Benson Drainage Strategy

Stage 1 - Initialise/Prepare

Thames Water

At the heart of daily life

Introduction

Why sewer flooding

Britain's first sewerage systems were constructed 150 years ago in the Victorian era, and have served us well for generations. The sewer network Thames Water operates today has been much improved and vastly extended over the years; yet it remains under increasing pressure.

Everyday our network manages the demands of one of the world's busiest and most densely populated capital cities, and its urbanised surrounding areas; together with the equally complex challenges arising in our predominantly rural catchments in the Thames Valley, Surrey and Kent.

A number of factors including population growth, less frequent but heavier rainfall, the urbanisation of green spaces and changes in agricultural land practices, and utilised machinery, occasionally overwhelm our sewer network. The result can be unwanted sewer flooding for customers and our neighbouring natural environments.

This document contains:

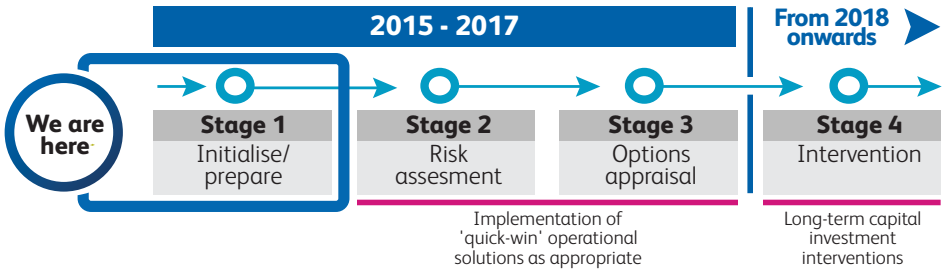
- an Introduction to the work we are undertaking to alleviate sewer flooding in our region
- a Feedback: Q&A section addressing key questions from customers and stakeholders
- the Benson Drainage Strategy technical document.

What can be done and when?

Sewer flooding is unacceptable. We have undertaken extensive customer research and initiated a programme of work to improve drainage and alleviate sewer flooding issues across our region.

We are adopting the good practice Drainage Strategy framework* developed by the Environment Agency and Ofwat, the water industry economic regulator, to produce a drainage strategy for our affected catchments with a primary focus on our sewerage network. As outlined in Figure 1, the strategies will develop throughout the 4-stage framework to define how we intend to alleviate sewer flooding or to address growth related issues in each area sustainably, and economically, over the next few years.

Figure 1 High-level Drainage Strategy framework* and estimated delivery and intervention timeline**



* The detailed 4-stage Drainage Strategy framework can be found in the following Drainage Strategy document. ** The estimated delivery timeline is dependent on factors including weather conditions and is, therefore, open to change. The intervention timeline includes the implementation of 'quick-win' operational solutions throughout Stage 2 & 3, and long-term capital investment interventions in Stage 4.

Who will resolve the sewer flooding?

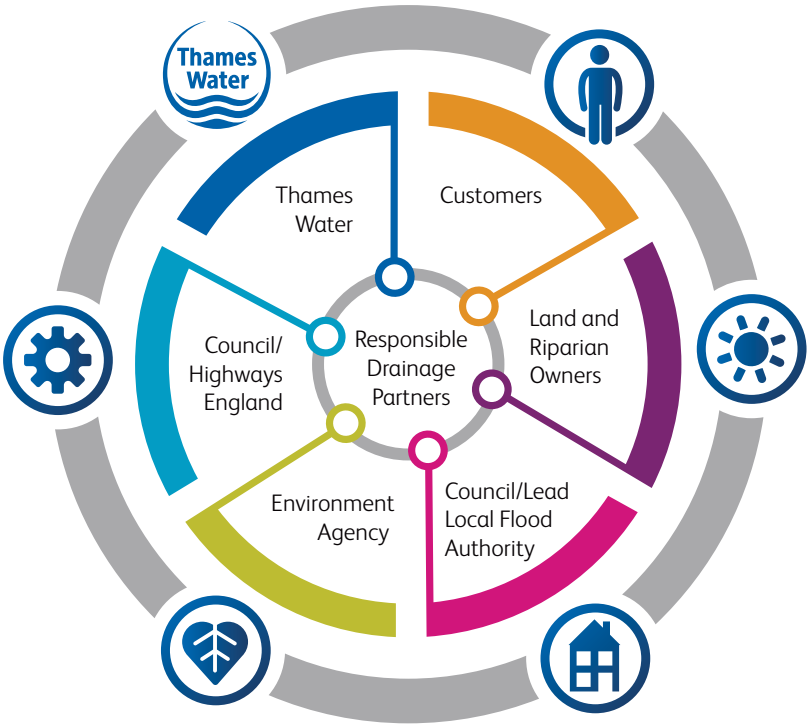
There are a number of stakeholders who, like us, have important drainage responsibilities and therefore, play an essential role in resolving sewer flooding in our region. These stakeholders include customers, private land owners and the Environment Agency; to name but a few. We are seeking to work in partnership with all stakeholders to ensure that together, we implement and maintain the most effective and sustainable drainage strategies.

Just as our responsibilities to improve drainage and alleviate sewer flooding focus on removing and treating wastewater; other stakeholders' responsibilities include managing local flood risk on riverbanks, ground water, land and highways, utilising appropriate agricultural practices and maintaining private drains.

We take full responsibility for resolving all drainage and sewer flooding issues that fall within our remit. If the causes of sewer flooding sit outside of this, we will support the responsible stakeholder to resolve the issue and to reduce the impact on customers.

Figure 2 provides a high-level view of the stakeholders responsible for drainage in each catchment area, more detail regarding responsibilities can be found in Section 1 of the following Drainage Strategy document.

Figure 2 Partners with Drainage Responsibilities



Next steps

Over the coming months we will undertake the following activities as this drainage strategy develops:

2015 - 2017

Customer Focus Actions

- Continue to consult with customers during this stage and every stage, through meetings, communications and surveys. We have gained important customer feedback during this first stage, which we are using to shape our activities
- Publish strategy documents for comment and contribution, throughout this framework process.

Partnership Actions

- Continue to establish partnership working with the regional drainage stakeholders, and agree ongoing consultation processes.

Other Key Actions

- Define catchment flooding uncertainties
- Prepare flooding risk data
- Undertake ongoing repair work to our sewer network, as the strategy develops and our investigations identify reparation work linked to drainage and flooding issues.

We will **regularly consult with customers and stakeholders, update and republish** this document throughout this 4-stage framework process.

Feedback: Q&A

Your questions answered

We are committed to listening to, consulting and collaborating with customers and stakeholders on our sewerage network activities and plans. We have addressed key feedback and questions raised by customers and stakeholders in the Benson catchment, and customers affected by flooding throughout the region, in this Feedback Q&A section. As far as possible, and as is relevant to Stage 1 in the framework process, we have incorporated feedback from customers and stakeholders into our network strategy development. More detail can be found throughout the following Drainage Strategy document.

We are committed to **listening to, consulting and collaborating** with customers and stakeholders on our sewerage network activities and plans.

Q1 Will undertaking this Drainage Strategy framework process defer essential work in our area?

Answer

It is essential for us to complete this drainage strategy process, which has been developed and recommended by the water industry economic regulator Ofwat, and the Environment Agency. This will enable us to better understand the root cause of the sewer flooding issues affecting the catchment, before any major investment can be considered. However, we may carry out some repair works as this strategy develops, in the event that our investigations identify faults or problems with the sewerage network that are highly likely to have caused flooding, as outlined in Section 7 of the Drainage Strategy document. Our previous investigations have identified some sources of inflow, such as the misconnection of surface water to foul sewers. However, as stated in the following strategy, we are not yet able to say how much this impacts on flooding and will update this as our plan develops through Stage 2 to Stage 3 –Option Appraisal. Therefore, this more detailed approach is required to ensure that the most effective and sustainable drainage strategies are implemented in the Benson catchment.

Q2 What drainage actions are you undertaking in our area, and when will they be happening?

Answer

As stated above, we are developing our plan for this area and will provide further details as our plan develops through Stage 2 to Stage 3 – Option Appraisal. The following drainage actions have already been undertaken, or are underway, in the Benson catchment:

Actions completed include: (For more information please see Table 2)

1 Manhole surveys
2 CCTV survey of our sewer network
3 Wet weather event survey
4 Sewer repairs – including lining and sealing of sewer
5 Installation of non-return valves
6 Installation of flow monitors at the sewage treatment works
7 Installation of depth monitors into the network
8 Installation of low-leak manhole covers
9 Flooding clean-up.

Actions underway or planned include: (For more information please see Table 4)

1. Stakeholder engagement activities
2. Connectivity surveys
3. Ongoing sewer repair works
4. Monitoring of pumping station
5. Impact study
6. Innovative solution analysis.

Q3 Are you renovating the sewers in our area?

Answer

We will renovate sewers which have been damaged, either as they have aged or through other streetworks activities. As outlined in Table 2, extensive sewer repairs have been undertaken across the network within the catchment to try and limit the inflows. This action prevents the ingress of ground water into sewer pipes through leaking joints. We will continue to target and repair localised sewer defects identified through our investigations as contributing to, or causing, drainage and flooding issues in the catchment throughout this 4-stage framework process.

Q4 What are the improvement plans for Benson's sewage treatment works to manage capacity?

Answer

The Benson sewage treatment works has undergone a number of upgrades over the years to meet changing performance criteria. The capacity of the works has been assessed to be adequate under current normal design flow conditions however, this is currently being reviewed in light of plans for RAF Benson. In accordance with the consent for the sewage treatment works it operates a fully-compliant permanent storm overflow which permits us to discharge into local watercourses during storm events.

Q5 How are you planning for future development in the catchment?

Answer

As per Section 5.3 in the following Drainage Strategy document, we will continue to closely monitor development applications in the catchment and assess the impact that they may have on the capacity of our operations in the future. We are currently reviewing the capacity of the sewage treatment works to deal with plans for RAF Benson and those projected for the catchment, as outlined in the latest South Oxfordshire District Council Development Plan. We will continue to work with all involved stakeholders through our stakeholder engagement activities, to monitor local plans and planning applications and to incorporate current and projected developments into our business planning cycle, to ensure that our service is maintained for customers throughout the catchment's development.

Q6 Are you working with the Highway Authority to resolve blocked gullies, sewers and ditches, and with landowners to reduce field run-off, as both affect drainage and our sewers?

Answer

In Section 1of the following Drainage Strategy document, we outline the other stakeholders who, like us, have important drainage responsibilities and therefore, play an essential role in resolving sewer flooding issues in this catchment area. As highways maintenance activities and agricultural land maintenance practices sit outside of our remit we will work with the responsible stakeholders, to highlight these issues if this is found to have a major influence and impact on our sewerage network.

We will continue to work closely with the Oxfordshire County Council and South Oxfordshire District Council and Highways England to understand the extent to which floodwater may be escaping from highway or land drainage systems; and impact the foul sewer network. An update on this issue will be shared with customers and featured in the later stages of this Drainage Strategy document.

Q7 Is an Infiltration Reduction Plan (IRP), required for this catchment?

Answer

Ensuring that our drainage strategies fully meet the requirements of an Infiltration Reduction Plan, as set out in the Environment Agency's Regulatory Position Statement, is a fundamental consideration in their development. Therefore, to maintain our service to customers during future wet weather events, if we need to discharge to watercourses through temporary overflows, a dedicated section will be included in each affected strategy, providing details of their location and intended use. This section will be included and /or revised when each strategy is updated.

In the event that temporary overflows are required, as stated above, we will describe their location and the circumstances under which we would use them. Together with plans to reduce infiltration, this drainage strategy would then fully meet the requirements of an Infiltration Reduction Plan.

Q8 Why are costs a consideration within your Wastewater outcomes?

Answer

The service we provide is the most fundamental of all – at the heart of daily life for the 15 million customers we serve. Getting it right is our focus every day, and we never forget it is paid for by customers.

As a regulated company we have to carefully balance service and cost in order to keep customer bills affordable, whilst delivering our outcomes and customer service commitments.

Q9 How are you ensuring that our local pumping stations are operating effectively?

Answer

The pumping stations within the Benson catchment are supported by 24 hour diagnostic monitoring. This enables us to tightly control their operation through a flow of real-time information. Based on this performance data we can respond quickly through site visits by our engineers, and both project and rectify potential issues before they occur.

As we move through this 4-stage framework process and further develop our Drainage Strategy for this catchment, we will review the operational control options of these stations, particularly during wet weather, carefully avoiding increasing the risk of sewer flooding in doing so.

Q10 Are growth and urban creep minor factors in these rural catchments?

Answer

Whilst the growth and urban creep rate for Benson is fairly average across the Thames area, relatively small population increases in these smaller rural catchments can be influential on sewer flows, hence the need for us to closely monitor planning applications. Similarly urban creep, and in particular misconnection of surface water and change of land use, can have a significant impact on sewer flooding; particularly when permeable areas such as grass are replaced with hard-standings and driveways.

