveyance.

Table 10-26 - LFRZ_025 Options

Option Ref.	Option Category (Source / Pathway / Receptor / Other)	Option	Potential	Considered	Economic	Environmental	Objectiveness	Social	Technical	Total Score	Summary of scheme / General discussion
2	**Do minimum**	Do minimum - continue current maintenance	Yes	Yes	2	2	0	2	1	7	
5	Source	Permeable Paving	Yes	Yes	0	1	1	0	2	4	High ground water, but considered to be worth investigating.
7	Source	Rainwater Harvesting	Yes	Yes	2	2	1	2	2	9	Installation of water butts in upstream catchment to reduce surface water runoff.
12	Source	Sealing of manhole covers and protecting gullies	Yes	Yes	1	2	2	2	1	8	Reduce surface water inflow.
13	Source	Sealing Sewers (Reduce ground water / rainfall induced infiltration)	Yes	Yes	1	2	2	2	0	7	
15	Pathway	Increasing Capacity in Drainage System (Storage, Upsize)	Yes	Yes	0	0	2	0	2	4	Consider increasing capacity if optimisation of existing assets fails to reduce flood risk. See figure 9.13.
17	Pathway	Improved maintenance regimes	Yes	Yes	-2	0	2	0	2	2	Optimisation of existing assets
24	Receptor	Improve resilience to flooding	Yes	Yes	2	2	2	2	1	9	This should be considered.
26	Receptor	Raising doorway / access threshold	Yes	Yes	2	2	2	2	1	9	This should be considered.
27	Receptor	Planning policies to influence development (Development Control, SUDS Strategy, Blue Development Corridors, and New Development).	Yes	Yes	2	2	2	2	1	9	Implement SUDS on new Brownfield developments
29	Strategy	Further Study / Investigations	Yes	Yes	1	1	1	1	1	5	Detailed hydraulic investigation is required to evaluate need for increased conveyance using the ICM model to assist the investigation.
30	Strategy	Survey, Advise & Monitoring	Yes	Yes	0	1	1	1	2	5	Survey surface water drainage assets.

LFRZ_025 – Limmer Lane, Felpham

Increased Surface Water Conveyance

(This area is subject to a separate investigation which will determine a hydraulic scheme)

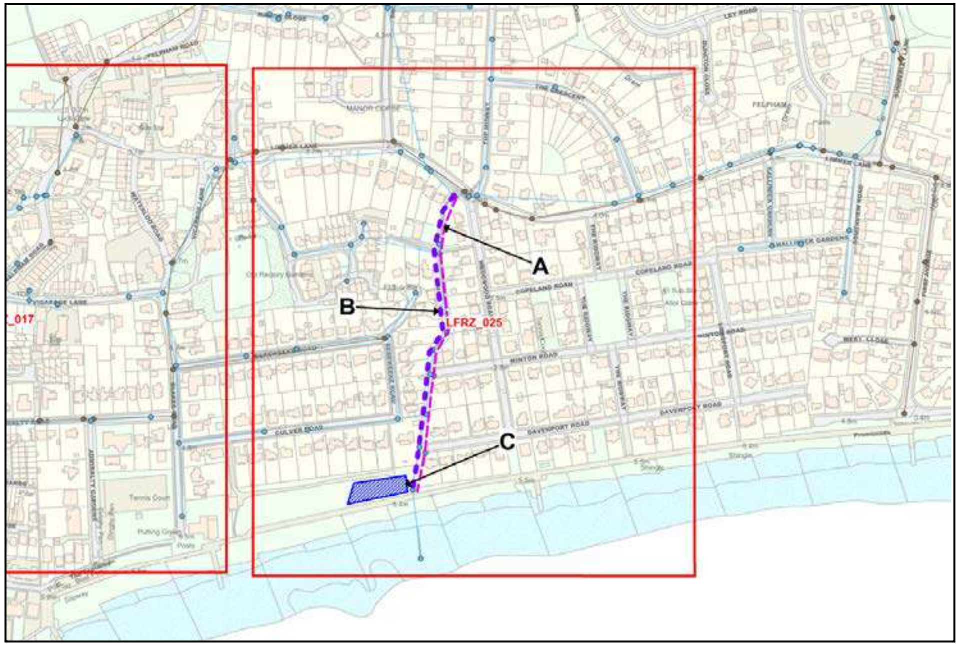
A: Upsize surface water network (size to be determined)

B: Install new sewer either running a parallel or upgrade existing surface water sewer.

C: Provide ~ storage at downstream of network to protect against tidal locking or provide a new pumping station to pump outfall during tide locking.

Note: This option has not been hydraulically modelled.

Figure 10.13 - Limmer Lane, Felpham



LFRZ_026 – Eastergate Lane, Eastergate

Preferred Interventions: Planning activities and asset management.

Table 10-27 - LFRZ_026 Options

Option Ref.	Option Category (Source / Pathway / Receptor / Other)	Option	Potential	Considered	Economic	Environmental	Objectiveness	Social	Technical	Total Score	Summary of scheme / General discussion
2	**Do minimum**	Do minimum - continue current maintenance	Yes	Yes	2	2	0	2	1	7	
17	Pathway	Improved maintenance regimes	Yes	Yes	-2	0	2	0	2	2	Clear drainage ditches. CCTV culverts
18	Pathway	Increase Gully Assets	Yes	Yes	-2	0	2	1	2	3	Install large gully on highway drainage system

LFRZ_027 – Downsview Road, Barnham

Preferred Interventions: Planning activities and asset management.

Table 10-28 - LFRZ_027 Options

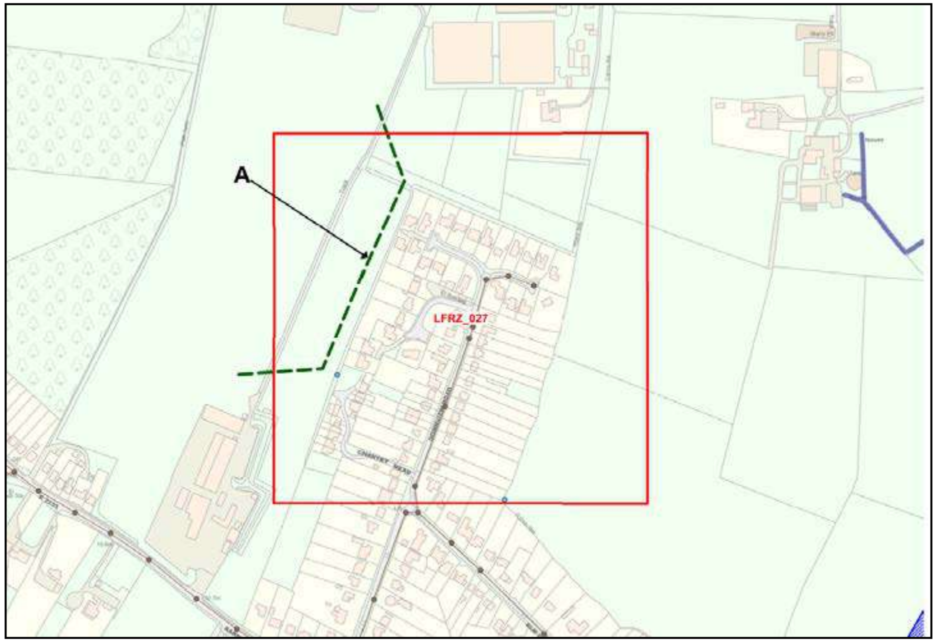
Option Ref.	Option Category (Source / Pathway / Receptor / Other)	Option	Potential	Considered	Economic	Environmental	Objectiveness	Social	Technical	Total Score	Summary of scheme / General discussion
2	**Do minimum**	Do minimum - continue current maintenance	Yes	Yes	2	2	0	2	1	7	
4	Source	Detention Basins (Attenuation / Retention)	Yes	Yes	0	1	2	0	2	5	Investigate reducing runoff from the fields to the west. Retain surface water within the fields to the west of Downsview Road. See figure 9.14.
12	Source	Sealing of manhole covers and protecting gullies	Yes	Yes	1	2	2	2	1	8	Reduce surface water inflow.
13	Source	Sealing Sewers (Reduce ground water / rainfall induced infiltration)	Yes	Yes	1	2	2	2	0	7	Reduce ground water inflows.
15	Pathway	Increasing Capacity in Drainage System (Storage, Upsize)	Yes	Yes	0	0	2	0	2	4	store surface water
17	Pathway	Improved maintenance regimes	Yes	Yes	-2	0	2	0	2	2	Clear drainage ditches
27	Receptor	Planning policies to influence development (Development Control, SUDS Strategy, Blue Development Corridors, and New Development).	Yes	Yes	2	2	2	2	1	9	Ensure suitable development controls are placed on new developments in this LFRZ to reduce flood risk.

