User Guide

It is anticipated that this Level 1 SFRA will have several end users with slightly different requirements; this Section describes how to use the SFRA and how to navigate the report and mapping deliverables. The report is set out as follows:

- Section 1 Introduction
- Section 2 Planning Policy and Guidance
- Section 3 Methodology
- Section 4 Assessing Flood Risk
- Section 5 Avoiding Flood Risk
- Section 6 Managing and Mitigating Flood Risk
- Section 7 Site Specific FRA guidance
- Section 8 Recommendations for Policy and Practice
- Section 9 Next Steps
- Appendix A – Figures
- Appendix B – Data Register

Strategic Planning and Policy

The main purpose of the Level 1 SFRA for London Borough of Croydon (LB Croydon) as explained in the National Planning Policy Framework (NPPF)[1], is to provide a strategic overview of flood risk within the Planning Authority Area in order to enable effective risk-based strategic planning for the future, through the preparation of the Local Plan. Sections 2 to 4 present the information that should be used by LB Croydon to inform their knowledge of flood risk from all sources throughout their area.

As part of this SFRA, several policy options have been developed and presented in Section 8. These should be taken forward to inform the application of the Sequential and Exception Test during the process of allocating development within the Planning Authority Area.

Applying the Sequential Test

The NPPF sets strict tests to protect people and property from flooding which all Local Planning Authorities (LPAs) are expected to follow. The aim of the Sequential Test, under the NPPF, is to steer new development to areas with the lowest probability of flooding. Section 5 provides specific guidance on applying both the Sequential and, where appropriate, Exception Test.

Compliance with the Exception Test requires a detailed assessment of flood risk to a specific site, for example to quantify flood hazard. This level of information is provided in a Level 2 SFRA and is not addressed in this Level 1 SFRA report.

Emergency Planning

LB Croydon is a Category One Responder under the Civil Contingencies Act 2004[2] and therefore has a responsibility, along with other risk management authorities, to develop emergency plans to help reduce, control or ease the effects of an emergency.

The Level 1 SFRA deliverables should be used by LB Croydon's Emergency Planning team as a useful source of up to date information about flood risk. The SFRA should be reviewed by the team, such that the findings can be

[1] MHCLG (July 2018 - updated February 2019). *Revised National Planning Policy Framework*. Available at: https://www.gov.uk/government/collections/revised-national-planning-policy-framework
[2] HSMO (2004) Civil Contingencies Act. Available from: http://www.legislation.gov.uk/ukpga/2004/36/contents

1. Introduction

1.1 Background

1.1.1 In its role as the Local Planning Authority (LPA), Croydon Council is currently preparing documents to support the Croydon Local Plan Review to develop the vision for future development across the Borough.

1.1.2 The National Planning Policy Framework[5] (NPPF) and accompanying Planning Practice Guidance (PPG)[6] emphasise the responsibilities for LPAs to ensure that flood risk is understood and managed effectively using a risk-based approach through all stages of the planning process. As such, LPAs are required to undertake a Strategic Flood Risk Assessment (SFRA) to support the preparation of their Local Plan.

1.1.3 AECOM has been commissioned by LB Croydon to review and revise their existing SFRA which was a joint document with the London Borough of Merton, London Borough of Sutton and London Borough of Wandsworth, completed in December 2016. This updated Level 1 SFRA is a standalone document for the London Borough of Croydon and the methodology applied complies with the NPPF[5] as well as the updated guidance from the Environment Agency (August 2019). The SFRA has been completed in collaboration with LB Croydon, the Environment Agency and Thames Water. The results of this SFRA are intended to inform strategic land use planning and decision making from a flood risk perspective and to support the development of the Local Plan Review.

1.2 Study Area

1.2.1 The study area is defined by the administrative boundary of the London Borough of Croydon, located in south London. London Borough of Croydon borders the London Boroughs of Merton and Lambeth to the north, London Borough of Bromley to the east, London Borough of Sutton to the west, and Surrey County to the south.

1.2.2 The Borough boundary encompasses an area of 8,600 ha and comprises of four Environment Agency designated Main Rivers; the River Wandle, the Norbury Brook, Caterham Bourne which a is tributary of the River Wandle, and Chaffinch Brook, which is a tributary of the Ravensbourne.

Topography

1.2.3 The Borough topography, as shown in Figure 1.1, is characterised by steep slopes in Coulsdon in the south of the Borough which then level off to flatter land in the north. Brighton Road is in a natural valley, which is the flow path of the former River Wandle, now entirely culverted until it emerges at Wandle Park in South Croydon.

1.2.4 Much of the Borough drains into the catchment of the River Wandle, which passes into London Borough of Sutton. The northern part of the Borough drains into the Norbury Brook which feeds into the River Wandle further downstream. The south-eastern part of the Borough including the settlements of Forestdale and Addington is characterised by steeper topography and more rural land which drains into the tributaries of the River Ravensbourne which flows eastwards into London Borough of Bromley.

[5] Ministry of Housing, Communities and Local Government. February 2019. *National Planning Policy Framework*. Available at: https://www.gov.uk/government/collections/revised-national-planning-policy-framework
[6] Communities and Local Government. 6th March 2014. Planning Practice Guidance: Flood Risk and Coastal Change. Available at: http://planningguidance.planningportal.gov.uk/blog/guidance/flood-risk-and-coastal-change/

4. Assessing Flood Risk

4.1 River Flooding

River Network

4.1.1 All watercourses in England and Wales are classified as either 'Main Rivers' or 'Ordinary Watercourses'. The difference between the two classifications is based largely on the perceived 'importance' of the watercourse with reference to its potential to cause significant and widespread flooding. However, it is not always the case the watercourses classed as ordinary watercourses can cause localised flooding.

4.1.2 The Environment Agency 'Detailed River Network' dataset has been used to identify watercourses in the study area and their designation (i.e. Main River or Ordinary Watercourse). The Environment Agency 'Statutory Main River Map' has been used to map the main rivers within the borough.

Appendix A Figure 1 Flood Map for Planning (Rivers and Sea)

4.1.3 There are four Main Rivers present within the Borough (Norbury Brook, River Wandle, Caterham Bourne and the Chaffinch Brook) as described below.

Norbury Brook

4.1.4 The Norbury Brook begins in Selhurst as an ordinary watercourse which flows in open channel through Heavers Meadow and is then culverted beneath Selhurst Road and Whitehorse Road. It then becomes a main river and flows northwest in open channel through the residential area of Thornton Heath and the Recreation Ground, beneath the railway line and into Norbury Park. Upon leaving Norbury Park the Norbury Brook flows north into London Borough of Lambeth and becomes the River Graveney, which itself is a tributary of the River Wandle.

River Wandle

4.1.5 The River Wandle catchment, which includes the River Graveney tributary, drains a total area of approximately 200km^2. The Wandle flows from south to north from London Borough of Croydon through London Borough of Sutton, London Borough of Merton and discharges into the Thames at Bell Lane Creek in London Borough of Wandsworth. The southern half of the catchment is underlain by Chalk, which is highly permeable, allowing surface water to infiltrate into the ground rather than runoff into the Wandle. The northern half of the catchment is underlain by London Clay with very limited permeability which can generate significant volumes of rapid surface water runoff during periods of heavy rainfall.

4.1.6 There are two sources for the River Wandle, springs at Carshalton and Waddon, which rise at the junction between the Chalk and the overlying Clays and Gravels. In London Borough of Croydon, the River Wandle rises from natural springs at Waddon Ponds immediately west of Croydon town centre. It has recently been de-culverted to flow in an open section through Wandle Park before it is culverted again and flows west into the London Borough of Sutton.