More growth and urban creep information can be found in Section 5.1 of the following Drainage Strategy document.

Q11 Are best practice techniques already used by other water companies being considered?

Answer

We are constantly reviewing and improving our business to meet and exceed industry standards, to implement best practice and to drive innovation. We lead and participate in a large number of industry forums both in the UK and worldwide, to share and expand our learning; with the ultimate aim of improving services for customers.

We are deploying industry best practice techniques throughout our Drainage Strategy work, and also trialling new technology that is innovative within our industry, to achieve the best possible drainage outcomes for customers and their local environment.

Q12 Why are you collecting climate change data rather than 'climate proofing' assets?

Answer

We are committed to responding to climate change and to reducing our contribution to it by reducing emissions in accordance with government policy. Our voluntary target is to achieve a challenging 20 per cent reduction in emissions (compared to 1990 levels), for our Scope 1 and 2 emissions*. We continue to assess and collect climate change data and its impact on assets across our region, to ensure that we are fully informed and can prioritise our plans, targeted actions and investments. For more information please see the Climate Change section on the Homepage of our website.

*Scope 1 emissions refer to greenhouse gas emissions associated with the operation of our assets. Scope 2 emissions are emissions associated with the use of grid electricity.

Q13 What is the impact on local rivers of overflow points?

Answer

During extreme weather conditions foul sewers may become overwhelmed through a combination of surface water or ground water, resulting in a much diluted sewage. The impact on local rivers is dependent on the nature and size of the river, and on the overflow.

To reduce the environmental impact on local watercourses we will only use overflow points when groundwater and river levels are high, and therefore sewage dilution rates are also high. Additionally, we are also investigating deploying mobile biological filters to prevent litter and other matter from entering local rivers. If during the development of our drainage strategy we consider that temporary overflow points are necessary in the local network, we will update the Drainage Strategy document to reflect this position.

Benson Drainage Strategy

Technical Document

Thames Water

At the heart of daily life

Stage 1: Initialise / Prepare

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About this document

Based on customer research

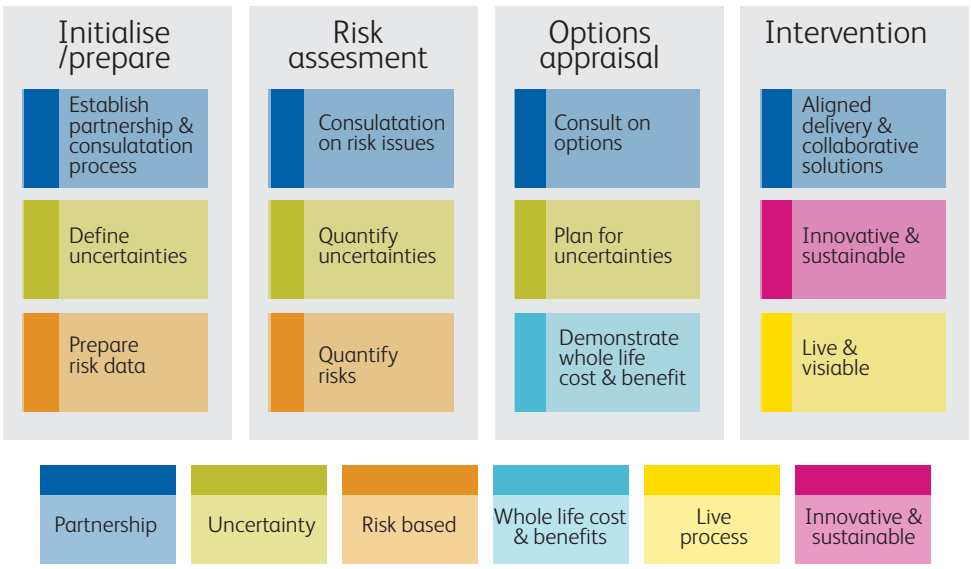
Undertaking extensive customer research has been a fundamental step in our business plan preparation for 2015-20. Our research findings have informed our business planning activities, and contributed to the development of a set of long-term customer 'outcomes'.

The water industry economic regulator, Ofwat, defines 'outcomes' as "High-level objectives that company actions, activities and achievements are intended to help deliver..[they] represent what customers and society value". As a company, we are committed to achieving our customer outcomes, a number of which are focussed on alleviating sewer flooding issues within our region, through effective, economic and sustainable drainage. This document describes the strategy that we will follow in delivering our long-term customer outcomes for drainage, specifically in the Benson catchment, in a sustainable and economic manner.

Approved approach

We have adopted the Drainage Strategy Framework[1] outlined in Figure 1 below, developed by the Environment Agency and Ofwat. It identifies 4 key stages to producing a good-practice drainage strategy. Drainage strategies typically focus on the sewerage network, and not the performance of sewage treatment works. The Benson drainage strategy is currently at the first stage of this framework - the Initialise/Prepare stage. In this document, we describe the activities that we plan to undertake to address current issues and future challenges facing the catchment, and the data that we need to gather to complete the risk assessment and options appraisal stages.

Figure 1 The Drainage Strategy Framework



[1] http://www.ofwat.gov.uk/future/sustainable/drainage/rpt_com201305drainagestrategy.pdf

Consultation and publication

We will update and republish this document to provide the results of our risk assessment, options appraisal and our selected strategy for intervention, once data from instrumentation and other fieldwork has been collected and analysed.

Throughout this process we will attend local flood forums for ongoing communication and consultation with customers and stakeholders. We will also make the Drainage Strategy documents available on the Drainage Strategies webpage of our website.

Meeting the Infiltration Reduction Plan (IRP)

To ensure that this Drainage Strategy meets the requirements of an Infiltration Reduction Plan, as set out in the Environment Agency's Regulatory Position Statement on discharges made from groundwater surcharged sewers, we have included a section in this document which defines if, how and when we propose to operate temporary overflows. This is in addition to our plans to reduce infiltration over time, where it has been identified as a root cause of sewer flooding. Please see Section 8 in the Drainage Strategy document below.

Executive summary

In recent years the foul sewerage system in the Benson catchment has become overwhelmed in some locations for weeks and even months, following prolonged heavy rainfall and high ground water levels. This has resulted in some properties suffering from sewer flooding and restricted toilet use.

We believe that significant volumes of surface water run-off from the surrounding saturated fields entered the foul sewerage network during the wet winters of 2012/13 and 2013/14, causing the network to surcharge. The surveys we have carried out also suggest that there is some evidence of groundwater infiltration into the foul sewerage network when groundwater levels are high, fluvial flooding and inundation from highways, public spaces and properties. Surface water misconnections (i.e. downpipes from roofs), into the foul sewerage network may also be a contributing factor, however further analysis is required to determine the extent to which this has contributed to sewer flooding.

The root causes of sewer surcharges are therefore numerous and the resolution of the issues complex, requiring all stakeholders responsible for drainage in the catchment to work together to resolve them. The Floods and Water Management Act 2010 places a duty on lead local flood authorities (LLFAs) to manage flood risk from surface and groundwater, plus a duty on all risk management authorities (RMAs) to cooperate with regard to flood risk. In our role as a RMA, Thames Water will work with the Oxfordshire County Council who is the Lead Local Flood Authority, South Oxfordshire District Council and the Environment Agency to ensure that a collaborative approach can be developed to address the problems.

In response, this drainage strategy follows the Environment Agency and Ofwat's 4-stage framework. The Benson strategy is currently at Stage 1 (Initialise/Prepare). We describe in this document the actions that we plan to carry out to complete the risk assessment and options appraisal stages. We will update and republish this document once this work is completed.

In preparing our company business plan for the 5 year period 2015 to 2020 we have listened very carefully to the views of customers. Beyond being able to maintain the current service that we provide, customers have told us that they would like to see a reduction in instances of sewer flooding and odour nuisance and an improvement in river water quality. Our research indicates that customers are willing to pay for these improvements to service ; a summary of our related customer research can be found on our website via the hyperlink below.

We have therefore developed a set of company outcomes that we are committed to working towards over the next 5 years and beyond. The outcomes relevant to the Benson drainage strategy are:

- Asset health - a composite range of measures against which we will manage the health of our sewerage network
- Properties and public areas protected from sewer flooding
- River water quality meets customer's expectations and regulatory requirements.

This Drainage Strategy must also address future challenges to the Benson catchment. We assess these to be:

- Climate change – analysis of the latest data suggests that rainfall could become 15% more intensive by 2080 increasing the likelihood of flooding. Longer wetter winters may also mean groundwater levels are high more often; this could also exacerbate fluvial flooding from local watercourses
- Urban creep – paving over of front gardens, roof drainage from building extensions misconnected to the foul drainage, and loss of green space results in more strain on the sewerage network when it rains heavily. Modelling we have undertaken suggests urban creep rates

[2] http://www.thameswater.co.uk/cr/Howwedobusiness/Engagingwithourstakeholders/Publicconsultationresearch/index.html

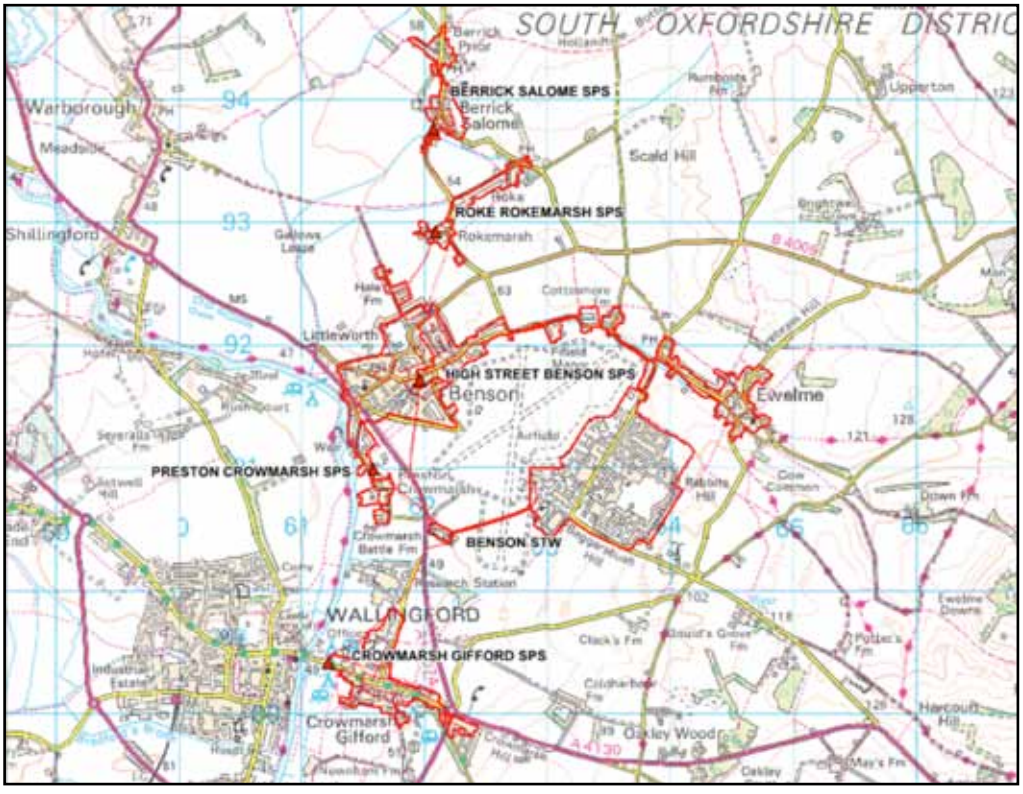
in Benson are average for the Thames Operational Area

- Population growth – the population in the South East is set to grow rapidly. A number of possible developments are identified around Benson and we will continue to track these and any other emerging applications for this catchment arising in the future.

Our strategy is to understand the relative impact on this catchment of overland flow from saturated fields, groundwater infiltration, fluvial flooding and surface water misconnections. We will then try to identify cost beneficial solutions to reduce the risk of sewer flooding using customer willingness to pay research. We may carry out sewer rehabilitation works as the strategy develops, in the event that our investigations identify faults or problems with the sewerage network that are highly likely to have contributed to flooding. Although rehabilitation and lining work has been carried out on the sewerage network within Benson in recent years, flooding has still occurred. This demonstrates that we need to understand the root causes of problems in the catchment in order to deliver effective solutions.

Our next steps are to continue monitoring the sewer depth monitor that we installed in the catchment last winter, to collect real-time flow information and to gather sewer flooding information from our customers. The depth monitor will remain in place as we move through this 4-stage framework and develop our plans. We will share the data collected from this monitor when we update the next stage of this strategy.

Figure 2 The Benson catchment



The extent of the catchment is outline in red.