LFRZ_027 – Downsview Road, Barnham

Attenuation

A: Install an 80m long, 0.7m high Bund

Figure 10.14 - Downsview Road, Barnham



10.3. Public Sewer Infiltration Reduction

10.3.1. Sewer Rehabilitation Process

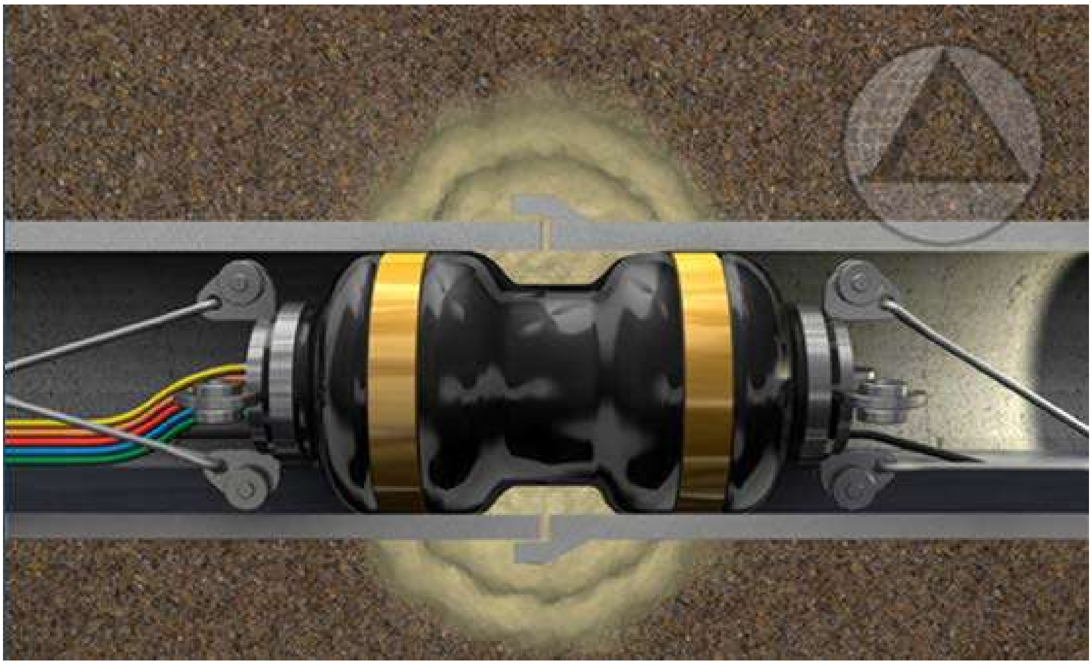
As discussed in Section 4.7.4 opportunities have been identified to reduce clear water inflows entering into the public sewer system from infiltration. An appraisal of approaches to reduce the extent of infiltration is discussed in this section.

Infiltration into sewers in the Lidsey Catchment can be addressed in a number of ways. In general it is better to avoid excavation and replacement, although there are instances where this is the only method of stopping infiltration. The fact that there is infiltration is indicative of the sewer being below the water table. Excavations are therefore likely to require extensive de-watering depending on local ground conditions and rainfall. Furthermore it is highly likely that the ground will be unstable and a greater level of support will be required to sides of excavated trenches. However in cases where the water table fluctuates and drops below the level of the sewer in the summer months excavation and replacement would be a viable prospect during this period of time.

With respect to no dig methods, these fall into two basic types for smaller non man entry sewers. Relining either isolated sections or the whole sewer or sealing of points of infiltration.

A large proportion of infiltration occurs through defective joints in what appears to be a structurally sound sewer. In this case pressure sealing the joints has been the most widely used method. This technique involves isolating a joint usually with a two ended inflatable packer and pumping the sealant into the space between the two inflated sections. The sealant is forced through the joint and into the surrounding ground sealing the joint against infiltration as shown in Figure 9.15. Sealants are typically cement based compounds or polymer resin based compounds.

Figure 10.15 - Sewer Joint Sealing Packer

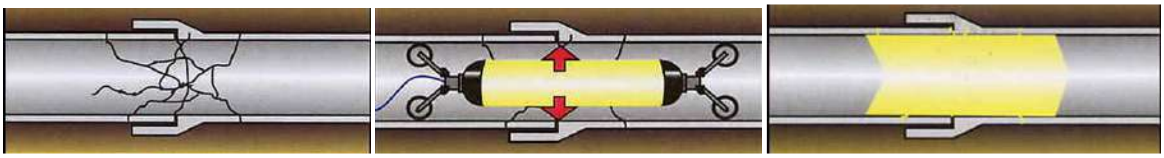


Joint sealing is generally faster and costs less than relining. There have however been some issues regarding the longevity of this form of repair. Subsequent ground movement can damage the seal compromising its integrity causing the infiltration to return. There has also been an issue with some of the older sealants when used where the level of the water table fluctuates. If the water table dropped in the summer months below the level of the sewer; the sealing compound would shrink when it dried and not re-expand when the water table rose again in the winter. This could also cause the infiltration to return. Newer products on the market claim that this no longer happens. There is anecdotal evidence that joint sealing was carried out on a number of sewers in the Lidsey Catchment approximately 25 years ago and the infiltration has returned in these sewers. Experience has shown that 30% of the joints in a given length of sewer will fail.

As discussed the other standard method of preventing infiltration is relining either isolated sections of the sewer where infiltration is occurring; or the whole sewer. Patch liners are the most common method of relining isolated sections of sewers. These tend to be used where there is infiltration through a very small number of joints relative to the length of sewer or, more commonly, where the infiltration is through a structural defect such as a hole or break. In the case of infiltration through structural defects, the patch liner not only seals the infiltration but also strengthens the sewer where its structural integrity has been compromised.

The process is fairly straight forward. A section of glass mat is cut to a dimension that is sufficient to cover the internal circumference of the sewer. The glass mat is then soaked (impregnated) with a polymer resin and wrapped around an inflatable packer. The packer is then towed or pushed into the position of the damaged section of sewer and inflated to make full contact the inner wall of the sewer. Once the resin has hardened the packer is deflated and removed leaving the resin impregnated glass mat stuck to the wall of the sewer. The process is illustrated in Figure 9.16. The most commonly used resins are silicate resins which are also hydrophobic thus repelling the water.