Caterham Bourne

4.1.7 The Caterham Bourne is a groundwater-fed watercourse, which flows intermittently following periods of wet weather. Heavy flows are recorded approximately every 7 years. Source location can vary between flood events. The watercourse rises in Caterham in Surrey and flows northwest in and out of culverted sections through Whyteleafe, Kenley and Riddlesdown. It then becomes culverted and is designated as a surface water sewer which continues towards Purley. At Purley Cross the sewer passes north beneath the A23 Brighton Road and the A236 before discharging to the River Wandle at Wandle Park.

Chaffinch Brook

4.1.8 Chaffinch Brook catchment is a highly complex system of Main Rivers and ordinary watercourses. It flows in the north-east of the borough with some open sections close to the boundary with London Borough of Bromley. The Chaffinch Brook eventually joins the Pool River and River Ravensbourne.

Ordinary Watercourses

4.1.9 According to Environment Agency records, the mapped ordinary watercourses in Croydon include the upstream section of the Norbury Brook, near Selhurst in the north of the Borough, and the tip of the

Beck, which flows into the London Borough of Bromley. A number of other watercourses have been identified, including ephemeral bournes, which only flow when the groundwater is high. The London Borough of Croydon LFRMS[13] identifies the requirement for these watercourses to be mapped and riparian responsibilities clarified to aid future management.

4.1.10 Within Croydon, significant lengths of ordinary watercourse are culverted, with trash screens often located on the upstream end of culverts. Trash screens and culverts have the potential to become blocked by items such as plant debris and rubbish. Blockages can restrict the natural flow of water, increasing the chance of water flowing out of bank and causing local flooding due to the reduced conveyance potential of the associated watercourse. Further asset information and actions in place to address their risk to flooding are available in the London Borough of Croydon LFRMS[13] and Action Plan.

4.1.11 LB Croydon is aware of flooding problems associated with ordinary watercourses. The Merstham Bourne, an ephemeral watercourse which has an open section near Coulsdon South Station, caused flooding to residents' gardens during the wet weather of winter 2014, as did the drainage ditch running behind Wharfedale Gardens in Norbury. Several problems have been noted with flooding at Heavers Meadow allotments, which sit alongside the Norbury Brook in an open section where it is an ordinary watercourse. Numerous other open ditches and streams around the borough can cause problems where trash screens or downstream culverts get blocked. Problems associated with a drainage ditch in Park Hill Park in recent years have led to flooding threatening the main London to Brighton railway line. These issues have been exacerbated by a blockage in the downstream culvert and a burst water main in addition to local geography and capacity of the ditch itself.

Flood Map for Planning (Rivers and Sea)

4.1.12 Flooding from rivers occurs when water levels rise higher than bank levels causing floodwater to spill across adjacent land (floodplain). The main reasons for water levels rising in rivers are:

- Intense or prolonged rainfall causing runoff rates and flows to increase in rivers, exceeding the capacity of the channel. This can be exacerbated by wet conditions and where there is significant groundwater base flow.
- Constrictions in the river channel causing flood water to back up; and
- Constrictions preventing discharge at the outlet of the river e.g. locked flood gates, or tide locking.

4.1.13 The risk of flooding is a function of the probability that a flood will occur and the consequence to the community or receptor as a direct result of flooding. The NPPF seeks to assess the probability of flooding from rivers by categorising areas within the fluvial floodplain into zones of low, medium and high probability, as defined in Table 4-1.

Table 4-1 Fluvial Flood Zones (extracted from the PPG, 2014)

Flood Zone	Fluvial Flood Zone Definition	Probability of Flooding
Flood Zone 1	Land having a less than 1 in 1,000 (0.1%) annual probability of river flooding. Shown as clear on the Flood Map – all land outside Flood Zones 2 and 3.	Low
Flood Zone 2	Land having between a 1 in 100 and 1 in 1,000 annual probability of river flooding (between 1% and 0.1% annual probability of flooding each year).	Medium
Flood Zone 3a	Land having a 1 in 100 or greater annual probability of river flooding (greater than 1% annual probability of flooding each year).	High
Flood Zone 3b	Land where water has to flow or be stored in times of flood, or land purposely designed to be flooded in an extreme flood event (0.1% annual probability). The functional floodplain is not separately distinguished from Flood Zone 3a on the EA Flood Map for Planning (Rivers and Sea). LPAs are required to identify areas of functional floodplain as part of their SFRA, in discussion with the Environment Agency. For the purposes of this SFRA, the identification of the functional floodplain considers local circumstances and land modelled to flood during a 5% AEP event or greater in any year has been mapped, in agreement with the Environment Agency.	Functional Floodplain

4.1.14 The 'Flood Map for Planning (Rivers and Sea)' dataset is available on the Environment Agency website[9] and is the main reference for planning purposes as it contains Flood Zones 1, 2 and 3 which are referred to in the NPPF and presented in Table 4-1. The 'Flood Map for Planning (Rivers and the Sea)' provides information on the areas that would flood if there were no flood defences or buildings in the "natural" floodplain.

4.1.15 The 'Flood Map for Planning (Rivers and Sea)' also identifies areas which, in the event of a river flood with a 1% AEP (or a tidal flood with a 0.5% AEP) would be protected from flooding by the presence of flood defences. These areas are described as 'Areas Benefitting from Defences' (ABD).

Appendix A Figure 1 Flood Map for Planning (Rivers and Sea)
Appendix A Figure 2 Flood Modelling Outlines for the River Wandle

4.1.16 The majority of London Borough of Croydon (97.8%) is defined as Flood Zone 1 Low Probability of flooding from rivers. Approximately 1.7% is defined as Flood Zone 2 Medium Probability, and less than 0.5% is defined as Flood Zone 3a High Probability and Flood Zone 3b Functional Floodplain.

Table 4-2 Flood Zones within London Borough of Croydon

Watercourse	Flood Zones
River Wandle:	Flood Zone 3a associated with the River Wandle extends across the western part of Wandle Park and the industrial area up to Factory Lane. Flood Zone 2 extends further to the north and west across the A23 Purley Way and up to the borough boundary. The open channel section of the River Wandle through Wandle Park is designated Flood Zone 3b Functional Floodplain.
Norbury Brook:	The floodplain associated with the Norbury Brook is approximately 100m wide along the majority of its open channel sections. Areas within the Recreation Ground and Norbury Park are designated Flood Zone 3b Functional Floodplain.
Caterham Bourne:	The floodplain associated with the Caterham Bourne in the south east of the borough is approximately 30m wide, increasing to approximately 100m wide along Brighton Road.
Chaffinch Brook:	There is a small portion of Flood Zone 2 and 3 in this part of the Borough, primarily associated with parkland areas.

4.1.17 It should be noted that a separate map is available on the Environment Agency website which is referred to as 'Risk of Flooding from Rivers and Sea'[10]. This map takes into account the presence of flood defences and so describes the actual chance of flooding, rather than the chance if there were no defences present. While flood defences reduce the level of risk, they do not completely remove it as they can be overtopped or fail in extreme weather conditions, or if they are in poor condition. As a result, the maps may show areas behind defences which still have some risk of flooding. This mapping has been made available by the Environment Agency as the primary method of communicating flood risk to members of the public, however for planning purposes the 'Flood Map for Planning (Rivers and the Sea)' and associated Flood Zones remains the primary source of information.

Hydraulic Modelling Studies

4.1.18 Table 4-3 provides a summary of the hydraulic modelling studies that have been undertaken for the Main Rivers in London Borough of Croydon and used to inform the Environment Agency's Flood Map for Planning (Rivers and Sea). The type of model (1D or 2D) is also specified, along with the corresponding available sources of flooding used for each model.