1 Thames Water and drainage

1.1 Our statutory responsibilities

Thames Water is a regulated Water and Sewerage Company. We supply water to 9 million customers in London and the Thames Valley and provide wastewater services to 15 million customers across an area that stretches from Gloucestershire to Essex. We operate 108,000km of sewer through which an average of more than 4.4bn litres of wastewater is collected and treated every day at our 350 sewage treatment works.

The primary legislation that sets out our role and responsibilities is the Water Industry Act (1991), which describes the duties and services that we are responsible for and the powers that we have to connect, operate, maintain and extend the sewerage network. We are regulated by the Water Services Regulation Authority (Ofwat). The original 1991 Act has been amended by further legislation in recent years, transferring some drains and sewers that were hitherto in private ownership to Thames Water's responsibility[3].

Other recent pieces of legislation relevant to this Drainage Strategy are the Flood & Water Management Act (2010) and the Water Act (2014). These set out new responsibilities for Thames Water to manage flood risk in partnership with local councils and the Environment Agency, with more emphasis on Sustainable Drainage Systems (SuDS), such as swales and permeable paving to mimic natural drainage.

Thames Water also has a statutory obligation to comply with environmental legislation, including European Directives. The Water Framework Directive establishes a strategic approach to managing the water environment, which the Environment Agency achieves through River Basin Management Plans and setting environmental objectives for groundwater and surface water. The environment is also protected from adverse effects of discharges of urban wastewater through the Urban Wastewater Treatment Directive, which requires us to improve and extend the sewerage system according to section 94 of the Water Industry Act (1991).

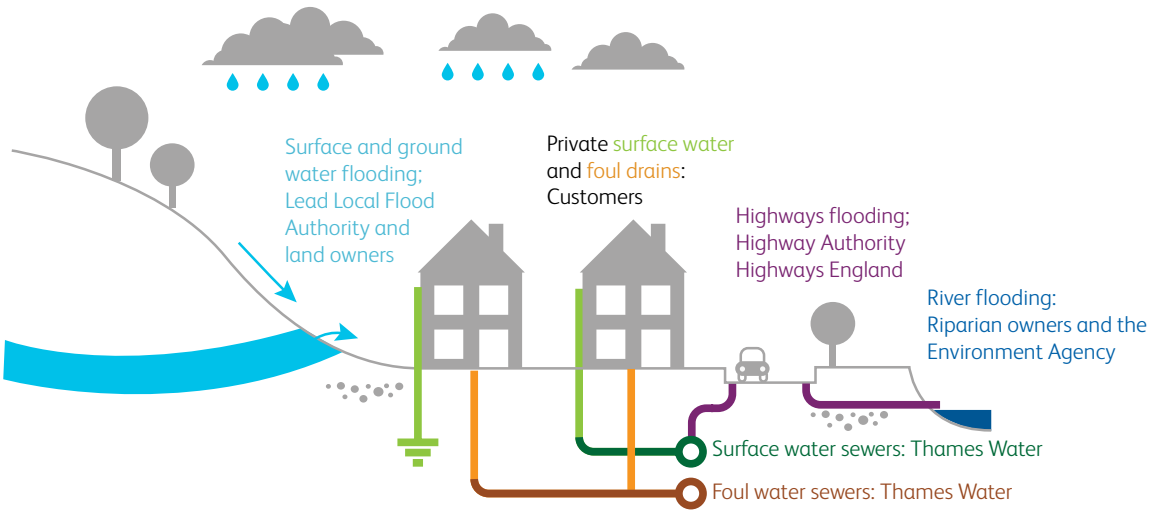
A comprehensive and detailed list of all legislation relevant to Thames Water can be found in the 'statement of obligations' published by Defra[4].

[3] See http://www.thameswater.co.uk/help-and-advice/8654.htm for more information.
[4] See https://www.gov.uk/government/publications/statement-of-obligations.

1.2 Working in partnership with other stakeholders

Other stakeholders responsible for managing various forms of drainage need to work together with us to reduce the risk of flooding. Each has specific responsibilities as summarised in Figure 3 below.

Figure 3 Stakeholder responsibilities for drainage



Thames Water

We are responsible for removing and treating wastewater, which includes the foul sewers, and in some areas the combined sewers that are in some of the older large urbanised areas, such as London[5]. We also manage and maintain surface water sewers where they exist, these will typically discharge to a watercourse or river. In some cases, the cause of sewer flooding may not fall under our responsibility. In these circumstances, we will explain what we can do to help and continue supporting the relevant authorities or third parties to reduce the impact for customers

Environment Agency

The Environment Agency is responsible for main rivers and part of its remit includes monitoring and informing the levels of ground and river water. The Environment Agency also investigates pollution incidents and monitors the quality of the water in rivers.

Lead Local Flood Authority and District Council

Oxfordshire County Council is the lead local flood authority and has the responsibility under the Flood & Water Management Act for managing the local flood risk from groundwater and surface water runoff e.g. local watercourses and culverts[6]. They work with landowners to maintain privately owned ditches, drainage and watercourses, keeping them clear of blockages. They are also responsible for managing the risk of groundwater flooding, both inside and outside of properties. Water from these local authority gullies and drains and privately owned ditches can also impact Thames Water's sewers, therefore, we work with all responsible stakeholders to resolve the excess flow. South Oxfordshire District Council is the Planning Authority responsible for approving new development, but equally may have responsibility for ensuring maintenance of watercourses; particularly on council-owned land.

Highway Authority

Oxfordshire County Council is responsible for highway maintenance and highway drainage and for clearing roadside gullies. Highways England is responsible for the drainage of motorways and certain trunk roads.

Customers

Customers own, and are responsible for, the maintenance of private drains within the curtilage of their property, which did not transfer to Thames Water ownership in October 2011[7].

Riparian Owners

Riparian Owners are landowners who own land with watercourses or land adjacent to watercourse (ie road side ditches). The responsibility for the operation and maintenance of ditches, local watercourses and general land drainage lies mostly with riparian owners.

Land Owners

Land owners include farmers and both residential and commercial customers, but includes trusts etc. They are responsible for ensuring the adequate drainage of their land, such that it is not a nuisance to others.

[5] Thames Water is responsible for the collection and treatment of commercial and domestic sewage. Typically this will be the foul sewerage. Domestic or commercial roof and paved drainage will often go to a soakaway or directly to a water course/river, which if so is not the responsibility of Thames Water.

[6] Some local watercourses and/or culverts are termed as 'Riparian' meaning that a land owner, possibly adjoining or owning the land containing the watercourse/culvert is responsible for the maintenance and free-flowing of the watercourse/culvert.

[7] See http://www.thameswater.co.uk/help-and-advice/8654.htm for more information.

2 Catchment description

2.1 Geology and topography

The Benson sewerage catchment is located approximately 18km southeast of Oxford. As outlined in Figure 2 above, it includes the towns and villages of Benson, Crowmarsh Gifford, Ewelme, Roke and Berrick Salome; it also includes the RAF Benson airbase.

The underlying geology of the catchment consists of mudstone, sandstone and limestone to the west and chalk to the east.

The catchment is situated in an area that is prone to significant seasonal fluctuations in groundwater levels, with the added likelihood of rainfall induced infiltration[8] owing to its permeable soils.

Appendix B includes maps showing the fluvial, pluvial and groundwater flood risk areas in the catchment and the geology of the area.

The Environment Agency identifies the Ewelme Stream and the River Thames within the catchment to have a current ecological status of 'Moderate Potential'[9], and the Berrick Stream and Lady Brook have a status of 'Moderate'.

2.2 Sewage treatment works

The Benson sewage treatment works is located to the south of Benson, serving the villages of Benson, Berrick Salome, Roke, Ewelme and RAF Benson, a population equivalent of approximately 6,430. The flows are pumped up to the sewage treatment works from three sewage pumping stations in the catchment and from an on-site sewage pumping station serving RAF Benson.

The Benson sewage treatment works has a dry weather flow consent of 2,517 m^3/day, but can treat a daily flow of up to 7,551m^3/day during wet periods. Inflows pass from the inlet works to a balancing tank before passing to treatment. The treated effluent discharges to the River Thames via Howbery Ditch. The works includes a storm tank to handle excess flows above the flow to full treatment during storm periods, this returns the stored flows to the balancing tank, but can discharge to the Howbery Ditch when full, with the flows receiving only settlement and screening prior to discharge.

The works and sewerage network are believed to have been constructed in the 1960s by the Local Authorities incumbent at that time – Bullingdon and Henley Rural District Councils. The sewage treatment works has undergone a number of upgrades over the years to meet changing performance criteria and to accommodate new development within the catchment. The sewage treatment works underwent an upgrade to meet changing performance criteria in 2007, and its capacity is assessed to be adequate under current normal design flow conditions. However, this is currently being reviewed due to the increase in use of RAF Benson as a main operational base taking operational capabilities and servicemen and women from RAF bases that have been closed. Investigations are taking place to examine what requirements, if any, may be needed to ensure a robust operation of the site.

[8] Rainfall Induced Infiltration is the term given to sewer infiltration that occurs as a result of rainfall percolating into the ground impacting the sewer on route to recharging the groundwater table.

[9] Environment Agency website, interactive map, Basin Management Plans.

2.3 Foul sewers

The foul drainage system serves an area of 246 hectares and a population of approximately 6,430. The catchment is served by a series of foul water sewerage systems, which are pumped to the Benson sewage treatment works via sewage pumping stations at High Street Benson, Preston Crowmarsh, Crowmarsh Gifford and via an onsite pumping station serving RAF Benson.

The foul sewers range from 100mm to 300mm in diameter. Due to the flat nature of the catchment, a number of further pumping stations are required to lift flows towards Benson sewage treatment works - see figure 4 for a schematic representation of the catchment.

It is believed that most of the sewers were constructed in the 1960s by the Local Authorities incumbent at that time – Bullingdon and Henley Rural District Councils. In the 2000s, the sewerage network was extended to include Berrick Salome. Additions have also been made by developers to serve new developments within the villages.

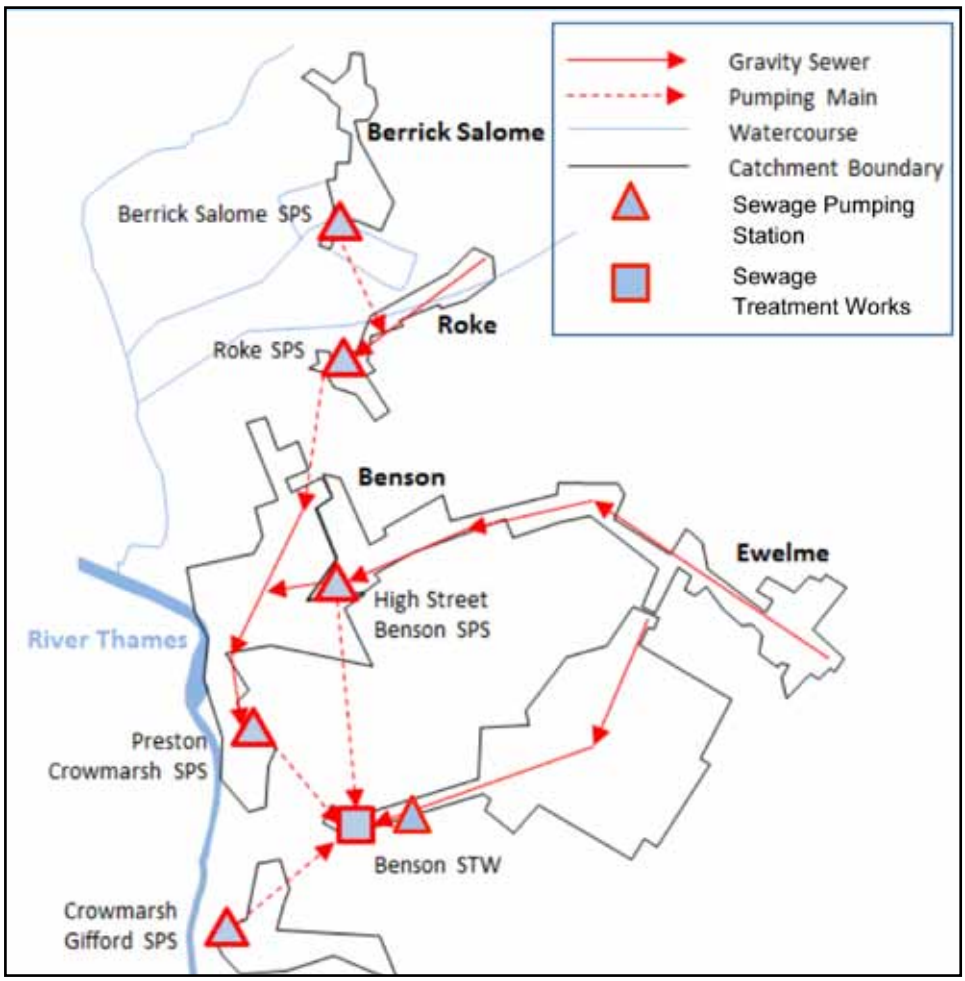
The design of the sewerage network ensures the appropriate sizing and laying of pipes at a gradient to maintain a satisfactory self-cleansing characteristic. Sewers are usually sized to cope with a maximum of six times Dry Weather Flow (DWF) and a 10% allowance is included for infiltration[10].