Figure 10.16 - The Patch Lining Process



The cost of patch lining is greater than joint sealing hence its limited use. Furthermore it is often the case that if one area of infiltration is sealed in a sewer another area of infiltration will occur at the next weakest point. This would result in installing further patch liners which could become very expensive.

Where infiltration occurs along a large proportion of a sewer it is more economically viable to reline the entire length. This has several advantages, the first being that the entire sewer is sealed with a new continuous pipe so no further infiltration can occur. The second is that it will strengthen any structurally defective sewers and guard against any future structural deterioration. The process of installation is as follows. A tube, with an outer circumference equal to the inner circumference of the sewer is soaked (impregnated) with resin. The tube is typically constructed from a plastic coated felt however materials such as glass mat and plastic coated woven fibres are also used. The impregnated tube is then inserted into the sewer by inverting it, which a process where the liner is turned inside out through the sewer by either air pressure or water pressure. The liner is then inflated to create a close fit with the inner wall of the sewer and the resin allowed to harden. When the resin has hardened (cured). The ends of the liner are cut off to allow flow through the sewer and any connections onto the sewer are re-opened by a robotic cutter. Figure 9.17 gives an indication of the process using an inversion drum.

Figure 10.17 - Overview of Sewer Relining

This method is relatively expensive as the entire length of the sewer needs to be relined irrespective of the location of the infiltration. The flows in the sewer need to be diverted during the installation process and the sewer needs to be thoroughly cleaned prior to installation. Not all types of liner are suitable for infiltration. Liners using polyester resin tend to slightly shrink after installation leaving a small annulus between the inner wall of the sewer and the liner through which water can pass and enter the sewer. This would require further sealing around the manholes and connections. Liners using epoxy resins do not suffer from this problem however the resin is more expensive. There is also higher risk of failure during installation.

10.3.2. Sewer Rehabilitation Optioneering Approaches

When considering the options a number of factors need to be taken into consideration. Cost is a prime consideration in relation to the benefit. Coupled with this is the expected lifespan of any solution as well as risk. Table 9.29 summarises these factors basing the costs on a total sewer length of 69.2km suggested for survey from the I&I investigation. This does not include for rehabilitation of private sewer/drain lengths. Given drainage records associated to private sewers are not available it is not possible to realistically place an estimate on private drainage improvements. As such this should be allowed for in future planning / budgets.

Table 10-29 - Comparison of No Dig Methods

Method of Repair	Estimated Percentage of Sewer Requiring Repair	Budget Cost / Metre	Total Budget Cost	Comment
Joint Sealing	30%	£250.00	£5.52M	Fast method of repair with minimal disruption. Low risk installation Possible longevity issues. Resin usage is unknown with a potential for costs to escalate if large quantities of resin are required.
Patch Lining	30%	£700.00	£14.7M	Fairly fast installation time with little disruption. Provides structural support to defective sewers. Long effective lifespan. Relatively low risk installation. Cost prohibitive.
Full Length Lining	100%	£130.00	£9.1M	Permanent long term solution if the correct resin is selected. Provides structural support for defective sewers. Relatively expensive. More ancillary works required for installation. Higher risk of failure during installation compared to other methods.

In reality a more measured and strategic approach would be recommended compared to the blanket approach outlined in Table 9.29. In the first instance it is recommended that all sewers that are permanently below the water table, and experience a constant external hydrostatic pressure head greater than 1.5m are relined. This will address the most significant infiltration and ensure that there is no future infiltration entering the public sewer system at these locations. The hydrostatic pressure head of 1.5m has been taken from Section 1.3.26 of Technical Guidance Document H of the 1997 Building Regulations that states that sewers up to 300mm diameter should withstand a hydrostatic head of 1.5m when undergoing a water test for leak tightness. Sewers that spend part of the year below the water table and at some point in the year experience external hydrostatic pressure head greater than 1.5m; should also be considered for relining.

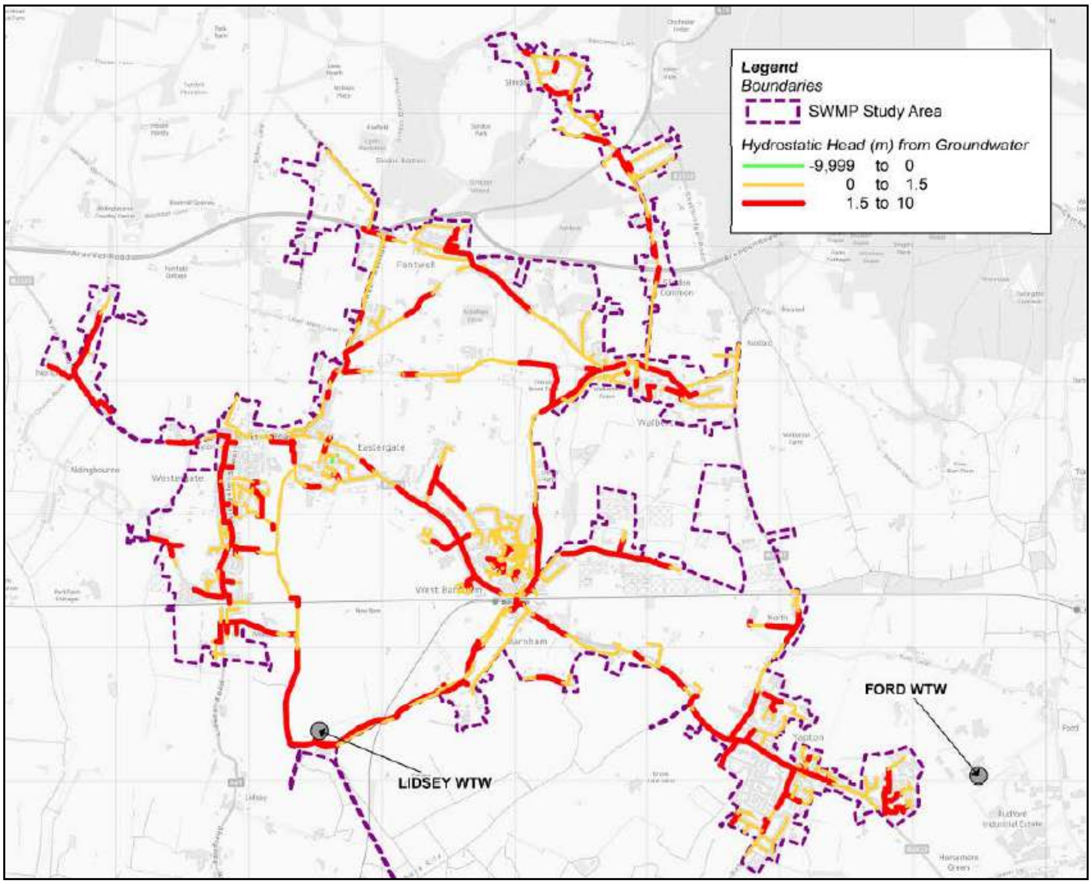
An assessment was carried out to find which sewers in the study area experience the greatest pressure head from ground water. Using borehole data taken from the Barn Rise boreholes for the period 2010-2011, a winter maximum and a summer minimum ground water level was taken. The freeboard of these to the ground level at the borehole location was applied across the study area, based on topography. This allowed an assessment of ground water levels across the catchment.