[9] Environment Agency Flood Map for Planning (Rivers and Sea) http://apps.environment-agency.gov.uk/wiyby/37837.aspx
[10] Environment Agency 'Risk of Flooding from Rivers and Sea' http://watermaps.environment-agency.gov.uk/wiyby/wiyby.aspx?topic=floodmap#x=237038&y=161974&scale=1

Table 4-3 Hydraulic models for Main Rivers in London Borough of Croydon (fluvial flood risk)

Watercourse	Modelling Study	Model	Source of flooding
River Wandle and Norbury Brook	JBA Consulting (2015), River Wandle Remodeling Study JBA Consulting (2017), Wandle Climate Change Modelling Technical Note	1D-2D ISIS-TUFLOW	The flood water source along the study reach is dominated by three mechanisms – fluvial flooding from exceedance of banks of the River Wandle, River Graveney, Norbury Brook and other channels – surface water flooding arising from rain falling onto the urbanised catchment and exceeding the capacity of the sewer system. – Groundwater contribution to flood flows from the upper parts of the catchment, but also potential groundwater emergence.
Caterham Bourne	ATKINS (2019), Caterham Bourne Flood Alleviation Study Stage 2 Options Appraisal Report	Infoworks Integrated Catchment Model (ICM)	Flood risk in the Bourne Catchment, though driven by groundwater, is a combination of fluvial, surface water and sewer flooding. The modelling study has considered all these sources of flooding to understand how the combined risk, along with existing drainage infrastructure, impacts flood risk in the Catchment. At the time of SFRA preparation this model is not in the public domain and cannot be used for planning applications.
Chaffinch Brook	AECOM (2020)	InfoWorks ICM	The model includes the following elements: – a hydrological model which represents a range of design rainfall events – a hydraulic routing model which represents where rainfall landing on the surface flows; and – a hydraulic model of the open channel watercourses, drainage and sewer networks within the catchment which represents how the systems collect, convey and ultimately discharge surface water. At the time of SFRA preparation this model is not in the public domain and cannot be used for planning applications.

Functional Floodplain Flood Zone 3b

4.1.19 The Functional Floodplain is defined in the NPPF as 'land where water has to flow or be stored in times of flood'. The Functional Floodplain (also referred to as Flood Zone 3b), is not separately distinguished from Flood Zone 3a on the Flood Map for Planning (Rivers and Sea). Rather the SFRA is the place where LPAs should identify areas of Functional Floodplain in discussion with the Environment Agency.

4.1.20 The PPG states that the identification of Functional Floodplain should take account of local circumstances and not be defined solely on rigid probability parameters. However, land which would naturally flood with an annual probability of 1 in 20 (5% AEP) or greater in any year or is designed to flood (such as a flood attenuation scheme) in an extreme (0.1% annual probability) flood, should provide a starting point for consideration. The guidance goes on to say that 'areas which would naturally flood with an annual probability of 1 in 20 (5% AEP) or greater but are prevented from doing so by existing infrastructure or solid buildings will not normally be defined as functional floodplain'.

4.1.21 LB Croydon have used the modelled outlines for the 1 in 20 (5% AEP) event for the River Wandle and Norbury Brook to define the Functional Floodplain (Flood Zone 3b) associated with these watercourses. These areas are chiefly undeveloped areas within Wandle Park, Norbury Park and the Recreation Ground adjacent to Melfort Road.

Climate Change

4.1.22 The NPPF[5] and supporting practice guide sets out how the planning system should help minimise vulnerability and provide resilience to the impacts of climate change. This includes demonstrating how flood risk will be managed now and over the lifetime of development, taking climate change into account.

4.1.23 In previous SFRAs and site specific Flood Risk Assessments an allowance of 20% was added to the 1 in 100 year (1% AEP) return period to account for increases in flood risk due to climate change. In

February 2016, the Environment Agency published revised guidance on climate change allowances[11] including predictions of anticipated change for:

- Peak river flow by river basin district
- Peak rainfall intensity
- Sea level rise
- Offshore wind speed and extreme height

4.1.24 The guidance reflects an assessment completed by the Environment Agency between 2013 and 2015 using United Kingdom Climate Projections 2009 (UKCP09) data to produce more representative climate change allowances across England. The full guidance can be found using the following link to the gov.uk website and is discussed further below. https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances.

4.1.25 Climate change allowances applicable to London Borough of Croydon (Thames River Basin District) are set out in Table 4-4 below. For the purposes of strategic planning and completion of the sequential test, LB Croydon are advised to use the '2070 to 2115' development lifetime. For more vulnerable, residential development this correlates to a climate change range of impacts of between + 35% and + 70% on the 1 in 100 year (1% AEP).

Table 4-4 Peak River Flow Allowances[12] for Thames River Basin District (using 1961 to 1990 baseline)

River Basin District	Allowance Category	Total potential change anticipated for the '2020's (2015 to 2039)	Total potential change anticipated for the '2050's (2040 to 2069)	Total potential change anticipated for the '2080's (2070 to 2115)
Thames	Upper End	25%	35%	70%
	Higher Central	15%	25%	35%
	Central	10%	15%	25%

4.1.26 In order to determine which range of allowances should be assessed for a proposed development or plan, the flood zone and vulnerability classification should be considered, as set out below.

Flood Zone 2:

- Essential Infrastructure – use the higher central and upper end to assess a range of allowances
- Highly Vulnerable – use the higher central and upper end to assess a range of allowances
- More Vulnerable – use the central and higher central to assess a range of allowances
- Less Vulnerable – use the central allowance
- Water Compatible – use none of the allowances

Flood Zone 3a:

- Essential Infrastructure – use the upper end allowance
- Highly Vulnerable – development should not be permitted
- More Vulnerable – use the higher central and upper end to assess a range of allowances
- Less Vulnerable – use the central and higher central to assess a range of allowances
- Water Compatible – use the central allowance

Flood Zone 3b:

[11] https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances
[12] Allowances' in this context is the amount as a % that is added to estimated peak river flows to account for climate change increases. Guidance is available at https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances.

- Essential Infrastructure – use the upper end allowance
- Highly Vulnerable – development should not be permitted
- More Vulnerable – development should not be permitted
- Less Vulnerable – development should not be permitted
- Water Compatible – use the central allowance

4.1.27 The lifetime of the development should also be considered when determining which climate change allowance time period should be used. The lifetime of a proposed development should be judged based on the characteristics of the development. In the case of a residential development, a minimum lifetime of 100 years should be taken when selecting climate change allowance percentages. For other types of development, the applicant should assess how long they anticipate the development to be in place for and justify the lifetime of the development. Otherwise, a 75-year lifetime should be used.

4.1.28 **River Wandle modelling: Appendix A Figure 2** includes the modelled outline for the River Wandle for the 1% AEP event including 35% and 70% allowances for climate change. These modelled scenarios also include the presence of flood defences along the watercourses. The results show a minimal increase in the flood outline north of Wandle Park.

4.1.29 **Caterham Bourne FAS modelling:** While modelling outputs have been provided for the Caterham Bourne, the 1 in 100 year (1% AEP) plus updated climate change outlines are not available. Therefore, existing Environment Agency mapping has been referenced.

4.1.30 **Chaffinch Brook modelling**: The study has provided outputs for the combined fluvial and surface water flooding for the 1 in 30 year (3.33% AEP) 1 in 100 year (1% AEP), 1 in 1000 year (0.1% AEP) and 1 in 100 year (1% AEP) including climate change events. The study is still ongoing

Flood defences

4.1.31 Flood defences are typically raised structures that alter natural flow patterns and prevent floodwater from entering property in times of flooding. They are generally categorised as either 'formal' or 'informal' defences. A 'formal' flood defence is a structure that is maintained by its respective owner, regardless of whether it is owned by the Environment Agency. An 'informal' flood defence is a structure that has often not been specifically built to retain floodwater and is not maintained for this specific purpose. Boundary walls and industrial buildings situated immediately adjacent to rivers often act as informal flood defences.