In terms of design capacity, a 225mm sewer laid at a gradient of 1 in 225 will have sufficient capacity to cater for the foul sewage from 1,000 to 1,500 houses or 3,000 to 4,500 people. Problems in these small diameter sewers tend to be a result of blockages in the pipes. However, occasionally surface water can be misconnected into the foul sewerage network – problems then arise when it rains heavily.

Materials used in the construction of the sewerage system are typical of the time, with clay pipework and brick and concrete manholes. The clay pipework can have a very long service life, but sometimes the joint seals deteriorate over time. The 1960s sewers were laid on bedding material such as pea shingle, with the trenches likely to have been backfilled with 'as dug' material. More recent drains and sewers, i.e. since the 1980s, are typically surrounded with pea shingle. The layout of the village suggests that most properties are likely to have their own foul drains (as opposed to shared drains) that connect directly into the public sewer. Private foul water drains within property boundaries in the villages are the responsibility of the property owners where they are not shared.

[10] Dry Weather Flow is the term given to the average flow rate observed over a 24 hour period and based on Sewers for Adoption, the industry standard, includes an allowance for infiltration of 10% of the calculated flow rate.

Figure 4 Benson catchment schematic, identifying principal assets



2.4 Surface water sewers

There are some small surface water sewer systems in Benson and Ewelme that drain to local watercourses. Surface Water from properties and the highway is likely to drain via soakaways, drainage ditches and highway drainage systems. Soakaways can only function satisfactorily when ground conditions allow soakage and may be completely ineffective when groundwater levels are high. In some areas, we have seen examples of customers draining surface water through their foul drains when their soakaways do not work. This exacerbates capacity problems for other customers connected further downstream in the sewerage network.

The catchment is mostly rural and incorporates a network of roadside ditches and minor watercourses that drain surface water in the area. The responsibility for the operation and maintenance of these ditches, local watercourses and general land drainage lies mostly with riparian owners. The local authority has overall responsibility for managing groundwater and land drainage.

The extent of highway drainage is uncertain, but it is likely that highways surface water runs off directly to roadside ditches, some of which will act as soakaways. Oxfordshire County Council is responsible for highways drainage and culverts crossing the highway.

The Environment Agency has the duty and the authority to ensure that the main rivers are maintained appropriately. The responsibility for the maintenance of local watercourses lies with riparian owners.

3 Long-term outcomes

We have listened very carefully to the views of customers before developing our plan for the Asset Management Period 6 (AMP6), regulatory period. Between 2009 and 2013 we carried out over 50 separate customer research and engagement activities.

Beyond being able to maintain the current service that we provide, customers have told us that they would like to see a reduction in instances of sewer flooding and odour nuisance and an improvement in river water quality. These are areas where customers are prepared to pay for an improvement in the current level of service.

In response to this, we have developed 4 company outcomes and 11 service outcomes for our wastewater service that we are committed to working towards over the next 5 years and beyond, further details can be found in Table 1 below and on our website[11].

Table 1 Wastewater outcomes

Company outcome	Wastewater service outcome	Why is this service outcome chosen
We will provide a safe and reliable wastewater service that complies with all necessary standards and is available when our customers require it.	Asset health: maintaining our assets to ensure we can provide a safe and reliable service in the long-term.	We must ensure an appropriate balance between reducing costs today and not compromising our future service.
	Properties and public areas protected from flooding.	Flooding is one of the worst service failures for customers.
	Resilient sewage treatment service that minimises the impact of extreme events on river water quality.	We need to be able to provide service against a variety of pressures such as climate change and population growth.
Our customers and stakeholders can trust us, we are easy to do business with and we care.	Do the basics excellently by getting things right first time.	This service outcome ensures our wholesale activity is completely aligned to our objective to improve our Service Incentive Mechanism (SIM) scoring.
We will provide the level of customer service our customers require, in the most economic and efficient manner, to ensure that bills are no more than necessary.	Reduced dependence on energy from the grid.	Reducing dependence on energy from the grid is one of a range of measures across our entire plan to keep costs down to an affordable level for customers.
We will limit our impact on the environment and achieve a socially responsible, sustainable business for future generations, including reducing levels of leakage.	Minimising our carbon footprint.	There is an expectation from society that we will play our part in reducing carbon emissions.

[11] See http://www.thameswater.co.uk/tw/common/downloads/about%20us%20-%20corporate%20responsibility/AMP6_-_Outcomes_Reporting_Policy.pdf for more information.

Company outcome	Wastewater service outcome	Why is this service outcome chosen
	River water quality meets customers' expectations and regulatory requirements.	We must meet environmental regulations, and river quality is a visible indicator to citizens of our environmental stewardship.
	Satisfactory sludge disposal.	Sludge is a resource that we should manage effectively to keep bills down.
	Corporate responsibility.	We will act as a responsible company, meeting expectations from wider society.
	Reduced odour from wastewater operations.	Odour is a problem for some of our customers.
	Compliance with new environmental regulations.	We must meet environmental regulations, and river quality is a visible indicator to citizens of our environmental stewardship.

Below we provide more information about our asset health, properties and public areas protected from flooding, and river water quality service outcomes, as these are relevant to the Benson drainage strategy.

3.1 Asset health

Our Asset Health performance commitment encompasses a composite range of measures against which we will manage the health of our sewerage network. This commitment underpins our outcome of a safe and reliable wastewater service. It includes sewer collapses, blockages, unconsented category 1 to 3 pollution incidents and properties internally flooded due to operational problems (such as blockages, collapses or equipment failures).

3.2 Properties and public areas protected from flooding

There are two performance commitments that underpin the delivery of this service outcome:

1. We commit to protecting properties from flooding due to rainfall. We estimate that our plan for 2015-20 will result in over 2,100 properties being alleviated from internal flooding, external flooding and also from restricted toilet use (for example when groundwater levels are high following prolonged periods of wet weather). Our customer research indicates that our sewer flooding programme will deliver £20m of benefit to customers every year by 2020.
2. We commit to reducing the risk of sewer flooding and pollution from combined sewers (i.e. those that convey both foul and surface water), by slowing down surface water run-off and re-routing the flow through sustainable drainage measures such as water butts, permeable paving, rain gardens and green roofs. We aim to retrofit over 20 hectares of sustainable drainage measures by 2020. We may also apply this commitment to areas where the network was designed to take foul flow only, but investigation shows that a substantial amount of surface water is in the foul sewer.

3.3 River water quality meets customers' expectations and regulatory requirements

We have a performance commitment to reduce the number of pollution incidents as a result of discharges from our sewerage network and treatment works. Pollution can occur as a result of blockages, collapses or failure of our equipment and also following heavy rainfall when our sewers have insufficient capacity to cope with the flow. All pollution incidents are reported to the Environment Agency's National Incident Recording System (NIRS).

4 Current issues

4.1 Recent wet weather events

The foul sewerage system in parts of the Benson catchment has become overwhelmed for weeks and even months at a time in recent years, following prolonged heavy rainfall and high ground water levels.

This has been associated with significant sewer flooding and restricted toilet use. Based on site reconnaissance that we have carried out we believe that the system has surcharged due to a combination of groundwater infiltration, surface water run-off from saturated fields, surface water inundation from highways, public spaces and properties, fluvial flooding and surface water misconnections. We are confident that this is a comprehensive list of factors that have caused flooding.

The following incidents have been observed with respect to the sewerage network, as outlined in Figure 5 below:

- Internal and external property flooding in the village of Rokemarsh
- Prolonged periods of restricted toilet use in Rokemarsh and Ewelme
- Sewer flooding in Benson in the Littleworth Road area
- Sewer flooding in Crowmarsh Gifford
- One 'Category 3' pollution incident in the village of Ewelme
- Surcharging sewers causing spills out of many public manholes
- Flow and depth monitors in the network and at the sewage treatment works show periods of prolonged high flows indicating a problem with inflows.

During these events, other sources of flooding have also been observed:

- Surface water flooding of highways caused by the highway drainage becoming overwhelmed
- Fluvial flooding of properties, highways and fields caused by local watercourses flooding – Crowmarsh Gifford, Roke, Ewelme and Berrick Salome
- Surface water flooding from water running off fields caused by land drainage issues.

Flow monitors at the inlet works at Benson sewage treatment works shows a prolonged period of high flows from January to May 2014 which strongly indicates the presence of groundwater infiltration and/or fluvial/pluvial inundation into the sewer network.

Figure 5 Benson key performance issues

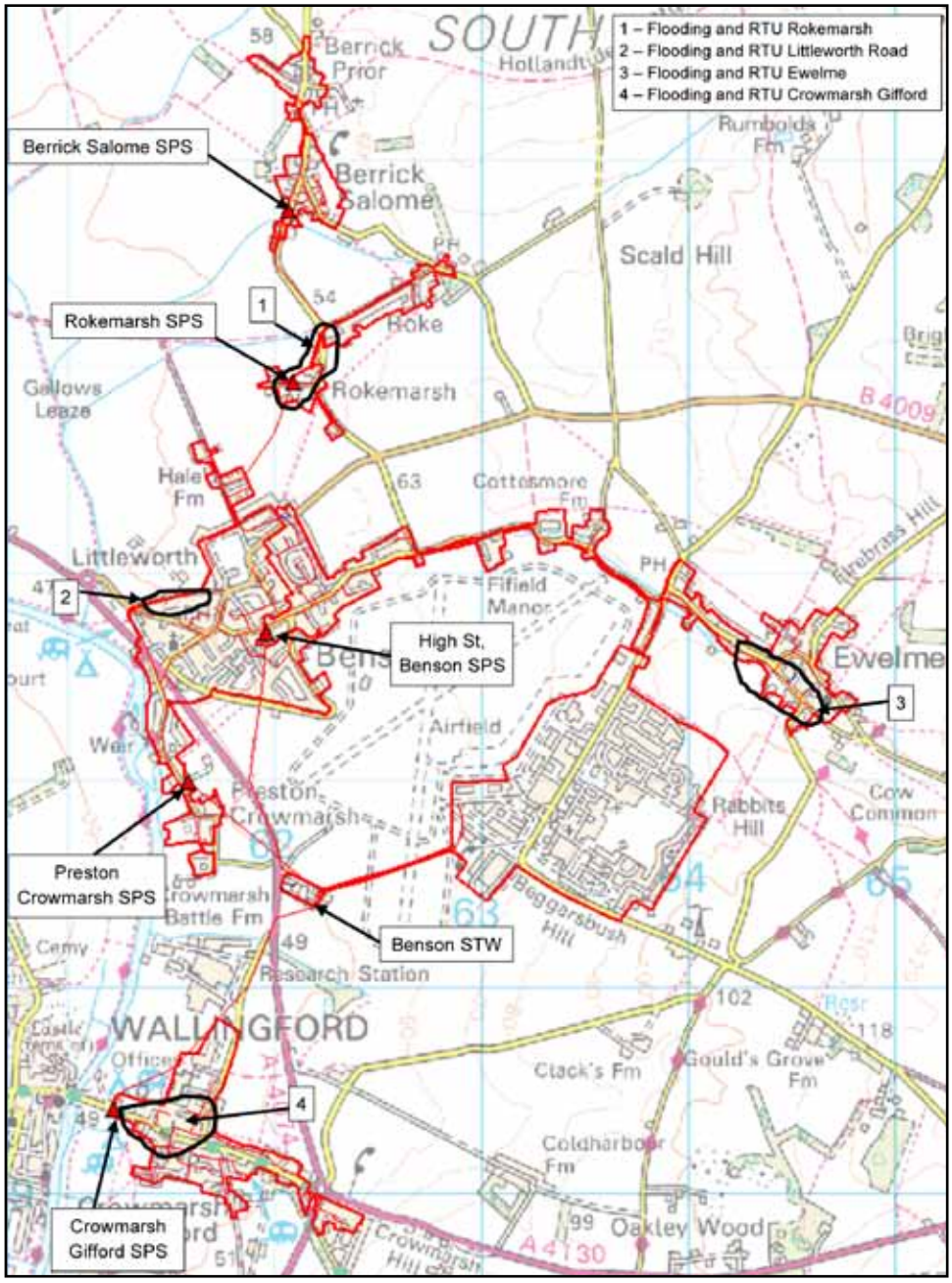
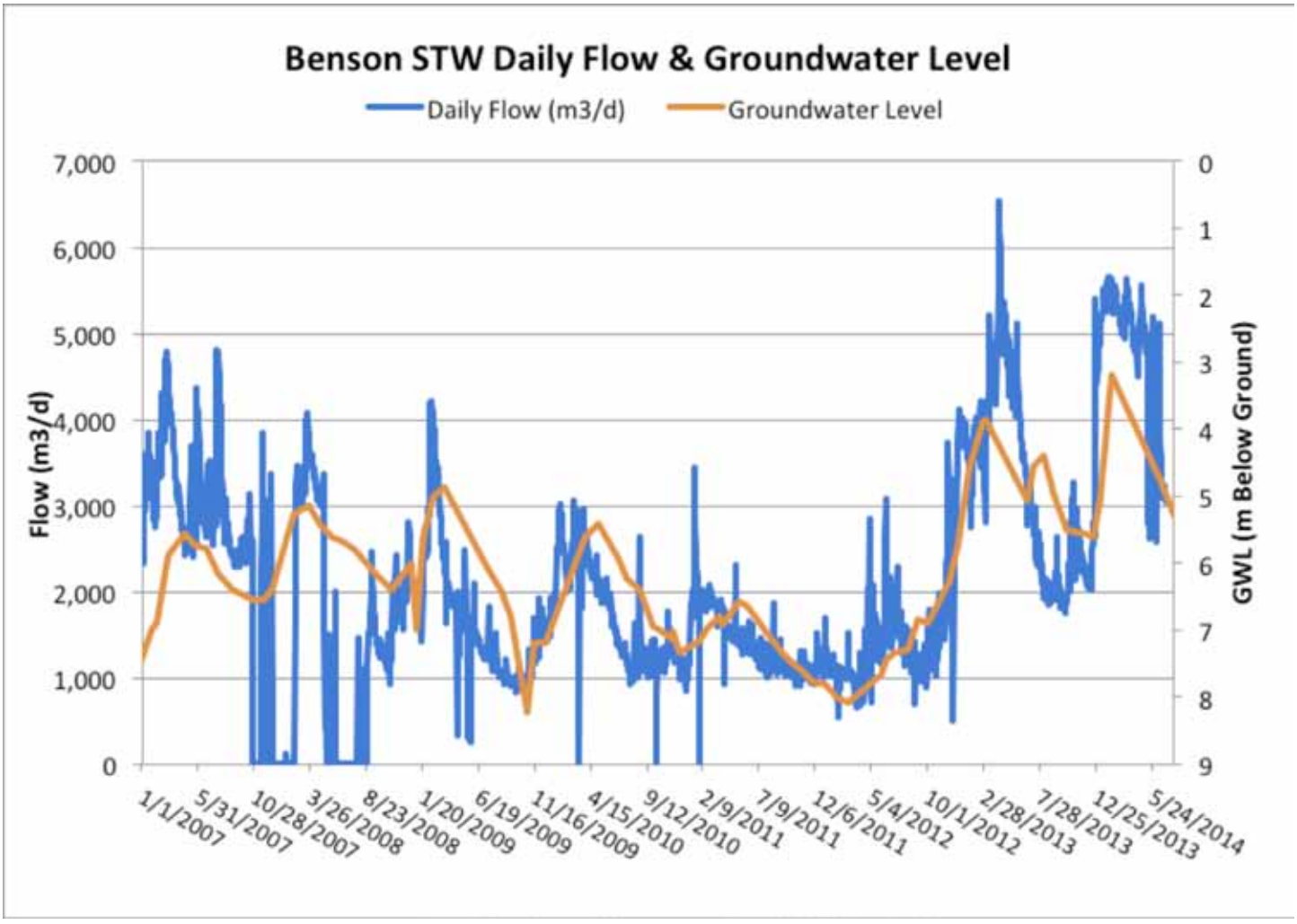