Approximately 5.3km of sewers have been identified as having a constant external hydrostatic pressure head greater than 1.5m (these experience over 1.5 m head ever during the summer months); and 26km of sewers have been identified as having an external hydrostatic head greater than 1.5m during the winter months only.

Figure 9.18 shows the Hydrostatic Pressure head above all sewers during a Winter Condition. This represents the worst-case sewers susceptible to infiltration, as they are under a persistent hydrostatic pressure head of greater than 1.5 m. Figure 9.19 represents the greatest hydrostatic pressure head that can potentially affect sewers in the study area – a winter condition ground water level.

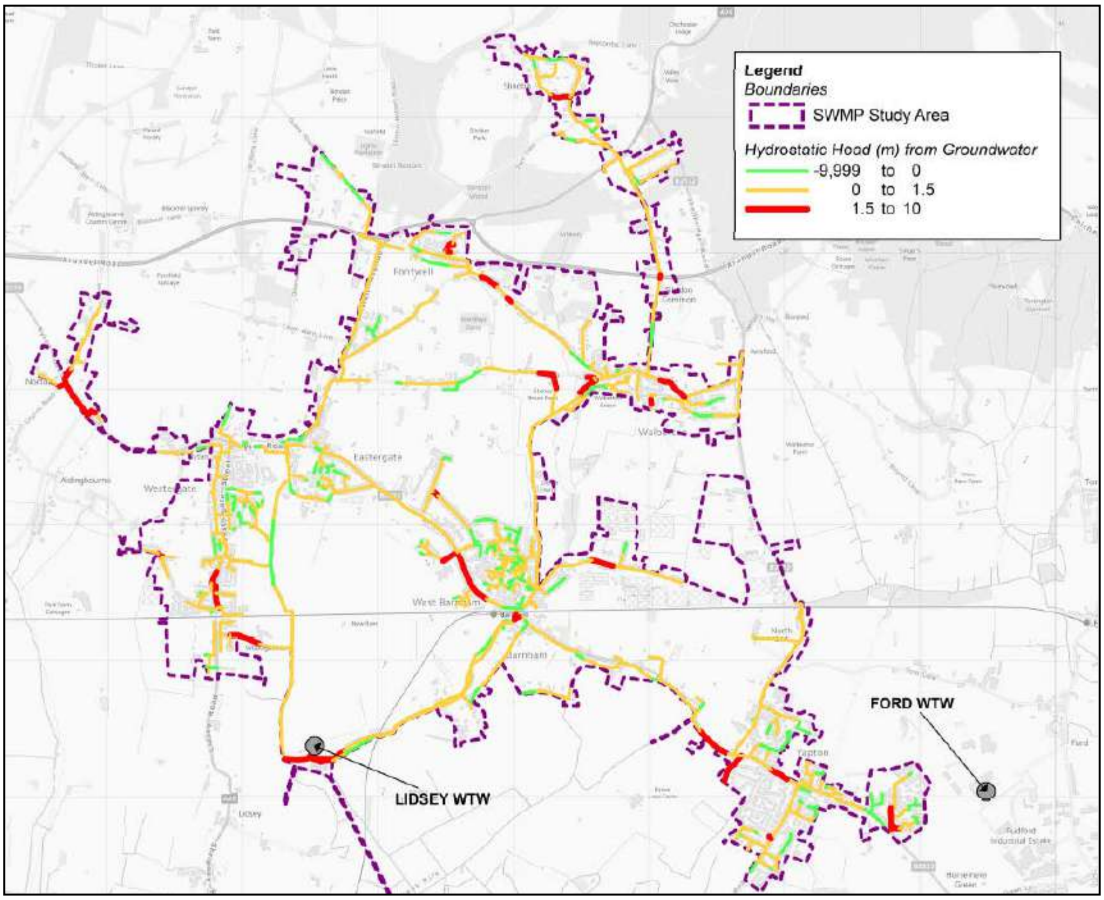
Investigations are recommended to assess sewers outside of the preceding categories to determine whether these have any infiltration. These investigations should be carried out when it is predicted that the water table will be at its highest. An appropriate method of repair can then be selected subject to the extent of the infiltration and whether the condition of the sewer is likely to deteriorate. Sewers that are permanently above the water table should not suffer from infiltration however water may find its way into the sewer during flooding through the manhole and cover. Manhole sealing and watertight covers should be considered to prevent this, as discussed in Section 4.7.4. It is, however, unlikely that the sewer will have infiltration as probably will be insufficient hydrostatic pressure.

Figure 10.18 - Winter Ground water head above pipe inverts.



Note: Assumes static freeboard from ground level to water table across catchment from Barn Rise Borehole.

Figure 10.19 - Summer Ground water head above pipe inverts.



Note: Assumes static freeboard from ground level to water table across catchment from Barn Rise Borehole.

Table 10-30 - Strategic 'No Dig' Rehabilitation

Method of Repair	Length (km)	Budget Cost / L Metre	Total Budget Cost (£M)
Lining Critical sewers with persistent >1.5m head from ground water	5.3	£130.00	£0.69M
Lining Critical sewers with potential >1.5m head from ground water	26	£130.00	£3.38M

Funding for such works would be required from SWS. No specific funding for the work outlined above has been allocated at this stage. However, the analysis conducted does provide SWS with further information on the level of investment potentially required to reduce ground water infiltration entering the public sewer system in the study area.

It is worth noting that every five years, the regulator Ofwat sets the level of customers' bills, which helps fund the improvements SWS carries out to the water and sewerage networks. Ofwat seeks to ensure bills are no higher than necessary by checking that these improvements represent good value for money. SWS is therefore required to demonstrate that the flood relief schemes or interventions (such as detailed above) included in its planned work have been subject to a cost benefit analysis. SWS also needs to demonstrate they have taken account of the results from research carried out with customers to see how much they were willing to pay in their bills for flood protection improvements. The same process is used by all water companies to help prioritise planned work across England, in a process supported by the Consumer Council for Water. These factors will have a bearing what type of investment SWS are able to commit to this particular issue in the future.

There will a residual risk of infiltration entering through private laterals. As such, cooperation with private sewers owners connecting into the public sewers showing evidence of infiltration will be required to remove or reduce infiltration at these locations. SW do not have powers it’s the EHO of ADC who can serve notice

10.4. Future Development - Impact

Within the Lidsey SWMP study area there is a significant proposed housing development site in Barnham / Eastergate / Westergate for 2,004 properties which is proposed for completion by 2028-2029 as detailed in the Local Plan. It is projected that the first 167 housing units shall be completed in 2017-2018 and then 167 housing units will continue to be completed each subsequent year up to 2028-2029.

It is recognised by residents, stakeholder and Partners that introducing increased flows into the public sewer system in its current state will not be a viable proposition. It has been confirmed that the additional inflow from 2,004 properties would exacerbate flooding from the foul sewer system during periods of high ground water and excess clear water inflows. The integrated model predicts flooding will increase by 7,080 m^3 for a 1 in 30 year storm event (1440 minute critical duration). Given the predicted deterioration in the system performance with the addition of 93 l/s (Design flow 6DWF) foul flow from the development (based on the current Sewers For Adoption rate of 4,000 litres/property a day) it is recommended that an independent growth study is completed to review the full impact that the development would have on the Lidsey Wastewater catchment and assess how best to cater for future additional foul flows.

Within the SWMP analysis it is assumed that all surface water runoff generated from the development site will be limited to the stipulated greenfield runoff rates and discharge to watercourses and/or ground, where soakage is viable (i.e. suitable ground conditions / water table levels)..