4.1.32 The Environment Agency Flood Map for Planning does not identify any formal flood defences along the Main Rivers in Croydon.

4.1.33 The Environment Agency has provided an extract from the Asset Information Management System (AIMS) which contains details of flood defence assets associated with Main Rivers in Croydon. This dataset provides a good starting point for identifying significant local defences and potential areas benefiting from defences, but the quantity and quality of information provided differs considerably between structures. The AIMS is intended to provide a reasonable indication of the condition of an asset and should not be considered to contain consistently detailed and accurate data.

4.1.34 The AIMS data identifies that the Norbury Brook flows through a concrete lined channel which is privately maintained. Concrete walls are present on both banks along sections of the watercourse. The watercourse is culverted in three locations, beneath Selhurst Road and Whitehorse Road, beneath the railway line adjacent to Norbury Park, and beneath the A23 at the borough boundary with London Borough of Lambeth.

Appendix A Figure 1 Flood Map for Planning (Rivers and Sea)

Historic Records

4.1.35 Significant flood events associated with the Caterham Bourne have been recorded. During January to March 2014, and throughout the winter of 2000-2001, disruption lasted over several months. The high groundwater levels that were experienced during these events resulted in floodwaters receding very slowly. There are also records of a number of similarly damaging floods during the 20th century, when the Bourne was in flow.

4.1.36 The London Borough of Croydon LFRMS[13] notes that historic flood records dating back to the 1960s indicate numerous incidents associated with the Norbury Brook as a result of overtopping in open sections as well as surcharging of manholes and culverts in its culverted sections.

4.1.37 The Environment Agency Historic Flood Map does not provide many records of fluvial flooding in Croydon. There is a small extent associated with the Chaffinch Brook at Elmers End, although this is more significant across the borough boundary in London Borough of Bromley.

4.1.38 Within the historic records supplied by London Borough of Croydon, none are identified as fluvial flooding. However, it should be noted that there are numerous records of flooding along Brighton Road, which is located in the topographic depression along the route of a former watercourse. The source of these events is typically recorded as surface water or sewer flooding rather than fluvial flooding, as the watercourse has been culverted and can no longer be seen.

4.2 Flooding from Surface Water

4.2.1 Overland flow and surface water flooding typically arise following periods of intense rainfall, often of short duration, that is unable to soak into the ground or enter the drainage systems. It can run off land quickly and result in localised flooding. This occurs most commonly in urban areas where water is unable to enter the ground due to the presence of impermeable surfaces.

Risk of Flooding from Surface Water

4.2.2 The Environment Agency has undertaken modelling of surface water flood risk at a national scale and produced mapping identifying those areas at risk of surface water flooding including, high risk (less than 3.33% AEP); medium risk (between 1% and 3.33% AEP); and low risk (between 0.1% and 1% AEP). The latest version of the mapping is referred to as the 'Risk of flooding from Surface Water' (RoFSW) and is available on the Environment Agency website.

4.2.3 The RoFSW provides all relevant stakeholders access to information on surface water flood risk which is consistent across England and Wales[14]. The modelling helps the Environment Agency take a strategic overview of flooding and assists LB Croydon in their duties as LLFA relating to management of surface water flood risk. For the purposes of this SFRA, the mapping allows an improved understanding of areas within the Borough which may be at risk from a surface water flooding. The RoFSW mapping has a 2m model resolution and includes the representation of buildings, flow routes along roads, and modifications to include structural features such as flyovers. A range of storm scenarios have been considered and the modelling incorporates local mapping, knowledge and flood incidents. However, it should be noted that this national mapping has the following limitations:

- Use of a single drainage rate for all urban areas,
- It does not show the susceptibility of individual properties to surface water flooding,
- The mapping has significant limitations for use in flat catchments,
- No explicit modelling of the interaction between the surface water network, the sewer systems and watercourses,
- In a number of areas, modelling has not been validated due to a lack of surface water flood records, and
- As with all models, the RoFSW is affected by a lack of, or inaccuracies, in available data.

Appendix A Figure 3A & 3B Risk of Flooding from Surface Water

4.2.4 The RoFSW mapping for the London Borough of Croydon illustrates that the risk of surface water flooding is widespread throughout the Borough. Overland flow follows the natural topography of the land

[13] Croydon Council. Capita URS, June 2014, London Borough of Croydon Local Flood Risk Management Strategy, Draft for consultation.
[14] Environment Agency (2013) ' What is the updated Flood Map for Surface Water? '

and accumulates in the natural depressions created by ditches, streams and tributaries of the primary watercourses.

Climate Change

4.2.5 The RoFSW mapping does not include a specific scenario to determine the impact of climate change on the risk of surface water flooding. However, a range of events are mapped and therefore it is possible to use with caution the low risk (between 0.1% and 1% AEP) event outline as a substitute dataset to provide an indication of the implications of climate change.

Surface water modelling – Purley Cross and Caterham Drive

4.2.6 London Borough of Croydon secured Defra funding to update local surface water modelling and Risk of Flooding from Surface Water (RoFSW) mapping information, as part of the Boosting Action for Surface Water programme. Arcadis Consulting (UK) Limited were subsequently commissioned by London Borough of Croydon to undertake detailed and up-to-date surface water modelling for two key Critical Drainage Areas (CDAs) covering the Purley Cross to River Wandle CDA and Caterham Drive area .

4.2.7 The project required the development of a detailed and integrated 1D-2D hydraulic model of the catchment to provide the necessary resolution and confidence in the prediction of flood depths and extent, commensurate with the requirements for the Environment Agency RoFSW.

4.2.8 The outputs from this modelling have been mapped in this Level 1 SFRA, where coverage is available. The maximum depth outputs and hazard outputs have been presented for both the 1% AEP (1 in 100 year) event the 0.1% AEP (1 in 1000 year) event.

Appendix A Figure 7 10 Surface Water Modelling

Drainage Catchments

4.2.9 Drainage Catchments (DCs) have previously been determined across the study area as part of the joint south west London Level 1 SFRA (2015)[15]. Drainage catchments outline the area of the land that influences the surface water drainage at a certain point. The scale of a drainage catchment varies depending on the point of interest. The extent of a natural drainage catchment follows peaks in the local topography that surface water will drain from. The DCs determined by this study are based on the natural catchments and watersheds that cover the borough, which are provided within the Flood Estimation Handbook CD-ROM and have then been amended using local knowledge to account for significant infrastructure within the study area that could impact on drainage such as railway lines.

4.2.10 It is intended that these DCs will be useful for identifying the natural drainage patterns in the local area when considering new development and future regeneration in the study area. The potential for implementing new approaches and requirements for surface water management can be considered by LB Croydon within the context of specific DCs. For example, local topography could be used to determine flow paths within each DC, which could highlight potential areas to focus surface water management techniques.

4.2.11 Nineteen DCs have been identified in London Borough of Croydon. The majority of the DCs in the south of the Borough form part of the River Wandle catchment. The DCs in the north of the Borough drain into the Norbury Brook. Along the north eastern edge of the Borough, the topography slopes towards London Borough of Bromley, and these DCs drain towards the River Ravensbourne.

Appendix A Figure 3A Risk of Flooding from Surface Water with Drainage Catchments

Critical Drainage Areas (CDAs)

4.2.12 The Environment Agency refers to a Critical Drainage Area (CDA) as an area within Flood Zone 1 which has ‘critical drainage issues’. However, within the Surface Water Management Plan (SWMPs) for London Borough of Croydon, CDAs were delineated based on the following working definition: ‘a discrete geographic area (usually within an urban setting) where there may be multiple and interlinked

[15] London Boroughs of Croydon, Merton, Sutton and Wandsworth (2015), Level 1 Strategic Flood Risk Assessment

sources of flood risk and where severe weather is known to cause flooding of the area thereby affecting people, property or local infrastructure'. Sixteen CDAs were identified in London Borough of Croydon and outlined in the Croydon SWMP (2011)[16].