Figure 6 compares the treated flows at Benson sewage treatment works with groundwater levels recorded at the Environment Agency borehole RBHL.2116 located in Ewelme. It can be seen from the graph that periods of high flow to the sewage treatment works correlate well with periods of high groundwater. However, high groundwater levels do not necessarily mean that infiltration levels will be high because pluvial and fluvial flooding will also show a correlation.

Figure 6 Benson Sewage treatment works (STW) treated flows and groundwater levels



4.2 Our operational response

To maintain service, tankers were used extensively in the winter of 2012/13 at Roke pumping station and Benson sewage treatment works to prevent external foul water flooding of properties. In 2012/13 a pump failure at Roke sewage pumping station meant that the station could not keep up with the inflow from Roke and Berrick Salome – the pumping station has subsequently been repaired.

Tankers have limited capacity and can only draw off water at a relatively low rate. They also cause considerable noise and disruption to local communities. Due to the significant impacts of fluvial and groundwater flooding across our region during the winter event of 2013/14, we decided to mobilise our tanker fleet of nearly 100 vehicles to protect our customers most at risk of internal property flooding. For this reason, and recognising the limited effectiveness of tankering following more extreme weather conditions, tankering was not utilised in the Benson catchment and the full fleet of tankers were deployed in other areas.

4.3 Investigations and activities completed to date

Table 2 below, details the investigations and actions that we have completed in recent years within the Benson catchment. These form the extent of our current understanding of issues within the catchment.

Table 2 Investigations and activities completed

Activity	Purpose	Date complete	Outcome
Look and lift surveys	Identify sources of inflows and infiltration whilst the wet weather conditions remained prevalent	Repeated over a number of years	Identified locations for patch lining and sealing of main sewer and lateral connections
Installing NRVs into the network	Non return valves installed to mitigate internal flooding	2010	Numerous non return valves installed on private drainage across the network
Tanker layby	To allow easy tanker access and reduce nuisance when removing flows	2010	Tanker layby built
Sewer repairs	To reduce inflow and infiltration	Spring 2010	67m of sewer was lined in the Roke Rokemarsh SPS area
Reduce Sewer surcharge by tankering	Manage sewer flows to minimise risk of property flooding and pollution incidents	08/02/13	Tanker in regular use in Berrick Salome and Roke between 27/11/12 and 08/02/13
Installing flow monitors at the STW	To provide a baseline and assist in locating sources of inflows and / or infiltration	Aug 2013	Flow monitors have been installed on the two incoming rising mains into the Benson sewage treatment works inlet works
Permanent monitoring of sewer levels	Installation of permanent depth monitors into the foul sewers at key locations in the Benson catchment. Plan is for monitors to remain in situ for at least 5 years and to capture the next wet weather event as a minimum. Analyse the recorded depths and compare with other catchment variables, such as rainfall events and changes in groundwater levels	Aug 2013 and Dec 2014	Use information to identify additional actions for inclusion in the drainage strategy for Benson. Share information with other agencies
CCTV surveys and sewer repairs	Identify sources of inflows and infiltration whilst the wet weather conditions remained prevalent	19/01/14	Informed patch fixing and sealing of main sewer and lateral connections (12/04/13 – 19/01/14)
Wet weather event survey	Identify sources of inflows whilst the wet weather conditions remained prevalent	February 2014	Sources of inundation and surface water ponding identified in Roke and Ewelme
Clean-up	Clear-up of internal and external sewage flooding	17/03/14	9 events between 12/01/13 and 17/03/14
Install low leak manhole covers across network	Reduce inflow from fluvial / pluvial flooding	02/04/14	Specific covers replaced in Roke and Ewelme

In summary, following pervious concerns that the sewerage network suffered excessive infiltration, considerable effort has been taken over a number of years to better understand the sources. Sewer repairs, including lining and patch repairs, have been undertaken across the network to try and limit the inflows, whilst mitigation works in the form of low leak covers, non-return valves and tankering have been undertaken to limit the impact of the flooding. It is clear that although the repairs carried out may have been locally successful, they have not significantly reduced the extent of surcharging and flooding subsequently experienced. This may be due to our earlier work focussing only on the public sewers within our ownership, and not private sewers and drains, or inundation from surface water flooding or misconnected properties. This can only be proven by further survey and investigation activity, which we will undertake as part of this 4-stage framework process.

A number of sewer depth monitors were also installed in the sewer network in 2013 and further depth monitors were installed into the sewer network in March 2015, these will remain in place for a minimum of five years and we will continue to monitor these as our strategy develops through this 4-stage framework process.

4.4 Activities carried out by drainage partners

Table 3 below, details the activities carried out by other stakeholders with drainage responsibilities within the Benson catchment, to reduce the risk of flooding in the area. For more detail on the other organisations responsible for managing various forms of drainage within the catchment, please see Section 1 of this Drainage Strategy document.

Table 3 Actions by other stakeholders to prevent flooding

Activity	Purpose	Impact on sewerage
Routine maintenance of surface water drainage	Increase surface water drainage capacity in Roke and Ewelme	Increased capacity and diversion of localised flows would prevent the inundation of the foul sewer network and significantly reduce problems within Roke and Ewelme
Routine maintenance of local watercourses and drainage ditches	Ensure free flow of river and ditches	Less risk of surface water inundation into the foul sewers and hence less risk of sewer flooding, pollution incidents and storm tank overflows at the sewage treatment works
Routine maintenance of private surface water drainage and soakaways	Ensure adequate surface water drainage from properties	Less risk of surface water inundation into the foul sewers and hence less risk of sewer flooding, pollution incidents and storm tank overflows at the sewage treatment works
Routine maintenance of highway drainage	Ensure adequate highway drainage	Less risk of surface water inundation into the foul sewers and hence less risk of sewer flooding, pollution incidents and storm tank overflows at the sewage treatment works
Strategy for infiltration through private drains*	Consider a strategy for reducing infiltration into the sewer network via private drains if the permanent monitoring identifies this as a significant cause for concern	Less risk of groundwater infiltration into private drains and hence less risk of sewer flooding, pollution incidents and storm tank overflows at the sewage treatment works
Monitoring and control of construction standards for private drains	Local Authority Building Control to ensure private drainage is fit for purpose	Less risk of groundwater infiltration into private drains and hence less risk of sewer flooding, pollution incidents and storm tank overflows at the sewage treatment works
Sharing of information	Agencies to share information to ensure collaborative approach to groundwater infiltration, surface water inundation, pluvial and fluvial flooding	Identification of most cost beneficial solutions and quicker resolution of issues

*Thames Water does not have powers to compel customers to repair defective private drains at their cost. At this stage, we do not have the data to show how significant infiltration from private drains is within the Benson catchment, but we will develop an appropriate strategy when this information becomes available. We note that local authorities are only able to instigate action under Section 59 of the Building Act where evidence is provided of a defective private drain.

5 Future challenges

In 2011, Ofwat commissioned Mott MacDonald to look at factors likely to affect sewerage networks in the future. The report 'Future impacts on sewer systems in England and Wales' (June 2011)[12] looked at the likely relative impact of climate change, population growth and impermeable areas up to around 2040. In preparing our plan for 2015-2020, we have also carried out research into these factors across the Thames Water region. We summarise our findings for the Benson catchment in this section.

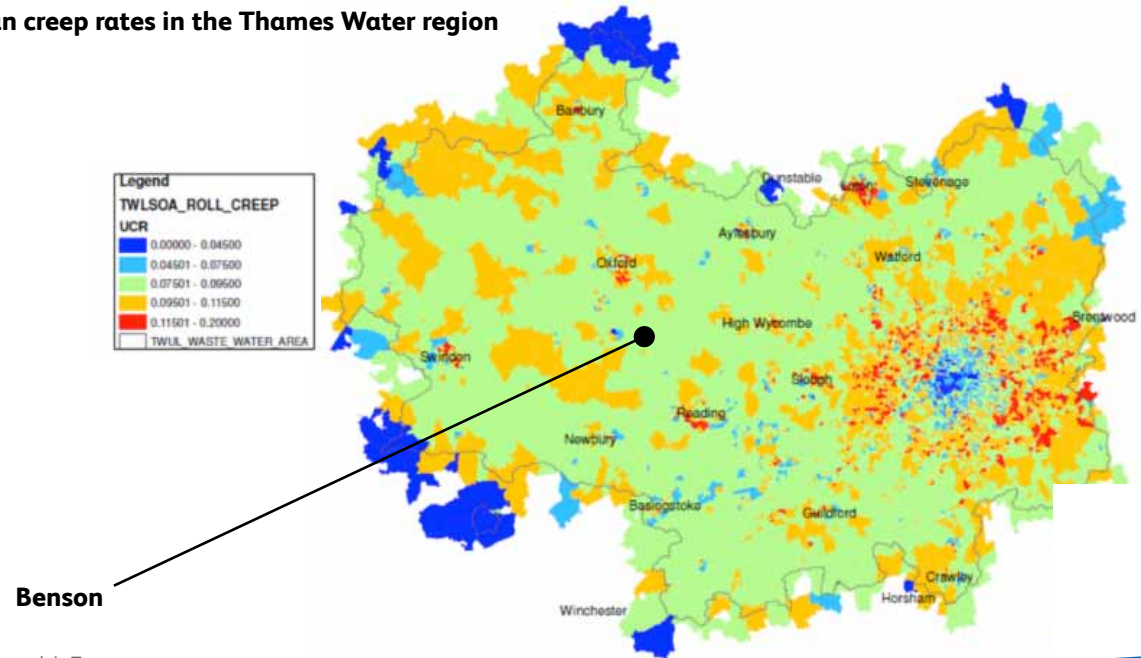
5.1 Urban creep

Urban creep is defined as the transformation of a catchment by the paving over of previously permeable areas. Rather than surface water soaking into the ground when it rains heavily, more water runs off into the sewerage network and can cause the sewers to surcharge and flood. It is therefore important to understand the rate at which urban creep is occurring.