10.5. Future Development – Strategic Options

Given the concerns raised by residents the SWMP Partners requested that a review of potential options was conducted and included within the SWMP to cater for these additional foul flows. These options are discussed in Table 9.31 and should be considered further in a separate growth study for the catchment.

Table 10-31 - Growth Options

Option Description	Broad Cost (£k)	Comments / Issues
Conduct sewer rehabilitation on the existing Lidsey Wastewater Network and make hydraulic upgrades to enable the additional foul flows from the development site can be accommodated into the Lidsey WTWs. It is understood there is some process headroom currently available at the WTWs.	-	Sewer rehabilitation will not provide adequate reduction in foul flows to permit all foul flows from the development to enter the Lidsey WTW catchment. Further upgrades will be required.
Construct a new 375 mm diameter 1.7 km long sewer draining the development to Lidsey WTW.	£450k	Note no costs included for upgrade of Lidsey WTW to accept additional flows from the development.
Construct a new 375 mm diameter 1.7 km long sewer serving the development to a new pumping station. Flows are pumped from the new pumping station and connecting rising main to Ford WTW 4.9 km to the east.	£1,800k	Note no costs included for upgrade of Ford WTW to accept additional flows from the development.

Funding for these upgrades and improvements would need to be sought from multiple funding mechanisms.

10.6. Future Development – Practical Guidance for New Drainage

Practical measures to reduce the potential adverse impacts of development on drainage systems have been prepared specifically to the catchment conditions associated with the Lidsey SWMP study area. Information detailed below should be considered by developers to reduce susceptibility of ground water and surface water entering the foul drainage system.

Table 10-32 - Practical Guidance for New Development

Reasons	Practical measures
Adequate and sustainable surface water drainage.	No surface water connections to the wastewater system. (See part H of the Building Regulations)
Guard against further ground water infiltration into the foul drains or sewers serving the development.	The use of fusion jointed MDPE pipes can prevent ground water infiltration and require a minimum of maintenance. The use of mass concrete surrounds to inspection chambers and manholes can prevent infiltration and require a minimum of maintenance.
Guard against surface floodwaters entering the foul system serving the development.	Overland surface water flow routes should be provided for flows greater than those for which pipelines and culverts have been designed. Wherever possible, foul sewer routes, manhole covers, sink waste gullies, etc. should avoid overland surface water flow routes and any areas where surface water ponding may occur. Failing that they should be sealed against potential surface water inflows. Any sink waste gullies in areas of potential surface water inundation should be sealed or defended by raised brickwork or similar. Bolt down sealed inspection chamber and manhole covers should be used in areas of potential surface water inundation. Raising the level of the development above the highways which serve it can protect buildings and their drainage systems from potential surface water inundation. However, care should be taken at local low spots in the highway where overland surface water flows may gather and overflow onto properties.
Protect the properties from foul flooding or unusable sanitation should the public sewerage system surcharge.	Part H of the Building Regulations contains suitable practical measures. However, the provision of an external gully is inappropriate where there is a risk of surface water flooding. In these circumstances, non-return valves are more appropriate. Dirgo or similar non-return air valves are now commonly fitted to soil vent pipes thereby allowing them to allow them to vent within the building. This practice can lead to problems with bubbling WCs, the blow out of U bend traps and odour within buildings when the sewerage system surcharges. The use of traditional external vent pipes without air valves can prevent this.

Vacuum Sewer Systems - In addition to the approaches outlined above given the high ground water and soils conditions in the catchment utilisation of vacuum drainage system may be an appropriate method of reducing the risk of clear water inflows entering new drainage systems through infiltration. Large vacuum drainage systems with numerous collection chambers can benefit from a remote monitoring of the vacuum valves and sump pits. Such systems allow much faster trouble shooting and easier preventive maintenance of collection chambers and valves. Such, monitoring systems are optional systems and not required for operation of vacuum sewer systems. If managed effectively, vacuum sewer systems should be free of exfiltration and infiltration issues. However there a number of further considerations with the vacuum drainage system which should be highlighted. These include:

- The cost of installing, maintaining and running this types of drainage system are more expensive than traditional gravity systems

- Specialist training maybe be required to maintain the system if it were to be adopted by the sewerage undertaker (SWS).
- Vacuum valves can get stuck open leading to pressure drops in the entire system.
- Excessive inflows, over that which has been designed, entering the vacuum system can lead to a hydraulic block in the system.
- Failure of the private drain leading to infiltration.
- Connection of surface water runoff when properties have flooding issues.

11. Phase 4 – Implementation and Review

11.1. Introduction

Phase 4 of the SWMP relates to the Implementation and Review of the action plan as outlined in Figure 10.1.

Figure 11.1 - Phase 4 of the SWMP process

Following the completion of the SWMP, actions identified will need to be implemented. This will require continued work with WSCC and the steering group Partners (ADC, EA, SWS) and the Stakeholders. WSCC should coordinate and engage with internal and external Partners in order to ensure a holistic approach to implementation of actions and outputs. Key Local Authority Partners would probably include WSCC - Emergency Planners, WSCC - Highways department, WSCC - Planning Policy, ADC - Emergency Planning, ADC – Engineering, ADC – Planning, EA and SWS. The outputs from the SWMP should be used where considered appropriate to inform future plans and policies.

11.2. Action Plan

The Action Plan details a range of recommended measures to better manage surface water within the study area and wider region. The action plan details responsibilities and assigns a lead partner to look after specific actions. The Action plan provides details of each item and timescale.

Within the Action Plan there are general measures that could be implemented across the wider region. These are generally non-structural and focus on Planning, Management and Engagement. These are set out in the strategic Opportunities sections 10.2.1, 10.2.2 and 10.2.3.

An assessment of Options and associated Partner Actions for each of the LFRZ has been prepared and is detailed in section 10.2.4. It is recommended that actions listed for each LFRZ are ranked against the relative flood risk impact of the Local Flood Risk Zones as detailed in Section 7.6.

All Partners are committed to progress with the actions based on suitable strategic prioritisation within their respective organizations.

11.2.1. Strategic Opportunities – Planning

Action		Responsible		Benefits	Timeline
		Lead	Support		
Planning	**SO Action 1 - Planning Policy** - Prepare planning policy to prevent and reduce surface water runoff from entering the combined and foul sewer system through the adoption of SUDs techniques.	ADC / WSCC - *planning*	WSCC & SWS	Reduction in flood risk. Provides headroom for additional foul loads (as part of population growth) in the combined system thereby reducing pressure on Southern Water's sewer network. Supports the enhancement of "green corridors" and thus the social and aesthetic qualities of the Lidsey Catchment.	For inclusion in next draft of the Local Plan.
	SO Action 2 - Drainage Design - Recommend integration of the principals detailed in the "Practical measures to reduce the potential adverse impacts of development" issued by SWS May 2012 are given to developers. As detailed in Table 9-32- Practical Guidance for New Development	ADC / WSCC - planning	WSCC & SWS	Reduce inflow from ground water and surface water into the public foul sewer system.	To be considered within the SUDS Approval Body (SAB) process.
	SO Action 3 - Hydraulic Capacity - Ensure both tidal locking does not affect and capacity is available downstream to receive new / refurbished drainage from the Local Flood Risk Zones (LFRZ).	WSCC	WSCC & SWS	Reduction in flood and water quality risk. Considered drainage designs prepared for new / refurbished developments.	For inclusion in the Local Plan and policy for inclusion in the next draft of the Local Plan.
	SO Action 4 - Positive Drainage - Positively drain coastal frontage development to the sea where practical without compromising existing / future flood risk. These opportunities will be limited given the relatively low topography on the coastal catchment fringe.	WSCC	WSCC & ADC - *planning*	Reduction in flood and water quality risk. Provides headroom for additional foul loads (as part of population growth) in the combined system thereby reducing pressure on Southern Water's sewer network.	For inclusion in the Infrastructure Delivery Plan which will support the Local Plan and policy for inclusion in the next draft of the Local Plan.
	SO Action 5 - Planning - Utilise the Flood / Hazard Maps presented in the SWMP to ensure suitable planning control is implemented within the Lidsey SWMP study area in areas prone to flooding. Refer to Appendix A - Plan 7, 8 and 9 for a 1 in 30, 1 in 100 and 1 in 1000 return period flood hazard plans. In addition, Appendix A – Plan 10, 11 and 12 provides plans of the predicted flood depths for a 1 in 30, 1 in 100 and 1 in 1000 return period.	ADC - Planning	WSCC & ADC	Reduce future flood risk.	On-going. To be considered in future updates to the SFRA.
	SO Action 6 - Investigate the feasibility of proposed developments in urban areas at risk of flooding in Local Flood Risk Zones (LFRZs).s.	ADC / WSCC	ADC - Planning	Mid-long term reduction in the probability of flooding	On-going