Appendix A Figure 3B Risk of Flooding from Surface Water with CDAs

Historic Records

Historic Records of Surface Water Flooding

4.2.13 Historic flooding records from local residents and businesses, Network Rail, Transport for London and the Environment Agency have been gathered by London Borough of Croydon as part of the preparation of the PFRA, SWMP and the LFRMS. These records have been obtained and used to inform this Level 1 SFRA Where possible, the source of the flooding has been identified. Records of flooding which are reported to be from a surface water source are presented in **Appendix A Figure 3A & 3B**.

4.2.14 London Borough of Croydon has experienced a number of historic surface water flood events, the most notable of which were in July 2007, December-February 2014/2015, August 2015,June 2016 and June 2019. The most frequent area to surface water flooding is Brighton Road and the Purley Cross roundabout. Specific episodes of surface water flooding are also recorded in the following locations:

- Kenley Lane and Kenley Station
- Brighton Road in Coulsdon
- Purley Oaks Road and station
- Norbury and Thornton Heath
- Caterham Drive.

4.2.15 Approximately 460 records of surface water flooding have been provided by LB Croydon and mapped in Appendix A Figure 3.

Croydon S19 Flood Investigation Report[17] (24 August 2015)

4.2.16 During August 2015, the London Borough of Croydon experienced severe surface water flooding in several locations around the Borough due to torrential rain. Areas particularly affected included Purley Cross Underpass, Purley Oaks Road and localised highway flooding in Kenley, Purley, Coulsdon and New Addington. Flooding affected a number of commercial and residential properties and major transport routes as well as more localised incidents. Risk Management Authorities with responsibilities in respect of this event included, Croydon Council, the Environment Agency and Thames Water. Additionally, London Fire Brigade and the Metropolitan Police carried out emergency response roles. Surface water was the main source of flooding, but sewer and fluvial flooding were also identified as sources.

4.2.17 The flood events reported across the Borough in August 2015 are considered to be as a result of an exceptional rainfall event, which exceeded the design capacity of road gullies and the highway drainage network. Whilst some road gullies were reportedly blocked, the volume of water meant the flood events were considered to be largely unavoidable, without increasing the design capacity of drainage networks throughout the Borough. Specifically, at Purley Cross, the drainage network upstream and downstream of the pump station did not have sufficient capacity to manage the volume of water encountered. In addition, the extreme nature of the rainfall event had a knock on effect leading to the failure of the Transport for London (TfL) operated pumps at the pedestrian underpass due to flooding of the control box, further exacerbating the flooding at this location. Therefore, actions included engagement with Thames Water and TfL about Purley Cross determining whether sewer condition influenced flood risk, engagement with Thames Water regarding the drainage mechanism of the sewer network at Purley Oaks and a review of the drainage capacity and gully cleansing schedules at flooding locations.

[16] London Borough of Croydon (2011), Surface Water Management Plan, available at: https://www.croydon.gov.uk/sites/default/files/articles/downloads/swplan.pdf
[17] AECOM, November 2016, Croydon Flood Investigation Report 24th August 2015 https://www.croydon.gov.uk/environment/flood-and-water-management/flood-investigations

Caterham Bourne Flood Investigation[18]

4.2.18 The period from December 2013 to January 2014 was the wettest two month period on record in the South London area , with 213mm of rainfall recorded in January 2014. The prolonged period of heavy rainfall experienced during this period caused groundwater levels to rise, which in turn led to significant flooding within the London Borough of Croydon from multiple sources:

- High groundwater caused Caterham Bourne to flow, with sources rising above ground in Woldingham, and Caterham, Surrey and flowing into Croydon along the route of the A22 towards Purley,
- Foul sewer flooding occurred as groundwater ingress and emergency pumping put pressure on the sewer system, and
- Surface water flooding occurred as a combination of the heavy rainfall and saturated soil and extreme pressure on the road drainage infrastructure.

4.2.19 Significant flooding was experienced in the areas of Kenley and Purley as well as Woldingham and Whyteleafe in Surrey, where the bourne flows prior to entering the London Borough of Croydon. The scale of the flooding was declared a Major Incident by Croydon Council (CC) on 6th February 2014 and a significant pumping operation was implemented in an effort to protect homes, businesses and critical infrastructure.

4.2.20 The Flood Investigation Report provides details of the mechanisms of flooding, areas affected, the response from risk management authorities, lessons learnt and future potential mitigation options.

Caterham Drive S19 Flood Investigation report[19] (7 June 2016)

4.2.21 In June 2016 heavy localised rainfall led to severe surface water flooding in south London before the weather system moved north across the country. The London Borough of Croydon was particularly affected on 7th June 2016 resulting in localised deep, fast-flowing water, which sub-merged/floated vehicles and entered properties at several locations. On the 7th and 8th June 2016 Thames Water received over 80 calls relating to flooding in the area around Caterham Drive. Four properties in the north of Caterham Drive and a further two in the south reported flooding to the council. It is likely that flooding of properties to the south of Caterham Drive was influenced by surface water runoff from Rydon's Lane. Surface waters then propagated northward down Caterham Drive following the road gradient and flooding properties at the end of the road adjacent to Dollypers Hill. Risk Management Authorities with responsibilities in respect of this event included, Croydon Council, the Environment Agency and Thames Water. Additionally, London Fire Brigade and the Metropolitan Police carried out emergency response roles.

4.2.22 Overall the responsible authorities carried out their legal responsibilities in their response to the event. Several actions to better address mitigation of flood risk in this area were identified in the Flood Investigation report; a key action going forward was to encourage further engagement between Risk Management Authorities and residents.

Croydon Flood Alleviation Study[20]

4.2.23 London Borough of Croydon has identified flood hotspots within the Borough that are frequently subjected to flooding following intensive rainfall but where the flooding is limited to roads, gardens and driveways and therefore do not meet LBC's current criteria for triggering a formal Section 19 flood investigation under the FWMA; nor do they meet requirements to gain additional government funding for flood alleviation e.g. through the national Flood and Coastal Erosion Management (FCERM) Grant in Aid (GiA) process administered by the Environment Agency. The locations are:

1. Asmar Close, Coulsdon
2. Stoneyfield Road, Coulsdon
3. Farm Fields, South Croydon
4. Sanderstead Court Avenue, South Croydon

[18] URS, October 2014, Caterham Bourne Flood Investigation March 2014. https://www.croydon.gov.uk/environment/flood-and-water-management/flood-investigations
[19] AECOM, January 2017, Caterham Drive Flood Investigation Report, 7th June 2016. https://www.croydon.gov.uk/environment/flood-and-water-management/flood-investigations
[20] AECOM, June 2018, Croydon Flood Alleviation Study (Surface Water Hotspots) Stage 1. Final Report.

5. Old Lodge Lane, South Croydon
6. Lower Barn Road, Riddlesdown Station,
7. Meadow Hill, Smitham Bottom Lane, South Croydon.

4.3 Flooding from Groundwater

4.3.1 Groundwater flooding usually occurs in low lying areas underlain by permeable rock and aquifers that allow groundwater to rise to the surface through the permeable subsoil following long periods of wet weather. Low lying areas may be more susceptible to groundwater flooding because the water table is usually at a much shallower depth and groundwater paths tend to travel from high to low ground.

Geology

4.3.2 The underlying bedrock of the London Borough of Croydon is Middle and Upper Chalk in the south, which is overlain by Thanet Sand Formation (fine sand), Lambeth Group (clay and sand), Harwich Formation (sand and flint) and the London Clay Group in the north. The Drift deposit geology is dominated by River Terrace Deposits, with Alluvium also present along the Wandle valley and Clay with flints present along the southern boundary of London Borough of Croydon.