We have studied aerial photography and satellite imagery across 11 catchments across the Thames Water region using data from two periods in the late 1990s and mid-2000s to determine the rate at which urban creep is occurring. We then carried out a statistical analysis and built a model to predict the rate of urban creep for the entire Thames Water region, taking account of factors such as property age, land use, demographics such as family sizes and financial income, need and available space. We found that affluent suburban areas with detached and semi-detached properties, where families have young children, are most likely to have high urban creep rates.

The results for the Thames Region are presented in Figure 7 below. The urban creep rate for Benson is 0.0879%. In other words, this is the increase in impermeable area per year as a percentage of the total area connected to the sewerage network. When compared against the rest of the Thames Water region, Benson is about average, but not as high as suburban areas around central London and major towns. Whilst the immediate issues in Benson appear to be strongly related to groundwater, we will continue to monitor change in impermeable area as the strategy continues to develop. If we observe an increase in urban creep, we will raise the issue with Oxfordshire County Council who is responsible for managing surface water. We may then also look to retrofit sustainable drainage measures (such as permeable paving and water butts) in the area to counter the increased run-off following rainfall, to reduce the risk of flooding.

Figure 7 Urban creep rates in the Thames Water region



[12] Mott MacDonald, Future impacts on sewer systems in England and Wales, June 2011.

5.2 Climate change

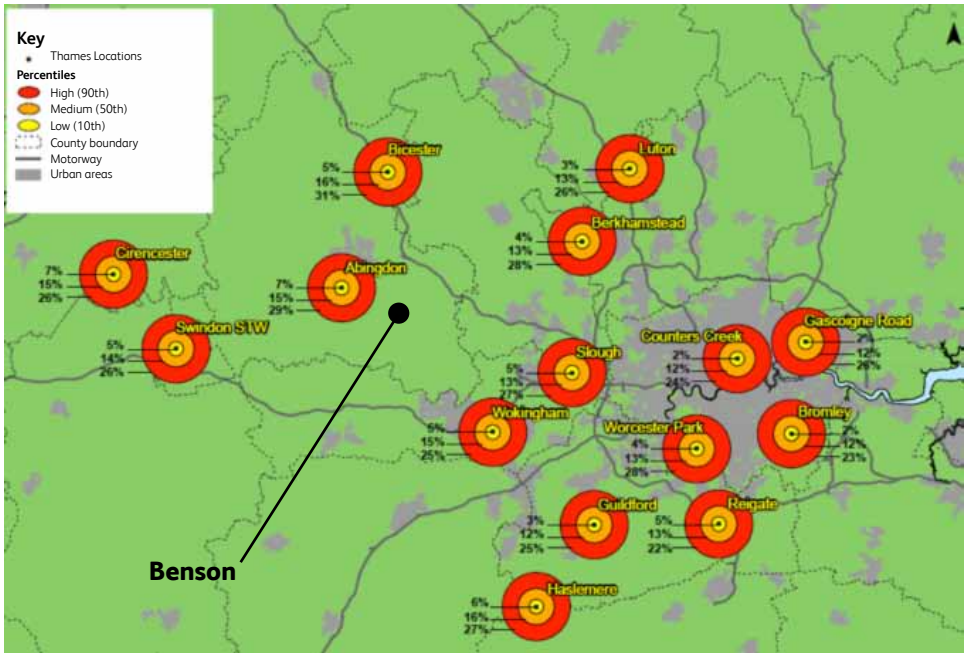
We have analysed the 2009 UK Climate Projections (UKCP09), to determine the likely increase in rainfall intensity due to climate change in 15 catchments across our region[13]. More intensive rainfall in the future will increase the peak flow in sewerage networks and with it the likelihood of sewer flooding.

15 catchments across our region were selected to give a representative sample of inner London, outer London and more rural areas in the Thames Valley. A number of these catchments are also areas which experience sewerage related issues like pollution, flooding and urban creep.

We assessed different combinations of emission scenarios and climate change percentiles for each of the 15 catchments.

The nearest catchment to Benson that was analysed was Abingdon. The results show a central estimate of an increase of 15 % in rainfall by 2080, but in some scenarios this could be as high as 29 % or as low as 7 %, as per Figure 8 below. We will ensure that our strategy takes account of these potential increased peak flows as it develops.

Figure 8 Locations assessed for increased rainfall intensity by 2080



Increased rainfall intensity may not be the only consequence of climate change. UKCP09 data also suggests that the UK is likely experience longer wetter winters in future. Further research is needed to understand whether high groundwater levels, such as those observed in the winters of 2012/13 and 2013/14 are likely to become more frequent in future. As the recent experience of prolonged rainfall and high groundwater levels have been shown to be the principal factors, this research will be very significant in informing any risk assessment and appraisal of costs and benefits of solutions.

[13] Atkins, Thames UKCP09 Rainfall Intensity Assessment Revised Report, October 2012.

5.3 Population growth and new development

We use a combination of top-down and bottom-up information to ensure that our forecast of population and new development is as robust as possible to keep costs down, in order to minimise the bill impact of any investment that may be necessary.

Our forecast of the number of new households is taken directly from Experian data. We have used the 'Plan-Based' projection, which uses information provided by local authorities about planned numbers of new dwellings in their respective areas. During the period 2015 to 2020 we expect to see an increase in new development across that Thames Water region and are forecasting a total of 263,000 new connections to the sewerage network during this time.

Our Development Tracker System (DTS), is used to track developer enquiries through the planning process to construction. When we are contacted by a developer, we typically carry out preliminary modelling to determine whether our network or treatment works has the capacity to accommodate the increase in flow. Where it does not, we propose planning conditions for consideration by the Planning Authority, although we encourage developers to contact us as early as possible in the planning process to avoid this.

The independent review into the causes of the 2007 floods (The Pitt Review), concluded Sustainable Drainage Systems (commonly known as SuDS), are an effective way to reduce the risk of 'flash-flooding' which occurs when rainwater rapidly flows into the public sewerage and drainage systems, causing overloading and back-up of water. Typically, SuDS slow the rate of surface water run-off entry into the drainage system and improve the percolating feature, ie rainfall recharging the groundwater system, thus mimicking natural drainage processes. In April 2015, the Government made changes to the planning process effecting planning policies and decisions on planning applications of 10 dwellings or more (or equivalent non-residential or mixed development), to ensure that sustainable drainage systems are put in place, unless demonstrated to be inappropriate. This requires that when considering planning applications, local planning authorities should consult the relevant Lead Local Flood Authority (County Council or Unitary Authority), on the management of surface water, to satisfy themselves that the proposed standards of operation are appropriate and ensure, through the use of planning conditions or planning obligations, that there are clear arrangements in place for ongoing maintenance over the lifetime of the development.

In the case of Benson, whilst SuDS might help to reduce the risk of flooding following rainfall when groundwater levels are low (i.e. typically during summer months), they may not be as effective in reducing the flood risk when groundwater levels are high (typically during the winter months). We will therefore take account of the potential influence of groundwater when we come to assess any options as part of this drainage strategy framework process.

South Oxfordshire District Council's Core Strategy allocates 1,154 homes to the

larger villages within the District and indicates that they need to find sites for at least 125 new homes in Benson. They advise that have not found any suitable brownfield sites for re-use so have looked at all the land around the edge of the village. Their Strategic Housing Land Availability Assessment shows sites they have identified and provides a summary of their potential. Further details are available on the South Oxfordshire District Council website.

Using sources that include the South Oxfordshire District Council Development Plan, South Oxfordshire Strategic Land Availability Assessment and third party planning enquiries, the key development sites that we are currently tracking in Benson include:

- Commercial development equivalent to net increase of 11 properties on Agrivert Compost Site, Battle Farm, Benson Lane, Preston Crowmarsh
- Commercial development equivalent to net increase of 47 properties on RAF Benson, Benson, OX10 6AA
- 100 dwellings at Howbery Park, Benson Lane
- 100 dwellings at Field Opp 53, Watlington Road, Benson.

Other applications exist but relate to developments where detailed numbers have either not been confirmed or are fewer than 10 properties. We will continue to monitor future plans for the catchment through our stakeholder engagement work.

Concerns have been raised with South Oxforshire District Council requesting that drainage conditions should be imposed on the more recent planning applications we asked that impact studies are undertaken. A key element of our assessments will be to establish the extent to which these developments may be significant in the context of the sewer flooding challenges currently experienced in the catchment. This assessment work will be undertaken and findings shared in an update to this Strategy document.

6 Strategy development

The Drainage Strategy for the Benson catchment is currently at Stage 1 (Initialise/prepare), of the 4-stage framework process. The following activities in Table 4, are planned and ongoing, in order to carry out the risk assessment and development of our strategy options.

Table 4 Activities planned and ongoing to enable strategy development

Activity	Purpose	Date planned	Outcome
Stakeholder engagement	This document will be circulated to the Environment Agency, Oxfordshire County Council (as Lead Local Flood Authority) and South Oxfordshire District Council (as local planning authority) before being published on our website for formal consultation. Flood forums will continue to be used as the primary route for stakeholder engagement	Ongoing	Stakeholders informed about progress and timing of works to reduce the risk of flooding. Work carried out by Thames Water is coordinated with activities of other partners involved with drainage
Customer surveys	Validate the historical records of flooding and restricted toilet use in the catchment to enable a detailed benefits assessment of potential further intervention options that could be implemented by Thames Water	From winter 2015	Use information to help test the cost benefit of options to improve drainage and reduce the risk of sewer flooding in Benson
Permanent monitoring of sewer levels	Continue monitoring sewer depth monitors installed last year. Plan is for monitors to remain in situ for at least 5 years and to capture the next wet weather event as a minimum. Analyse the recorded depths and compare with other catchment variables, such as rainfall events and changes in groundwater levels	Ongoing	Use information to identify additional actions for inclusion in the drainage strategy for Benson. Share information with other agencies
Connectivity surveys and private drainage inspections	CCTV survey and visual inspection of properties to determine the extent of roof drainage and other surface water drainage that discharges into the foul sewer network when appropriate	From winter 2015	A better understanding of the contribution that misconnections make to sewer flooding in the area
Sewer and manhole surveys	Ascertain sewer and manhole condition and evidence of infiltration via CCTV survey and manhole "lift and look" surveys when appropriate	From winter 2015	Use information to identify additional actions for inclusion in the drainage strategy for Benson. Share information with other agencies
Sewer repairs	Repairs to damaged and defective pipework as and when identified	Ongoing	Reduce ingress of groundwater into sewer network
Impact study	Hydraulic model build and verification to understand the impact of development in Crowmarsh Gifford	Ongoing	Identify impact and potential network requirements to accommodate growth

Activity	Purpose	Date planned	Outcome
Update drainage strategy	To improve the drainage strategy based on the initial results from the permanent monitoring, customer surveys, misconnection surveys and feedback from stakeholders	2017	Risk assessment, options appraisal and preferred strategy to be completed, subject to capturing weather events through monitoring and surveys
Pilot trials of mobile treatment plant	As part of our wider approach to managing high groundwater levels, we are trialling the use of biological filters elsewhere. Our findings will inform and may influence our strategy plans for the Benson catchment. If successful, these could be used to abstract dilute sewage from surcharged sewers and discharge it safely to a watercourse	Ongoing	Service may be restored for customers without the need for tankering
Consider innovative solutions	To identify quicker / cheaper / collaborative options that improve the benefit to cost ratio in order to keep customers' bills down, to prioritise investment and to ensure greatest benefit to customers	Ongoing	Enhanced toolkit available to reduce the risk of sewer flooding and then apply this once data becomes available

7 Preferred strategy and plan

We believe that the foul sewerage system in parts of the Benson catchment has surcharged and flooded predominantly due to a combination of groundwater infiltration, surface water run-off from saturated fields, surface water inundation from highways and public spaces, fluvial flooding and surface water misconnections.