Action		Responsible		Benefits	Timeline
		Lead	Support		
Planning	**SO Action 7 -** Use SWMP mapped outputs to require developers in areas at risk of flooding to demonstrate compliance with NPPF to ensure development will remain safe and will not increase risk to others, where necessary supported by more detailed integrated hydraulic modelling.	WSCC / ADC - Planning	EA / SWS / ADC	Reduction in consequences of flooding	On-going
	SO Action 8 - Ensure any development falling within the rural/open space plots are designed to limit runoff to low predevelopment Greenfield runoff rates.	WSCC / ADC	EA	Reduction in consequences of flooding	Annually
	SO Action 9 - Carry out more detailed studies including further investigation of the technical issues and consultation with local Stakeholders	WSCC	EA / SWS / ADC	Identify mitigation and hydraulic solutions.	Undertake investigations based on LFRZ prioritisation

11.2.2. Strategic Opportunities – Management

Action (no.)		Responsible		Benefits	Timeline
		Lead	Support		
Management	**SO Action 10 - Maintenance** (Asset Management) - Southern Water and WSCC to co-ordinate maintenance on drainage systems – enforcing maintenance schedules on new / refurbished drainage.	ADC (Ordinary Watercourses), EA (IDB) (Main River), WSCC (Highway), SWS (Public Sewers)	All	Reduction in the risk of flood and water quality issues being caused by blockage and operational issues stemming from poor maintenance.	On-going
	SO Action 11 - ICM Model Maintenance - Partners are to adopt the InfoWorks ICM model for all future flood and water quality management in Lidsey SWMP area enhancing where and when required. The SWMP hydraulic model should be updated with the verified river model components which shall be produced from the EA River Study in 2014 / 2015.	EA	SWS, EA, ADC	Robust and co-ordinated approach to managing surface water (flood and water quality risk). Cost efficiencies for all Partners.	2014 / 2015
	SO Action 12 - Asset Register - Enhance and develop the Flood Asset Register.	WSCC	WSCC & ADC	Identify critical drainage assets.	On-going
	SO Action 13 - Improve Hydrometric Data	SWS/EA/WSCC	ADC	Provide improved hydrometric data (continuous ground water monitoring and flow monitoring) for the Lidsey catchment. Where funding can be identified. This will assist with understanding drainage system response to ground water and rainfall. Also enable better understanding as the successful use of soakaway SUDS and allowances in SUDS designs.	On-going.
	SO Action 14 - Ownership and Responsibility (Asset Management) - Resolve issues surrounding the ownership, state of repair and flood risk. Where necessary creation of a Drainage Working Group should be created in areas of complicated ownership i.e. Middleton. The Drainage Working Group should have a common aim of affectively managing the maintenance and potential system upgrades based on an agreed prioritised approach.	WSCC	SWS, EA ADC	Clearly define responsibilities for riparian ownership of the ordinary watercourses to enable affective holistic management. With the clear aim of reducing flood risk, optimise existing asset capacity, encourage safe and sustainable development. Recommended early activities include map all critical drainage, determine condition, review / develop maintenance schedules, implement maintenance improvements.	On-going

Action		Responsible		Benefits	Timeline
		Lead	Support		
Management	**SO Action 15** - Undertake strategic feasibility study, in priority, to confirm significant level of flood risk predicted by SWMP study and use as justification for possible FDGiA funding applications.	WSCC	EA / ADC	Improved understanding of LFRZ flood mechanisms and potential funding opportunities for mitigation	On-going
	SO Action 16 - Carry out a **flood risk assessment for roads** (under WSCC control) highlighted to flood during extreme events e.g. major roads (A Roads) and determine if any contingency plans are required. This should include ascertaining the standard of protection currently provided and, if necessary, carrying out further investigation/ modelling to improve the level of understanding. Establish need for more detailed analysis and/or higher standard of protection.	WSCC	EA / ADC	Refine understanding of flood risk on key routes	On-going
	SO Action 17 - Continue to Investigate (confirm) whether flooding incidents occurring in LFRZs and other areas identified as being at risk of flooding.	WSCC	ADC	Improved understanding of LFRZ flood mechanisms and potential funding opportunities for mitigation	On-going
	SO Action 18 - Work proactively to monitor the condition of ordinary watercourse and its culverts.	EA / WSCC / ADC	-	Optimise existing drainage assets	On-going
	SO Action 19 - Work proactively with the EA to monitor the condition of Main Rivers, culverts and Defences.	EA / WSCC / ADC	-	Optimise existing drainage assets	On-going
	SO Action 20 - Engage WSCC Highways to monitor any future flooding and assess the associated risk on all major roads	WSCC (Highways)	-	Optimise existing drainage assets	On-going
	SO Action 21 – SWS to continue works to reduce inflows of ground water and surface water entering the public surface water system as prioritisation dictates.	SWS	-	Optimise existing drainage assets	On-going

11.2.3. Strategic Opportunities – Engagement

Action		Responsible		Benefits	Timeline
		Lead	Support		
Engagement	**SO Action 22 - Promote the SWMP** with wider Stakeholders to improve awareness of drainage in Lidsey catchment and potential options to resolve them.	WSCC	SW, EA, ADC	Should support the implementation of schemes by encouraging collaborative working. Wider stakeholder engagement increases potential opportunities for wider funding sources. Provides an evidence base of the decision making processes.	As the opportunity arises
	SO Action 23 - Riparian Ownership - Raise awareness of riparian owner responsibilities to ensure maintenance duties are implemented.	WSCC	SW, EA, ADC	Assist with ensuring existing drainage assets remain operable.	As the opportunity arises
	SO Action 24 - Flood Records - Raise awareness in the Community to report flooding. Utilise existing systems and media to record flooding (Fluvial and Pluvial) and operational problems i.e. http://love.westsussex.gov.uk/reports, and via WSCC / ADC call centres / and responsible departments.	WSCC	SW, EA, ADC	Provides a greater evidence base for future works and investigations. Flood incidents should contain information on the area or property affected, source of flooding, mechanism of flooding. Flood incidents where possible should be verified through site investigations.	As the opportunity arises
	SO Action 25 – Drainage Strategy Framework – Undertake a hydraulic appraisal of the public sewer system in relation to the catchment drainage systems.	SWS	EA, ADC, WSCC	Advances findings and recommendations from the Lidsey SWMP and infiltration reduction strategies	Programme to be supplied.