4.3.3 Due to the dominance of Chalk throughout the south of the study area, across the southern parts of London Borough of Croydon, extensive aquifers are found here with many used for potable and/or industrial water supply. In addition, most of the watercourses in the area are spring-fed, indicating groundwater levels are at or very close to the ground surface in some locations.

4.3.4 Further information on geology can be found on the British Geological Survey (BGS) Website.[21]

Susceptibility to Groundwater Flooding

4.3.5 In response to the need for more information on groundwater flooding, BGS has produced the first national dataset on the susceptibility of groundwater flooding. Based on geological and hydrogeological information, the digital data can be used to identify areas where geological conditions could enable groundwater flooding to occur and where groundwater may come close to the ground surface. Note, it is a susceptibility dataset, so it does not indicate hazard or risk, i.e. it does not provide any information on the depth to which groundwater flooding occurs or the likelihood of the occurrence of an event of a particular magnitude.

4.3.6 The 'Susceptibility to Groundwater Flooding' dataset is divided into three classes – High, Medium and Low risk as follows:

- High – areas with the potential for groundwater flooding to occur at the surface
- Medium – areas which may experience groundwater flooding of property situated below the ground surface i.e. basements
- Low – areas with limited potential for groundwater flooding to occur.

4.3.7 BGS state that the dataset is suitable for use for regional or national planning purposes where the groundwater flooding information will be used along with a range of other relevant information to inform land-use planning decisions. It might also be used in conjunction with other factors, such as, records of previous incidents of groundwater flooding, rainfall, property type, and land drainage information, to establish relative, but not absolute, risk of groundwater flooding at a resolution of greater than a few hundred metres. The susceptibility data should not be used on its own to make planning decisions at any scale and should not be used to inform planning decisions at the site scale. The susceptibility data cannot be used on its own to indicate risk of groundwater flooding.

Appendix A Figure 4 BGS Susceptibility to Groundwater Flooding & Flooding Records

[21] http://www.bgs.ac.uk

4.3.8 London Borough of Croydon is divided into two distinct areas with respect to bedrock geology. The north of the Borough is underlain by impermeable London Clay, whereas the south is underlain by permeable chalk. River terrace deposits are present along the river corridors throughout the Borough.

4.3.9 The BGS Susceptibility to Groundwater Flooding dataset identifies the areas along the river corridors to be potentially susceptible to groundwater flooding at surface. This stretches throughout the Borough from the land along the Caterham Bourne, north along Brighton Road and into the north of the Borough in the vicinity of the Norbury Brook.

Historic Records

4.3.10 LB Croydon has more than 40 records of groundwater flooding in the Borough which are shown in **Appendix A Figure 4**. Instances of groundwater flooding have been reported in several areas in Croydon with some regular hotspots in the north of the Borough.

4.3.11 The highest profile and widespread floods influenced by high groundwater have been associated with the Caterham Bourne in the south of the Borough, which caused significant disruption in the winter of 2000-2001, in early 2014, and the winter of 2019-2020, threatening significant numbers of homes, essential infrastructure and transport networks.

Caterham Bourne S19 Flood Investigation Report (January-March 2014)

4.3.12 December 2013 to January 2014 was the wettest two-month period on record in the South London area. The prolonged heavy rainfall caused groundwater to rise to exceptionally high levels which led to significant flooding in the London Borough of Croydon in the areas of Kenley and Purley around the route of the Caterham Bourne. Within the Borough, flooding was experienced at locations along the A22 and surrounding areas with residential properties affected at Bourne Park Close, Brighton Road, Dale Road, Foxley Hill Road, Godstone Road, Lansdown Road and Purley Park Road. There was a significant multi-agency response (including Croydon Council, London Fire Brigade, Metropolitan Police, Environment Agency, Sutton and East Surrey Water, Thames Water and Transport for London) following declaration of an emergency on 6th February 2014.

4.3.13 The number of properties which suffered internal flooding to the ground floor was limited due to the scale of the round-the-clock relief effort following declaration of an emergency. Short to medium term management options have been identified to recover and restore the Bourne following the flooding and to prepare for the coming winter as much as possible. Actions included clearance, dredging and de-silting of channels and culverts, establishing more regular maintenance and inspection and partnership working between LB Croydon and Thames Water to agree a way forward on asset maintenance. This included investigating influences on the problems at Dale Road.

Merstham Bourne S19 Flood Investigation Report (January-March 2014)

4.3.14 Exceptionally high rainfall in December 2013 and January 2014 caused groundwater to rise rapidly along the course of Merstham Bourne and this is the predominant source of flooding during this event. However, further sources (such as surface water, fluvial and sewer flooding) contributed to the scale of flooding, particularly where the catchment becomes more urban. Areas affected included Reddown Road, as well as a railway between Woodplace Lane and Start Bridge and Merstham Tunnel, both reported by Network Rail. The authorities which responded to this flood event were Croydon Council, Thames Water, the Environment Agency and Network Rail. Risk Management Authorities and Network, as riparian owner, carried out appropriate response activities to manage and respond to the flood.

4.3.15 However, several issues were identified which could be improved to manage the risk from the Bourne going forward. This flood event highlighted the need for an ongoing maintenance regime of the watercourse and better communication between Network Rail and Croydon Council regarding flood management works and clarification of riparian owner responsibilities. It is also evident that there is incomplete understanding about the full route and source locations of the Merstham Bourne and how sewer infrastructure interacts with other sources of flooding such as groundwater incursion.

4.4 Flooding from Sewers

4.4.1 During heavy rainfall, flooding from the sewer system may occur if:

(1) The rainfall event exceeds the capacity of the sewer system/drainage system:

Sewer systems are typically designed and constructed to accommodate rainfall events with a 3.3% AEP or less. Therefore, rainfall events with a return period of frequency less than 3.3% AEP would be expected to result in surcharging of some of the sewer system. While Thames Water, as the sewerage undertaker for the study area, recognise the impact that more extreme rainfall events may have, it is not cost beneficial to construct sewers that could accommodate every extreme rainfall event.

(2) The system becomes blocked by debris, sediment or fat:

Over time there is potential that road gullies and drains become blocked from fallen leaves, build-up of sediment and debris (e.g. litter). Fat build up within the main sewer system is also a contributing factor of sewer flooding.

(3) The system surcharges due to high water levels in receiving watercourses:

Within the study area there is potential for surface water outlets to become submerged due to high river levels. When this happens, water is unable to discharge effectively. Once storage capacity within the sewer system itself is exceeded, water will overflow into streets and potentially into properties. Where the local area is served by 'combined' sewers i.e. containing both foul and storm water, if rainfall entering the sewer exceeds the capacity of the combined sewer and storm overflows are hindered by high water levels in receiving watercourses, surcharging and surface flooding may again occur but in this instance floodwaters will contain untreated sewage.

Historic Records

4.4.2 Water companies are required to maintain a register of properties which are at risk of flooding due to hydraulic overloading of the sewers (the sewer pipe is too small, or at too shallow a gradient). Thames Water has provided an extract from their DG5 Flood Register for the study area, which records historic internal and external sewer flooding events. Due to data protection requirements the data has not been provided at individual property level; rather the register comprises the number of properties within four digit postcode areas that have experienced flooding either internally or externally within the last 10 years.

4.4.3 It should be noted that these are flooding incidents that have been reported to Thames Water by the property owners. There are likely to be incidents that don't get reported and therefore will not show on the database. Incidents of sewer flooding can be retrospectively reported to Thames Water via their website – http://thameswater.co.uk/help-and-advice/9782.htm. Records of sewer flooding can help to inform Thames Water of areas in need of funding for further maintenance and investment in the sewer system.