Our network strategy is to understand the relative impact that each of these factors has on the risk of sewer flooding, and then to develop a plan comprising cost beneficial solutions using customer willingness to pay research. In parallel, we will assess the extent to which new developments may be significant in the context of challenges currently experienced and where necessary we will develop solutions to accommodate the proposed development in the catchment.

We may carry out some repair works as this strategy develops, in the event that our investigations identify faults or problems with the sewerage network that are highly likely to have caused flooding. Table 5 below, details the repair activities that we have identified to date.

Table 5 Activities identified in preferred plan to date

Activity	Purpose	Date planned	Outcome
Replacement of manhole covers	Installation of low leak covers in areas deemed to be at risk of inflows from river, land drainage or highway	When identified	To reduce the risk of inundation of the foul sewer network
Permanent monitoring of sewer levels	Continued monitoring of depth monitors for at least 5 years and to capture the next wet weather event as a minimum. Analyse the recorded depths and compare with other catchment variables, such as rainfall events and changes in groundwater levels	Ongoing	To identify additional actions for inclusion in the Drainage Strategy for Benson

Our plan will be updated once the Risk Assessment and Options Appraisal sections have been completed in accordance with the Drainage Strategy framework.

8 Temporary overflows

We have not installed temporary pipework and pumps in the sewerage network during wet weather events in the Benson catchment to maintain service, but we would consider doing so to prevent the backup of sewerage into customers' properties and uncontrolled spilling from the sewer system into the environment.

As part of the stage 2 risk assessment and stage 3 options appraisal, we will be investigating the circumstances under which emergency discharges would be required in future, such as the use of temporary overflows, to pump out from the sewerage network through biological filters to maintain service to customers and prevent homes from flooding. As this Drainage Strategy develops, in this section we will describe the location of any proposed temporary overflows and the circumstances under which we would use them, in order that this Drainage Strategy, together with our plans to reduce infiltration, fully meets the requirements of an Infiltration Reduction Plan as set out in the Environment Agency's Regulatory Position Statement. We will continue to identify sewer rehabilitation and other permanent works to reduce groundwater infiltration alongside refining the use of temporary overflows.

Appendix A
Glossary of terms

Term	Definition
Blockages	Obstacles or the build-up of fat and grease, block or obstruct our sewerage pipes. This is normally caused by things which should not be flushed, or poured, into drains and sewers.
Combined sewer	A pipe conveying the combined rainwater and contaminated wastewater from two or more properties. A combined sewer is designed to carry wastewater to a sewage works for treatment but during periods of heavy rainfall or snowmelt, the volume in a combined sewer system can exceed the capacity of the sewer system or treatment plant. For this reason, combined sewer systems are designed to overflow occasionally and discharge excess wastewater directly to nearby streams, rivers, or other water courses.
Dry weather flow	The average flow rate observed over a 24 hour period in dry weather and based on Sewers for Adoption, the industry standard, includes an allowance for infiltration of 10% of the calculated flow rate.
Foul drain	A pipe conveying the contaminated wastewater from a single property. If the pipe extends beyond the property boundary, the portion of the pipe outside of the boundary is termed a lateral drain. The portion of the pipe inside the boundary is a private drain. On 1 October 2011 water and sewerage companies in England and Wales became responsible for lateral drains, which were previously the responsibility of property owners. Private drains remain the responsibility of property owners.
Foul sewer	A pipe conveying the sewage from two or more properties. On 1 October 2011, water and sewerage companies in England and Wales also became responsible for private sewers, which were previously the responsibility of property owners. A foul sewer is designed to carry contaminated wastewater to a sewage works for treatment. It disposes of wastewater from sources including toilets, baths, showers, kitchen sinks, washing machines and dishwashers.
Infiltration	Groundwater finds its way into the sewerage system (including private drains), via defective pipes or pipe joints and through the brickwork or defects in manhole structures.
Inundation	Accumulated surface water from rain and/or river floodwater that has resulted in localised flooding, finds its way into the sewerage system through manhole covers and drains. These may be public or private.
Lateral drain	See definition for Foul drain.
Misconnections (surface water to foul water)	Property owners have connected rainwater and/or land drainage to our sewers (e.g. roof drainage, paved driveways drains, soakaway overflows), and can cause major issues for the performance of the sewerage system.
Misconnections (foul water to surface water)	A plumbing mistake resulting in wastewater appliances being misconnected to the surface water system.
Private sewers	See definition for Foul sewer.
Rainfall induced infiltration	Sewer infiltration that occurs as a result of rainfall percolating into the ground impacting the sewer on route to recharging the groundwater table.
Riparian owner	If you own land adjoining, above or with a watercourse running through it, you have certain rights and responsibilities. In legal terms you are a 'riparian owner'. If you rent the land, you should agree with the owner who will manage these rights and responsibilities.
Soakaway	Surface water from a roof and driveway of a property is piped to an underground pit, usually filled with gravel or similar material. Some soakaways are situated within the boundary of the property.
Surface water drain	A pipe conveying uncontaminated rainwater from a single property.
Surface water sewer	A pipe containing uncontaminated rainwater from two or more properties. A surface water sewer is designed to dispose of rainwater from roofs, driveways, patios, roads, etc to a local watercourse.
Sustainable Drainage Systems (SuDS)	Measures designed to attenuate and slow down surface water before it enters sewers to reduce the risk of flooding following heavy rainfall. Includes green infrastructure such as raingardens, green roofs as well as other measures, such as permeable paving and water butts.

Appendix B
Supporting figures and photographs

Figure B1 Fluvial flood risk for Benson based on Environment Agency plans

This flood risk map information has been sourced from the Environment Agency website. For more detailed flood map information for this catchment, please access the Environment Agency website.

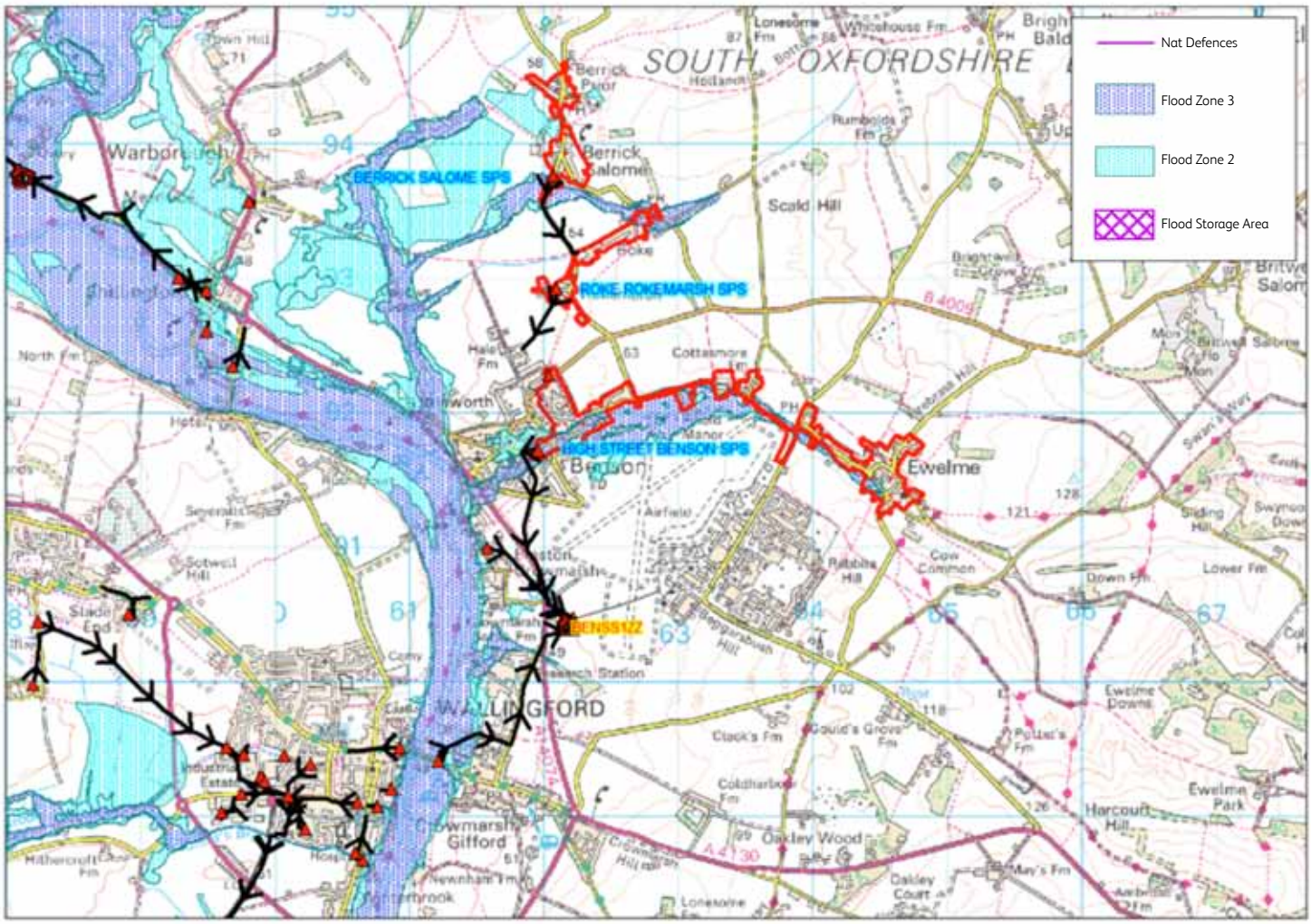


Figure B2 Surface water flood risk for Benson based on Environment Agency plans

This flood risk map information has been sourced from the Environment Agency website. For more detailed flood map information for this catchment, please access the Environment Agency website.

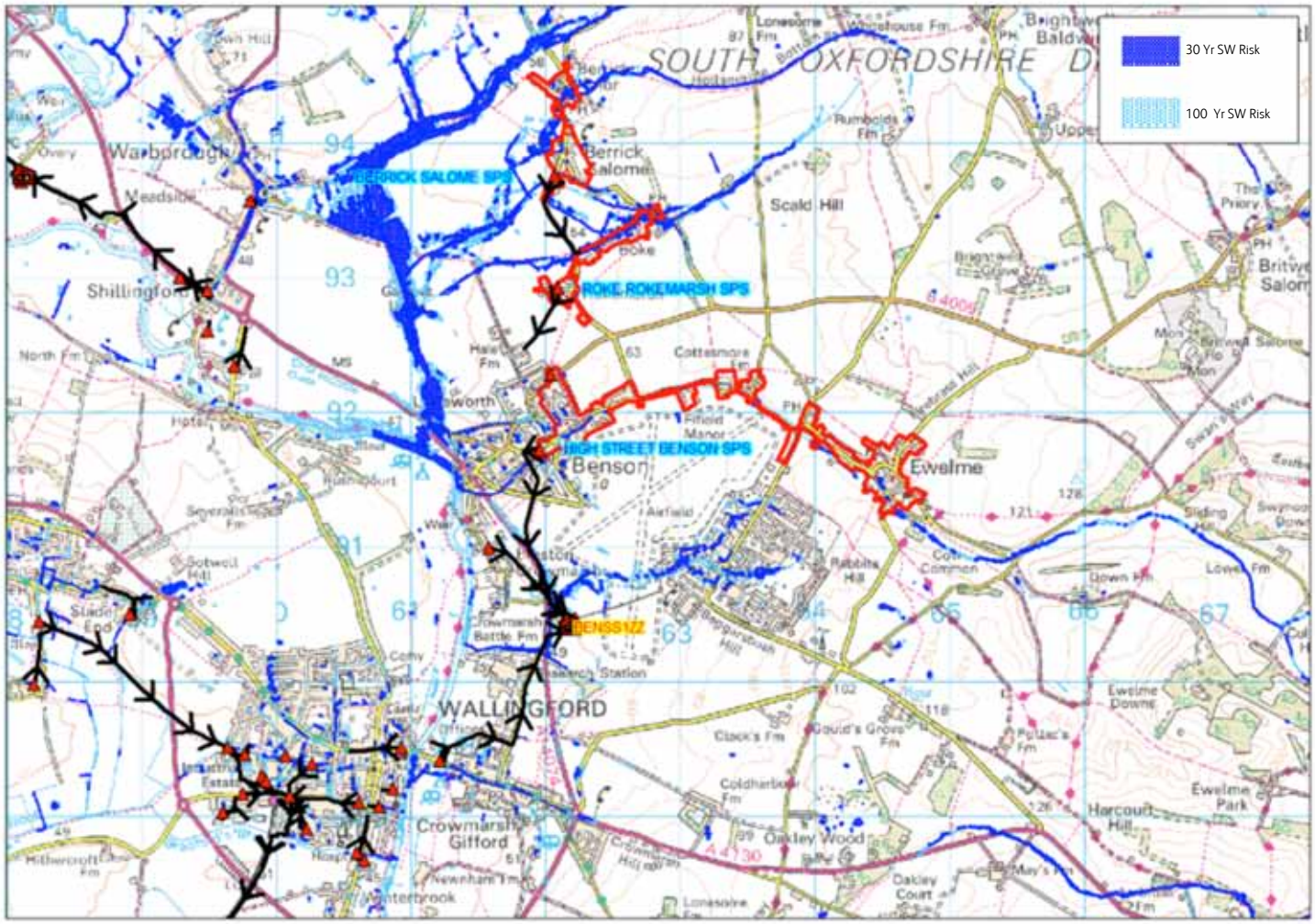


Figure B3 Benson watercourse quality based on Environment Agency plans

This watercourse map information has been sourced from the Environment Agency website. For more detailed flood map information for this catchment, please access the Environment Agency website.