11.2.4. LFRZ Actions

The summary below lists the actions by Partners and Stakeholders for each of the LFRZ. These actions have been ranked based on the LRFZ prioritisation. Responsibility has been allocated for each action to a dedicated Partner(s).

Priority	LFRZ	Action 1	Action 2	Action 3	Action 4	Action 5
1	**LFRZ_006** Lake Lane, Barnham	Establish regular inspection programme of culverts under the railway line checking they are maintained to optimise capacity. These culverts act as a throttle on the main river in Barnham during high flows. Investigate as part of the EA 2014 ARIFRM project.	Investigate Attenuation and Retention upstream to reduce flood risk from the Rife in Barnham. Strategic Options likely to be considered with LFRZ_003 and LFRZ_021. Complete as part of the EA 2014 ARIFRM project.	Investigate and prioritise interventions to reduce clear water inflow and Infiltration of public foul sewers. Work with Local Authority to target resilience improvements.	Investigate Nursery Drainage (Greenhouses)	Improve outfall headwall that projects into flow area of Barnham Rife behind Warren Way
2	**LFRZ_017** Felpham Road, Felpham	Use permissive powers where appropriate to ensure ditches receiving flows from highway drains are maintained.	Main River - investigate improved conveyance as part of the EA 2014 ARIFRM project.			
3	**LFRZ_013** Elmer Sands, Middleton on Sea	As detailed in the Elmer SWMP and progress with the FDGIA funded investigations.				
4	**LFRZ_019** Wandleys Lane, Eastergate	Investigate conveyance solution.	Assess Portsmouth Water emergency plan for spilling ground water. Confirm recent upgrade works at the abstraction pumping station.			
5	**LFRZ_023** Rudwicks Close, Broomcroft Road, The Loop, Jacken Close, Bramfield Road, Leverton Avenue, Limmer Lane (East End), Burley Road and Dryad Way in Felpham	Ensure highway drainage system is fully operational through the responsible asset owners. Complete asset surveys and condition assessments of surface water system.	Investigate and prioritise interventions to reduce clear water inflow and Infiltration of public foul sewers. Work with Local Authority to target resilience improvements.	Ditches are overgrown, heavily silted and in some cases (as reported by residents), filled in. Complete a condition assessment of these assets and develop a rehabilitation programme.	Assess flooding in Limmer Lane and investigate increased conveyance of surface water following asset surveys and condition assessment.	
6	**LFRZ_025** Limmer Lane, Felpham	Ensure public surface water drainage system is fully operational. Complete asset surveys and condition assessments of surface water system.	Investigate improved surface water conveyance.	Investigate and prioritise interventions to reduce clear water inflow and Infiltration of public foul sewers. Work with Local Authority to target resilience improvements.		

7	**LFRZ_003** Walberton Village (Barnham Lane (A))	Land Use Management + Policy and Planning	Investigate attenuation & retention of surface water. Remove weir on main river in Burch Grove. Desilt ditches and culverts at east end of Eastergate Lane.	Main River - investigate improved conveyance as part of the EA 2014 ARIFRM project.	Investigate and prioritise interventions to reduce clear water inflow and Infiltration of public foul sewers. Work with Local Authority to target resilience improvements.	Ditch clearance in West Walberton Lane. Desilt ditches and culverts at the east end of Eastergate Lane. Investigate management and removal of structures as part of ARIFRM project
8	**LFRZ_002** Elm Grove, Barnham	Investigate and prioritise interventions to reduce clear water inflow and Infiltration of public foul sewers. Work with Local Authority to target resilience improvements.	Establish development principles in the Local Plan / Core Strategy.	Undertake permanent monitoring of ground water and consider installing early warning system.	SWS to consider, in cooperation with the EA, opening the abandoned overflow in Elm Grove. This will require a full hydraulic assessment to confirm its viability and benefit. EA permission would be required to consent such an option.	
9	**LFRZ_026** Eastergate Lane, Eastergate	Discuss with riparian owner to maintain existing drainage ditches within the LFRZ.	Establish development principles in the Local Plan / Core Strategy.	Highway drainage improvements in vicinity of "Ashogle"		
10	**LFRZ_024** West Close, Middleton on Sea	Ensure highway drainage system is fully operational through the responsible asset owners.	Consideration of increasing conveyance of surface water system either via gravity or pumping to coastal outfall to reduce flood risk. To be undertaken through a detailed investigation.	Investigate and prioritise interventions to reduce clear water inflow and Infiltration of public foul sewers. Work with Local Authority to target resilience improvements.		
11	**LFRZ_014** Lodge Close & Willow Brook, Middleton on Sea	Would benefit from clearance of ditches to increase conveyance i.e. ditch running parallel to Ancton Lodge Lane. Ditch is heavily silted and water is stagnant. Silted pond in Willow Brook. No free outfall from culvert. (Work to be completed by riparian owners)	EA to investigate the influence of the main river on the LFRZ as part of the EA 2014 ARIFRM project.	Investigate culverts under Ancton Lodge Lane. It is considered these are currently at incorrect levels which is causing the siltation and surcharging upstream in the Lodge Close drainage system.		
12	**LFRZ_015** Sea Way, Middleton on Sea	Consider installation of more robust measures required to combat wave action on the flap valves.	Monitor performance of the Sea Way Outfall scheme,	Consider conducting a more detailed hydraulic appraisal to investigate the foul flooding and periods of RTU.	Investigate and prioritise interventions to reduce clear water inflow and Infiltration of public foul sewers. Work with Local Authority to target resilience improvements.	

13	**LFRZ_004** Maple Road, Walberton	Carry out a detailed investigation of flooding issue and where required develop hydraulic solution.	Investigate fat, oil, grease problems reported by residents.	Investigate and prioritise interventions to reduce clear water inflow and Infiltration of public foul sewers. Work with Local Authority to target resilience improvements.	Continue proactive maintenance of highway gullies and jetting of sewers to optimise existing drainage assets.	
14	**LFRZ_021** Marshalls Close / Church Lane, Barnham	Investigate the Operation of Marshalls Close CSO	Investigate options to reduce flood risk as part of the EA 2014 ARIFRM project.	Investigate additional flood protection measures for two properties in Marshalls Close i.e. sealing floors and walls.		
15	**LFRZ_022** Southdean Close, Middleton on Sea	Confirm surface water drainage arrangements and condition in Southdean Close.	Consider connecting existing or new highway drainage system into the Rose Avenue public storm water system. The storm system may require upgrade to accommodate increased inflows.	Consider use of ATAC (Temporary Treatment Plant)		
16	**LFRZ_018** Oak Tree Lane, Woodgate	Survey private road existing highway drainage and confirm condition and arrangements. Implement clearance of the ditch on the west side of Lidsey Road and investigate capacity downstream of the highway ditch	Area to be considered as part of the DSF study.	Consider use of flood mitigation to protect properties from pluvial flooding from highway based on outputs from the DSF study	Investigate and prioritise interventions to reduce clear water inflow and Infiltration of public foul sewers. Work with Local Authority to target resilience improvements.	
17	**LFRZ_020** Highground Lane	Investigate and prioritise interventions to reduce clear water inflow and Infiltration of public foul sewers. Work with Local Authority to target resilience improvements.				
18	**LFRZ_012** Yapton Road, Middleton on Sea	Optimise existing drainage assets. Continue maintenance of ditch system.	Monitor flooding to evaluate improvements in the ditch system.	Consider increased conveyance and provide attenuation for surface water flows into the fields to the north or east.	Consider more gullies along Yapton Lane to intercept highway runoff from Norton Road and Yapton Road.	Investigate flood mitigations.