4.4.4 Thames Water and London Borough of Croydon have supplied records of sewer flooding for the Borough. These indicate that incidents of sewer flooding have occurred throughout the Borough and are not limited to specific areas.

Appendix A Figure 5A Internal Sewer Flooding Records,
Appendix A Figure 5B External Sewer Flooding Records

4.4.5 The Croydon LFRMS identifies that numerous incidents in the historic flood register are attributed to surcharging sewers although evidence is anecdotal, and it is not always clarified whether highway drainage or culverted watercourses have influenced the incident. Several incidents are recorded in Thornton Heath and Broad Green in close proximity to the Norbury Brook as well as known surface water hotspots in Coulsdon.

Climate Change

4.4.6 Climate change is anticipated to increase the potential risk from sewer flooding as summer storms become more intense and winter storms more prolonged. This combination is likely to increase the pressure on the existing efficiency of sewer systems, thereby reducing their design standard and leading to more frequent localised flooding incidents. Any sewer flooding that may occur could be exacerbated as a result of surface water runoff during extreme rainfall events.

4.4.7 Thames Water continue to monitor the risk of sewer flooding and put plans in place to manage the risk, as required, based on their business plan and priorities. LB Croydon will work with Thames Water to identify flooding hotspots and locations of known sewer capacity issues where risk could be exacerbated. Thames Water prioritise investment for potential flood alleviation schemes depending on the severity and frequency of flooding, but this can only be identified where affected property owners report the incident to the water company.

4.5 Flooding from Other Sources

Risk of Flooding from Reservoirs

4.5.1 The failure of a reservoir has the potential to cause catastrophic damage due to the sudden release of large volumes of water. The PPG encourages LPAs to identify any impounded reservoirs and evaluate how they might modify the existing flood risk in the event of a flood in the catchment it is located within, and / or whether emergency draw-down of the reservoir will add to the extent of flooding.

4.5.2 The Environment Agency dataset 'Risk of Flooding from Reservoirs' identifies areas that could be flooded if a large[22] reservoir was to fail and release the water it holds. This dataset has been reviewed on the Environment Agency website[23] to inform the SFRA.

4.5.3 There have been no recorded incidents of reservoir flooding within London Borough of Croydon. The Environment Agency Flood Risk from Reservoirs mapping available online identifies that if the Russell Hill Reservoir were to fail it would impact areas of West Croydon and Waddon. If South Norwood Lake were to fail then the impact would be almost entirely within London Borough of Bromley, affecting areas of Penge, Beckenham and Lower Sydenham.

Table 4-5 Areas at risk of flooding from reservoirs

Name	Owner	Local Authority	Grid Ref	Areas affected
Russell Hill	Thames Water Utilities Ltd	Croydon	531451, 162811	From Roundshaw Park northwards along the A23 towards Stafford Road and Waddon railway station. Veers west and branches following the course of the River Wandle towards Beddington and Hackbridge.
South Norwood Lake	LB Croydon	Croydon	534189, 169419	Penge, Beckenham and Lower Sydenham (within London Borough of Bromley).

4.5.4 Reservoirs in the UK have an extremely good safety record. The Environment Agency is the enforcement authority for the Reservoirs Act 1975 in England and Wales. All large reservoirs must be inspected and supervised by reservoir panel engineers on an annual basis. As the enforcement authority for the Reservoirs Act 1975 in England, the Environment Agency are responsible for ensuring that reservoirs are inspected regularly, and essential safety work is carried out. As the undertaker for South Norwood Lake, LB Croydon is required to ensure that inspections are carried out by a qualified panel engineer and that necessary safety work is completed as required to reduce the likelihood of any failure. On this basis the possible risk of failure of these reservoirs is considered to be minimal.

Interaction between Flood sources

4.5.5 An overview of the flooding issues in the London Borough of Croydon reveals areas that are affected by multiple sources of flood risk. These include complex interactions between urban watercourses, direct surface water ponding, overland flow paths, groundwater ingress and the surface water sewer system.

Interactions between fluvial and surface water flooding

4.5.6 Surface water flooding often occurs in combination with fluvial flooding. An example area of fluvial and surface water flooding interaction has been modelled in the Chaffinch Brook study (ongoing study).

[22] A large reservoir is one that holds over 25,000 cubic metres of water, equivalent to approximately 10 Olympic sized swimming pools.
[23] Environment Agency, Long term flood risk assessment https://flood-warning-information.service.gov.uk/long-term-flood-risk/

Interactions between surface water and groundwater flooding

4.5.7 Groundwater flooding can often cause or exacerbate surface water flooding. Rising levels of groundwater can often lead to reduced infiltration during times of flooding as well as overwhelming road drainage that would otherwise accommodate surface water flows. A combination of surface water and groundwater has the potential to cause extensive flooding within an area.

Interactions between groundwater and sewer flooding

4.5.8 Sewer systems are vulnerable to groundwater through two main mechanisms:

- groundwater ingress forced through cracks in the access chambers or pipes
- Groundwater creating surface flows that flow into drain and sewers.

4.5.9 Sewer pipes aren't designed to carry the groundwater load in addition to surface water flows, and so can easily back up or create airlocks which mean that toilets and taps cannot work properly. At its worst, effluent could be pushed back up into the properties, creating a potential contamination hazard. Because of the sheer scale of groundwater below ground, it presents significant management challenges. Groundwater cannot be easily stored or pumped from site, so the sewer system needs to be more resilient to ingress. Sewers in areas at risk of groundwater flooding must be inspected closely and lined to ensure they are watertight, with priority given to particularly vulnerable areas.

4.5.10 Groundwater seepage can also create surface flows along roads and through properties.

4.6 Flood Risk Management Schemes

4.6.1 The following documents have been reviewed to identify flood risk opportunities.

London Borough of Croydon Surface Water Management Plan Preferred options

4.6.2 The SWMP (2011) identified several opportunities for next steps and quick wins in order to reduce the causes and impacts of flooding; some of them include:

- In conjunction with Thames Water, determining the capacity of the existing sewer network along Rees Gardens and Teevan Road (CDA_046 Woodside) and investigating options for increasing the surface water sewer capacity at this location
- Undertaking a Drainage Capacity Study for the three CDAs that cover the Purley Cross Junction and Brighton Road corridor (CDA_040, CDA_41 and CDA_042) to determine the drainage capacity and potential for future improvements such as the construction of a deep interceptor sewer or online storage tank
- Checking the capacity and maintenance of the oversized soakaway located at the junction between the B2032 and the A23 Brighton Road to ensure that it is providing adequate storage
- Undertaking a feasibility study to assess the potential for flood storage in South Norwood Country Park (CDA_047 South Norwood)
- Undertaking a feasibility study to assess the potential for flood storage in the South Croydon playing fields and the Whitgift House playing fields (CDA_042 South and Central Croydon)
- Undertaking a feasibility study to assess the potential for flood storage in the recreation grounds off Christchurch Road parallel to the Brighton Road (CDA_041 Brighton Road).

London Borough of Croydon Local Flood Risk Management Study Preferred options

4.6.3 The LBC Local Flood Risk Management Study Action Plan (2015) also identified several opportunities related to areas that should be prioritised for flood risk alleviation work. Several examples are below:

- Commencing first stage of Kenley flood alleviation scheme in CDA Group8_037;
- Developing flood alleviation scheme for Caterham Bourne;

- Investigating localised flood problems around the Chaffinch Brook in Ashburton; and
- Investigating influences of regular flooding hotspots.

4.6.4 Additionally, several actions that are related to meeting with Network Rail / Thames Water / Sutton & East Surrey Water / TfL to discuss areas where their infrastructure falls in Croydon's flood hotspots.