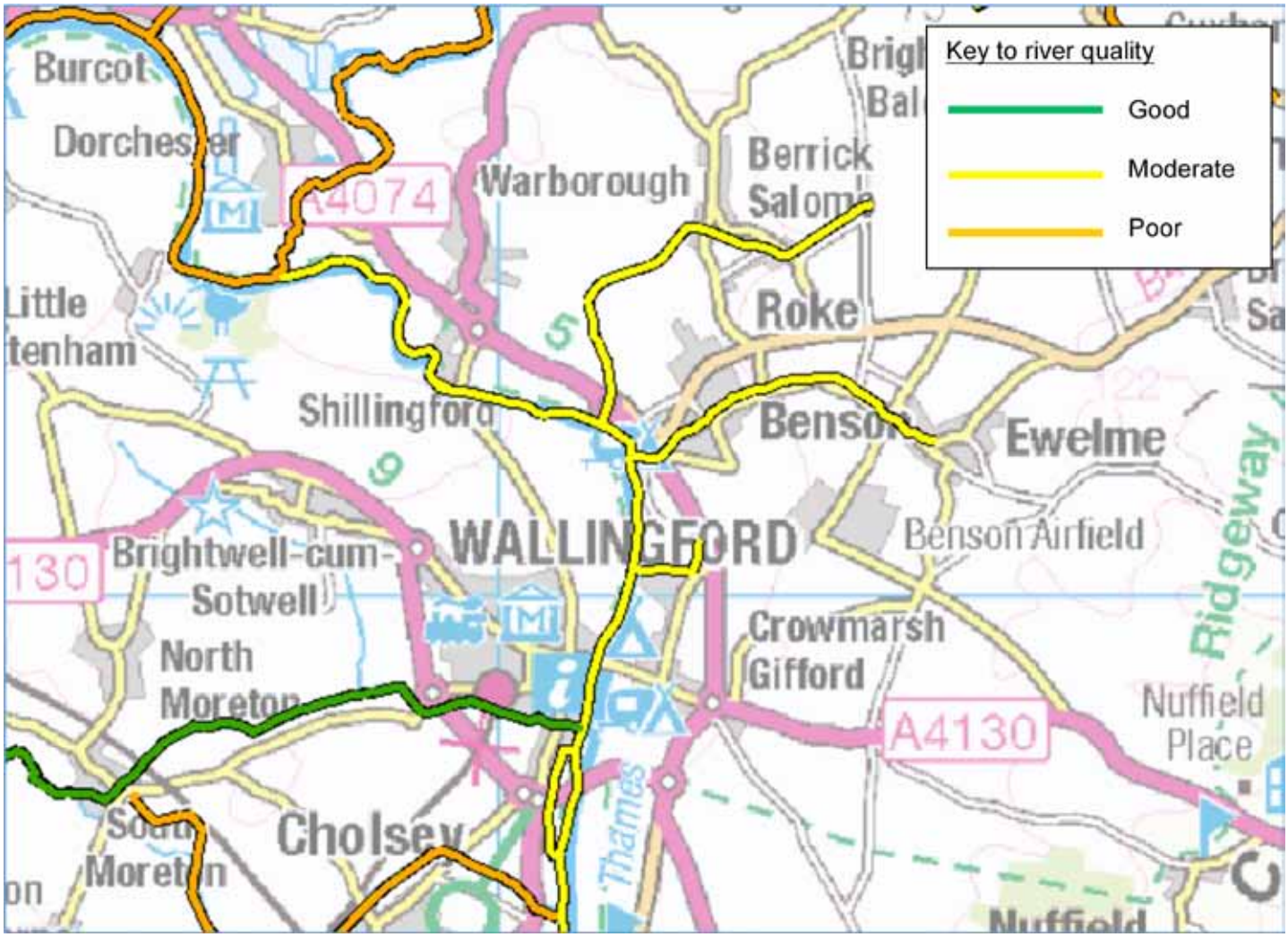


Figure B4 Bedrock and drift geology for Benson showing chalk extent based on BGS plans

This geological map information has been sourced from the British Geological Survey website. For more detailed geological information for this catchment, please access the British Geological Survey website.

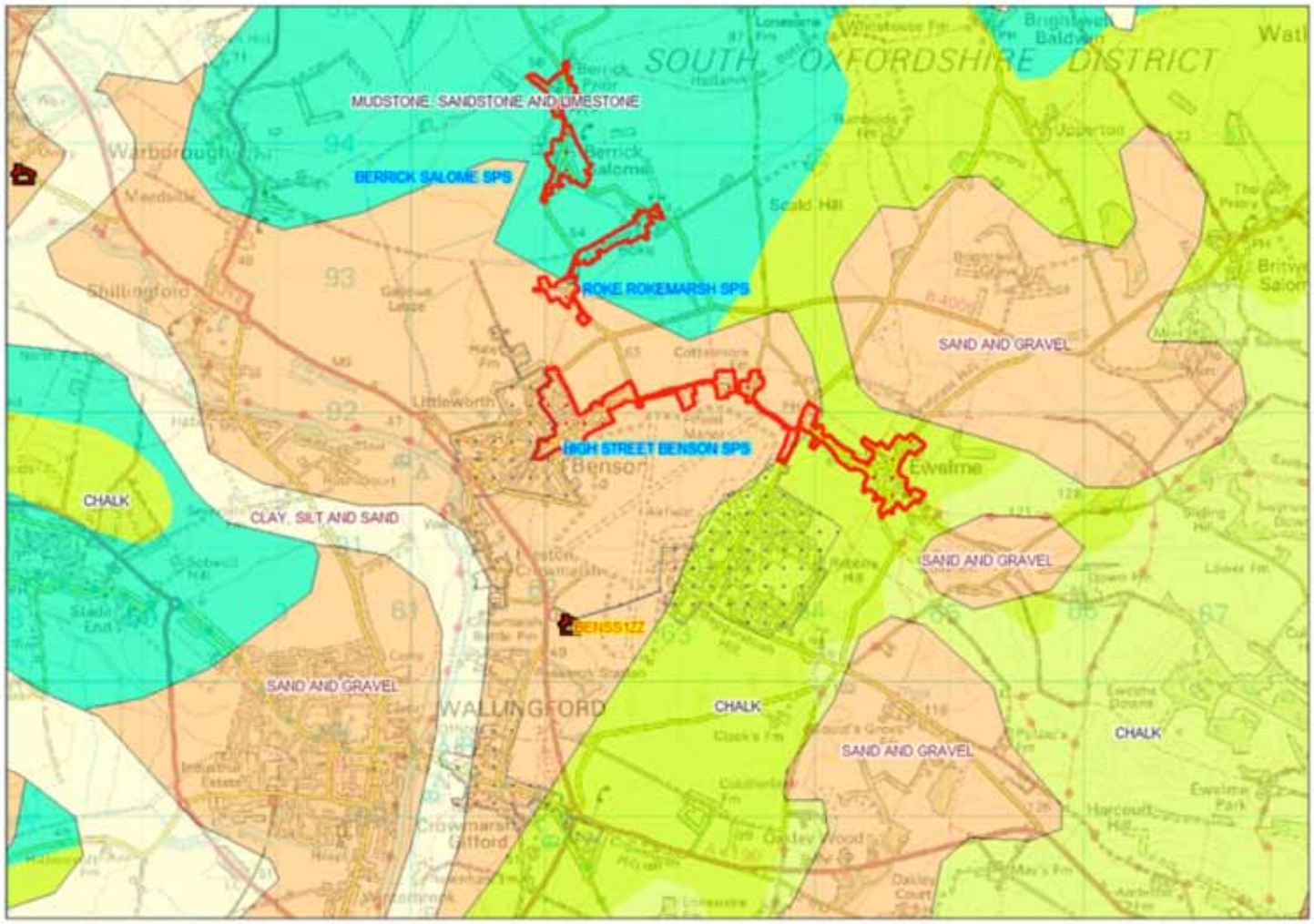
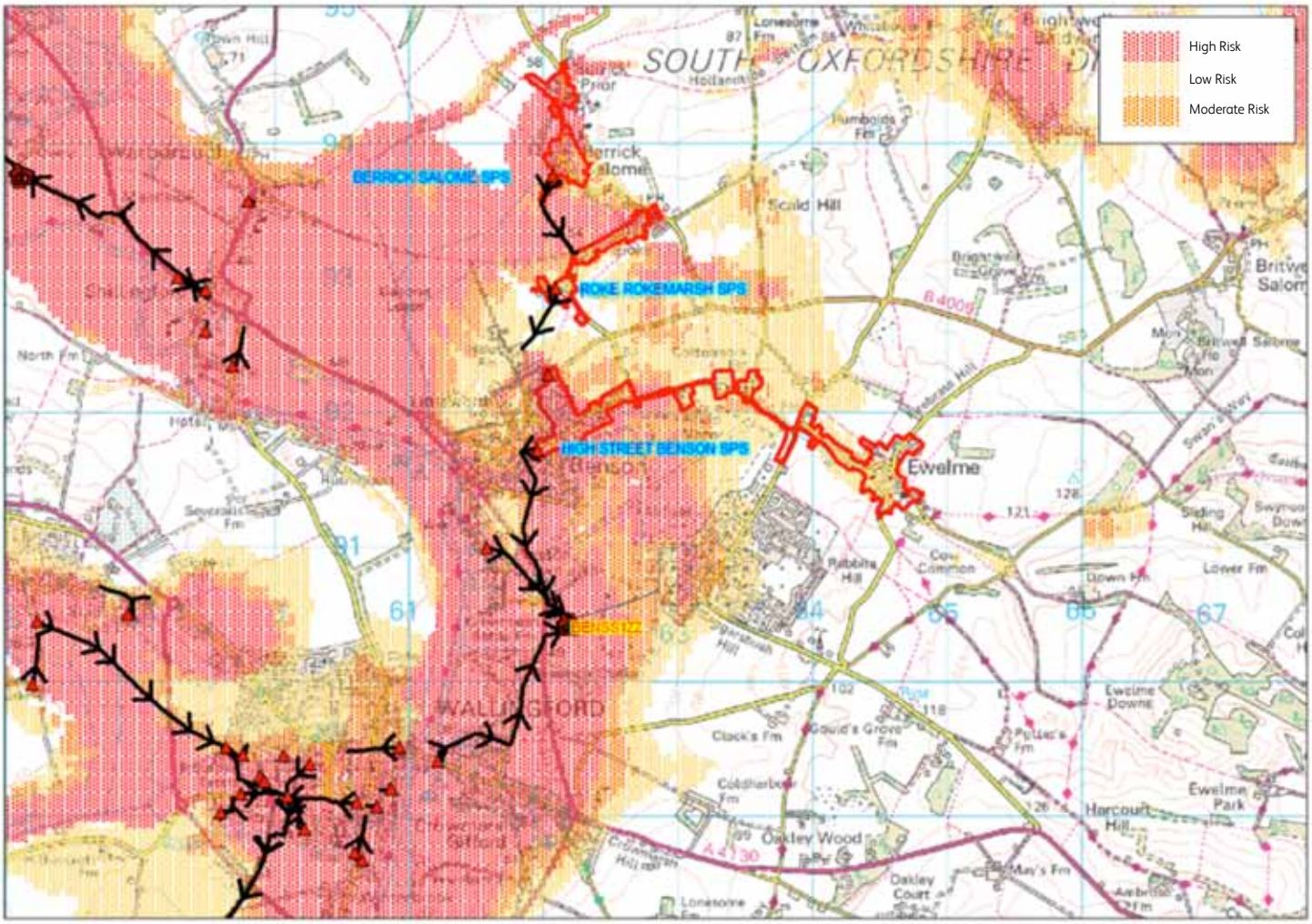


Figure B4 Groundwater flood risk for Benson based on ESI plans

This groundwater flood risk map information has been sourced from ESI Ltd.



ESI Groundwater Flood Risk Map of England and Wales © www.esinternational.com

Photo 1 – Highway flooding in Roke due to land drainage – Feb 2014

Photo 2 – Land drainage and sewer flooding, Roke - Feb 2014

Photo 3 – Property protection from highway flooding, Ewelme - Feb 2014

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