19	**LFRZ_010** Burndell Road, Yapton	Ensure landowner(s) maintain ditches receiving flows from highway drains.	Investigate and prioritise interventions to reduce clear water inflow and Infiltration of public foul sewers. Work with Local Authority to target resilience improvements.	Investigate local conveyance solution involving installation of a French drain to the rear of the affected properties connecting into an extended ditch line conveying flow south away from properties. Upgrade of existing highway drainage to connect into the extended ditch line.	A new large development to the north of Burndell Road/Goodhew Close is planned. There are old ditch lines on that site that transport surface water southwards towards Ferndale House. ADC shall explore possibilities with the developer to intercept these flows and connect these into their onsite drainage system.	
20	**LFRZ_027** Downsview Road, Barnham	Confirm ownership of the land drainage ditch which drains field runoff away from Ewens Gardens and Downview Road. Ensure owner(s) of the ditch understand their riparian responsibilities to maintain.	Establish development principles in the Local Plan / Core Strategy.	Attenuation & Retention of surface water in the fields to the west of Downview Road. Discuss with landowner.		
21	**LFRZ_001** West Walberton Lane, Walberton	Carry out a detailed investigation of flooding issue and where required develop hydraulic solution. Investigate and prioritise interventions to reduce clear water inflow and Infiltration of public foul sewers. Work with Local Authority to target resilience improvements.	Continue proactive maintenance to highway gullies and jetting of sewers to optimise existing drainage assets.	Consider Installation of Water butts / rainwater harvesting.		
22	**LFRZ_016** Golf Links Road, Felpham	Consider ditch maintenance required and creation of additional flood storage on golf course.	To consider this flood risk as part of the EA 2014 ARIFRM project.			
23	**LFRZ_009** Yapton Road, Yapton	CCTV inspection of the last leg of the 150 mm land drain to confirm if there is a blockage / partial collapse which is currently suspected.	Investigate and prioritise interventions to reduce clear water inflow and Infiltration of public foul sewers. Work with Local Authority to target resilience improvements.	Opportunity with landowner to improve drainage in local fields.	Consider pumping flows from Yapton Road WPS direct to Ford WTW)	
24	**LFRZ_008** Barnham Lane, Barnham (C)	Ditch clearance in Barnham Lane	Investigate and prioritise interventions to reduce clear water inflow and Infiltration of public foul sewers. Work with Local Authority to target resilience improvements.			

25	**LFRZ_005** Barnham Lane, Barnham (B)	Investigate ditch on northern side of track to North Choller Farm has potentially been filled (vehicular crossing). Some of the highway drainage system in Barnham Lane may discharge into this ditch. The outfall is assumed buried.	Investigate the ditch that flows from the highway toward the rife adjacent to the property and establish the reason for the pooling of water off the Highway. Identify if there is a hydraulic restriction.	Investigate and prioritise interventions to reduce clear water inflow and Infiltration of public foul sewers. Work with Local Authority to target resilience improvements.		
26	**LFRZ_007** Park Road, Barnham	Ditches are overgrown and require maintenance along Lake Lane. It is reported that many of these ditches were cleared a number of years ago. It is recommended a reminder letter is sent to landowners to remind of riparian responsibility to maintain drainage systems.	Investigate current surface water drainage from local nurseries. Investigation into the surface water disposal from the greenhouses to assess if improvements can be made to reduce peak flows entering main river. This may reduce flood risk at Meadow Farm. Also consider the affect of the attenuation ponds further in the EA River Modelling Study.	Investigate the screen arrangement in the ditch on northern boundary of Kilkenny in order to evaluate performance.		
27	**LFRZ_011** West View Drive, Yapton	Monitor foul flooding using the Area Asset Plan.				

11.3. Facilitation / Influences and Considerations

11.3.1. SWS

Ofwat, the water company regulator, has highlighted the need for water companies to positively influence the reduction in flood risk within their community. This is highlighted in the Drainage Strategy Framework (EA & Ofwat, 2013). This states that a

'Drainage Strategy should be developed by the water and sewerage company with a primary focus on its network of foul, combined and surface water sewers. However, the [water] company should work with other organisations so that their role in controlling the demand on sewers is confirmed and the company plays its part in the resolution of wider drainage, surface water flooding and water pollution issues in the catchment.'

The outputs from this study should be used to influence future business plans and associated investment and funding schedule in areas identified to be at risk of surface water flooding / pollution.

The overall output from the SWMP is to encourage a more shared approach to future funding and the development of schemes for drainage improvements across the region. A good example for this will be the use of the hydraulic model developed for the SWMP which may also inform investment plans into future hydraulic schemes.

11.3.2. Spatial Planning

The National Planning Policy Framework (NPPF) replaced Planning Policy Statement 25 Development and Flood Risk in March 2012. The NPPF stipulates national planning policy for development in relation to flood risk. Planning Authorities have a duty to ensure that any new development does not add to the causes or sources of flood risk.

The interrelationship between SWMPs and planning was highlighted by Recommendation 18 of the Pitt Review (Cabinet Office, 2008) which states that SWMPs should:

"build on Strategic Flood Risk Assessments (SFRAs) and provide the vehicle for local organisations to develop a shared understanding of local flood risk, including setting out priorities for action, maintenance needs and links into local development frameworks and emergency plans".

The following section identifies important implications for land use planning arising from the findings of the detailed SWMP modelling. It recommends actions for implementing the Surface Water Management Action Plan that fall within the responsibility of the statutory local planning authorities, i.e. those are responsible for the development and implementation of land use and spatial planning policy.

There are three areas which the findings of this Surface Water Management Plan (SWMP) are recommended to be taken forward through the planning system include:

1. The SWMP maps which identify potential areas that are vulnerable to surface water flooding should be used to update information in SFRAs.

2. The SWMP maps which identify potential areas that are vulnerable to surface water flooding should be used to update policies in Development Plan Documents (DPD).

3. The SWMP maps which identify potential areas that are more vulnerable to surface water flooding should be used to inform development decisions for sites or areas by either:

- Resulting in modifications to strategies, guidance, or policies for major development locations (e.g. through Area Action Plans and Supplementary Planning Guidance); or
- Influencing planning decisions in relation to the principle, layout or design of particular development proposals.

11.3.3. SWMP and SFRAs

Defra's SWMP guidance (March 2010) indicates that local authority planning departments should utilise the map outputs from a SWMP in order to update and enhance the SFRAs where surface water flooding has not been addressed in detail. It has been identified that the existing SFRAs do not address flooding from surface water, ground water or ordinary watercourses in any specific detail which is seen a significant limitation.

11.3.4. SWMP and Development Planning Documents

The SWMP should inform and update the SFRA initially therefore reference to the SFRA within the DPD will highlight any flood risk.

11.3.5. On-going Monitoring & Updates

The action plan should be updated as and when the need requires. Typical examples would be the. occurrence of flooding, enhancement of the model which may alter view of system performance and flood risk, or addition of major developments in the catchment.

Appendices

Appendix A. – Plans

Appendix B. – Communication Plan

Appendix C. - LZRZ 'Storyboards'

Appendix D. – Model Build Report

Appendix E. - LFRZ Option Assessment

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