- Engaging with Network Rail regarding planned maintenance to their assets along route of the Caterham Bourne; and
- Engaging with Sutton & East Surrey Water regarding their Flood Action Plan for Kenley Water Treatment work.

Flood Risk Feasibility studies

4.6.5 There are a number of Flood Risk Feasibility studies that are currently ongoing across the Borough. Examples include:

Graveney Flood Alleviation Scheme

4.6.6 The Environment Agency has identified more than 700 properties at risk of flooding in and around Graveney[24]. The Environment Agency is working together with LB Croydon to develop a scheme to reduce this risk to 340 homes along the River Graveney and Norbury Brook in Thornton Heath and Norbury. In February 2018, a Public Engagement event took place informing the residents about the scheme and considering three shortlisted options:

- A flood storage area in Norbury park with restoration of a natural river channel
- A flood storage area in Thornton Heath Recreation Ground
- Combined storage at Norbury Park and Thornton Heath Recreation Ground.

4.6.7 Subsequently, Option A (Norbury Park) was selected as the preferred option. This is the creation of a more natural looking river by removing the existing culvert, and the creation of a flood water storage area. This option fits in well with Croydon's existing masterplan for the area and was also the favoured option for residents around Norbury Park.

4.6.8 Should applications for funding be successful, the design will be refined further, environmental surveys will be undertaken and a planning application will be submitted.

Caterham-on-the-Hill Flood Alleviation Scheme Outline Business Case[25]

4.6.9 Caterham-on-the-Hill has a history of flooding, most recently in June 2016. A Strategic Outline Case (SOC), published in March 2018, outlined the flooding mechanisms in the catchment through modelling and local evidence. The catchment is at high risk of surface water flooding particularly in high intensity rainfall storm events. A short-list of five options mainly based on flood storage were identified to reduce flooding. The analysis also concluded that there is limited space to intercept overland flow in this predominantly steep urban area.

4.6.10 An Outline Business Case (OBC) was subsequently submitted in August 2020 to seek £1,900,000 to install property flood resilience (PFR) measures to 205 properties affected by flooding in Caterham Hill and Old Coulsdon, located in an upstream sub-drainage area of the Wandle catchment.

Croydon Flood Alleviation Study[20]

4.6.11 London Borough of Croydon has identified flood hotspots within the Borough that are frequently subjected to flooding following intensive rainfall but where the flooding is limited to roads, gardens and driveways and therefore do not meet LBC's current criteria for triggering a formal Section 19 flood investigation under the FWMA; nor do they meet requirements to gain additional government funding for flood alleviation e.g. through the national Flood and Coastal Erosion Management (FCERM) Grant in Aid (GiA) process administered by the Environment Agency. As a result, seven locations have been investigated to improve the understanding of the flooding mechanisms, identify viable long term

[24] Environment Agency (2019), Graveney Flood Alleviation Scheme Shortlist. https://consult.environment-agency.gov.uk/ksles/graveney-flood-alleviation-scheme-shortlist/
[25] Business Case for Caterham-on-the-Hill flood alleviation scheme, August 2020. https://mycouncil.surreycc.gov.uk/documents/s70674/ANNEX%201-%20Caterham-on-the-Hill%20OBC.pdf

measures that could alleviate or minimise the impact of future flooding and inform whether there may be benefits to implement flood management at multiple sites concurrently. The locations are:

1. Asmar Close, Coulsdon
2. Stoneyfield Road, Coulsdon
3. Farm Fields, South Croydon
4. Sanderstead Court Avenue, South Croydon
5. Old Lodge Lane, South Croydon
6. Lower Barn Road, Riddlesdown Station,
7. Meadow Hill, Smitham Bottom Lane, South Croydon.

4.6.12 Following this study, works at Lower Barn Road in Riddlesdown commenced in Summer 2021.

- Phase 1 – involves the installation of a linear drainage system across Lower Barn Road junction with Mitchley Avenue to intercept the flow of water flowing down Mitchley Avenue and then discharge into a soakaway in the green space adjacent to St Edmund's Church.
- Phase 2 – involves the installation of a new soakaway in the green space adjacent to the railway station. The new soakaway will act as an overflow for the existing soakaway located at the low point by the railway bridge. This work is expected to commence immediately after Phase 1.

Chaffinch Brook Flood Alleviation Scheme

4.6.13 A project is underway to alleviate flooding along the Chaffinch Brook in the east of the Borough. The option appraisal stage of the project is currently being undertaken which includes identification of options, screening from long list to short list, option modelling and economic assessment to select the preferred option(s).

Natural Flood Management

4.6.14 Natural flood management involves techniques that aim to work with natural hydrological and morphological processes, features and characteristics to manage the sources and pathways of flood waters. Techniques include the restoration, enhancement and alteration of natural features and characteristics, but exclude traditional flood defence engineering that works against or disrupts these natural processes. The NPPF[1] , paragraph 157 specifically cites considering opportunities for Natural Flood management where appropriate within new developments to reduce the causes and impacts of flooding. Further guidance on the use of natural flood management processes is available from the Environment Agency in their 'Working with Natural Processes –Evidence Directory'[26].

River Restoration

4.6.15 One of the methods for reducing flooding using natural flood management is river restoration. During the last century, many rivers were modified using hard engineering techniques to straighten or canalise them. The disadvantages of these techniques have now become apparent which include the damage to the environment and ecosystems as well as an increase in flooding.

4.6.16 River restoration contributes to flood risk management by supporting the natural capacity of rivers to retain water. By re-connecting brooks, streams and rivers to floodplains, former meanders and other natural storage areas, and enhancing the quality and capacity of wetlands, river restoration increases natural storage capacity and reduces flood risk. Excess water is stored in a timely and natural manner in areas where values such as attractive landscape and biodiversity are improved and opportunities for recreation can be enhanced.

[26] Working with Natural Processes – Evidence Directory
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/681411/Working_with_natural_processes_evidence_directory.pdf

9. Next Steps

9.1 Sequential Test

9.1.1 Using the strategic flood risk information presented within this Level 1 SFRA, LB Croydon should undertake the Sequential Test to document the process whereby future development is steered towards areas of lowest flood risk.

9.2 Level 2 SFRA

9.2.1 Where it is not possible to accommodate all the necessary development outside those areas identified to be at risk of flooding, a Level 2 SFRA will be required to provide information to support the application of the Exception Test for future development sites. The scope of the Level 2 SFRA will be to consider the detailed nature of the flood characteristics within a flood zone including:

- flood probability
- flood depth
- flood velocity
- rate of onset of flooding, and
- duration of flood.

9.2.2 The Level 2 SFRA will provide a more detailed assessment of the flood risk for specific development sites which may require the application of the Exception Test.

9.3 Future Updates to the SFRA

9.3.1 The Environment Agency review and update the Flood Map for Planning (Rivers and Sea) on a quarterly basis and a rolling programme of detailed flood risk mapping is underway. Future new modelling of watercourses in the area will improve the current knowledge of flood risk within London Borough of Croydon and may marginally alter predicted flood extents within parts of the Borough in the future.

9.3.2 New information may influence future development management decisions within these areas. Therefore, it is important that the SFRA is adopted as a 'living' document and is reviewed regularly in light of emerging policy directives, flood risk datasets and an improving understanding of flood risk within the Borough.

9.3.3 The Level 1 SFRA may need to be reviewed and updated following amendments to:

- the predicted impacts of climate change on flood risk
- detailed flood modelling - such as from the Environment Agency or lead local flood authority
- the local plan, spatial development strategy or relevant local development documents
- local flood management schemes
- flood risk management plans
- shoreline management plans
- local flood risk management strategies
- national planning policy or guidance

9.3.4 **The SFRA should be reviewed after a significant flood event.**