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Croydon Flood Investigations January - March 2014

Caterham Bourne Flood Investigation

Final:
October 2014

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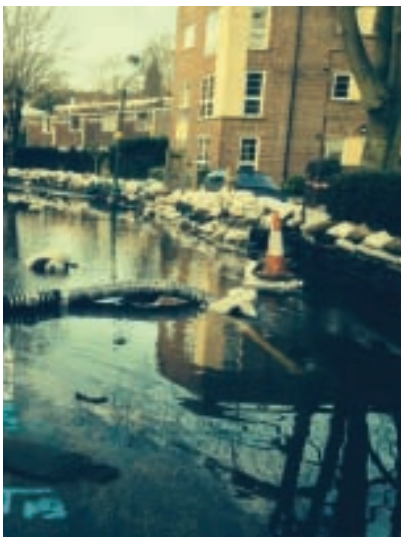
Prepared for:
Croydon Council

UNITED KINGDOM & IRELAND



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Rev	Date	Details	Prepared by	Checked by	Approved by
1	August 2014	First Draft for comment	Craig Boorman Assistant Hydrologist Amy Ruocco Water and Flood Risk Consultant	Andrew Woodliffe Associate Director	Jon Robinson Operations Director
2	September 2014	Second Draft with comments	Amy Ruocco Water and Flood Risk Consultant	Sarah Kelly Principal Consultant	
3	October 2014	Final Version	Amy Ruocco Water and Flood Risk Consultant	Sarah Kelly Principal Consultant	Jon Robinson Operations Director

URS Infrastructure and Environment UK Ltd
Scott House
Alençon Link
Basingstoke
Hampshire
RG21 7PP

Tel: +44(0)117 917 1200
Fax: +44(0)117 930 0342

www.urs.com/uki

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EXECUTIVE SUMMARY

Introduction

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.

This investigation has been carried out under Section 19 of the Flood and Water Management Act 2010 (FWMA) by Croydon Council (CC) in their role as a Lead Local Flood Authority (LLFA). The FWMA dictates that LLFAs should investigate a flood event to the extent that it 'considers it necessary or appropriate'. Flooding from the Caterham Bourne in February and March 2014 met a number of the thresholds prompting an investigation under the Croydon Council Draft Flood Investigation Protocol, including flooded residential property, commercial property and critical infrastructure.

Risk Management Authorities (RMAs) with a response role under the FWMA within the London Borough of Croydon were identified as CC (as LLFA and Highways Authority), the Environment Agency, Transport for London (as a Highways Authority) and Thames Water (TWUL) (as the Water and Sewerage undertaker). Due to the nature of this event, significant emergency response roles were also carried out by the London Fire Brigade (LFB) and Metropolitan Police (MPS). As significant landowners around the Caterham Bourne, Network Rail and Sutton and East Surrey Water (SESW) also carried out response work.

Caterham Bourne Catchment

The Caterham Bourne is a groundwater-fed watercourse, which flows intermittently following periods of wet weather, rising in Tandridge in Surrey. Heavy flows are recorded approximately every 7 years. Source location can vary between flood events. Emerging flows were observed in 2014 from two pathways in Woldingham, east of the Railway aqueduct over Woldingham Road. Another flow path originates near Caterham Station. These flow paths combine at the Wapses Lodge Roundabout on the A22 where the Environment Agency map the start of the Caterham Bourne Main River.

The route of the bourne then follows the approximate route of the A22 through Whyteleafe and into Kenley where it passes through a mixture of different sized culverts and open ditches. When the bourne reaches Purley Cross, it flows north entirely within a culvert until joining the River Wandle at Waddon. Croydon Council have records supporting regular historic flooding from the bourne.

The Flood Event

The main source of flooding during this event was groundwater resulting from exceptional levels of rainfall during December 2013 and January 2014. Groundwater levels in Woldingham were recorded to increase by over 22 metres between late December and Late January. However, the complex nature of an urbanised catchment meant there were also combined influences from surface water, sewers and artificial infrastructure which may have been blocked, damaged or failed to function correctly.

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. A number of locations have been identified along the route, which were either significantly affected or particularly important in the management effort including;

- **Bourne Park** – Combined issues of high flows in the bourne, additional groundwater emergence and surcharging sewers caused the park to flood. A temporary flood storage area was created to hold the flood waters in the park.

- **Bourne View Flood Storage Area** – Constructed following serious flooding from the bourne in 2001, which functioned effectively as a storage area although some issues were identified relating to blockages of the trash screen, capacity and fluctuating water levels.

- **Kenley Water Treatment Works** – The Waterworks supplies drinking water to approximately 47,000 people and was considered at significant risk from Caterham Bourne flows and rising groundwater. Relief efforts were focussed on preventing high floodwaters reaching the works to a degree that would cause shutdown, which in turn would add large quantities of water to the flood that under normal operation are abstracted, with severe consequences for hundreds of properties in the area.

- **Harris Academy** – The bourne is an open ditch here and there was some overtopping. The school was closed during the flooding and a temporary flood storage area erected in the field to be used if the Kenley Waterworks were shutdown.

- **Kenley Cricket Ground** – The open ditch continues here and shallow flooding of the field was experienced from overtopping.

- **Dale Road and Foxley Hill Road** – The deepest flooding of approximately 1 metre occurred here with over 56 properties evacuated in the area. Intensive pumping was required between Dale Road and Purley Cross. A temporary flood storage area was constructed in the car park at the church on Dale Road.

- **Purley Cross** – Water was pumped from Dale Road into an open section of the bourne north of the Railway line. The pedestrian underpass was purposefully flooded to direct floodwaters away from properties.

- **Purley Oaks Pond** – The pond quickly filled with water as the bourne flow increased. The pond was not draining and significant pumping was required to move water into the downstream drainage network. It was later established that the outlet pump was not functioning.

Multi-Agency Response

There was a significant multi-agency response following declaration of an emergency on 6th February 2014. CC set up a Borough Emergency Control Centre (BECC) which monitored the situation 24 hours a day for 20 days. Gold command was established by CC to determine a framework with emergency services dealing with the incident and Gold meetings were held daily. Representatives from all RMAs and emergency responders attended the Gold and Silver meetings. A short summary of some of the actions carried out by different agencies are included below;

- **Croydon Council** – CC declared a major incident on 6th February and set up BECC. They led Gold command with daily meetings. They monitored situation 24 hours a day for 20 days and identified vulnerable communities and properties at risk. CC deployed thousands of sandbags with assistance of other agencies. CC established diversion plans and communication networks and mobilised significant extra resources to assist the BECC and resident liaison on the ground.

- **London Fire Brigade** – following the declaration of a Major Incident, LFB implemented an operational plan to protect local communities and critical infrastructure in line with the London Emergency Services Liaison Panel Major Incident Procedure Manual (2012). LFB deployed significant numbers of high volume pumps to move flood water away from areas at risk, particularly at the Kenley Waterworks and Purley Oaks Pond. Numerous other local flood management activities were carried out simultaneously to minimise damage to property.

- **Metropolitan Police** – MPS supported all agencies involved throughout the incident whilst maintaining core responsibility of crime prevention, protecting life and supporting a traffic plan to allow emergency to take place. Overall responsibility of the Major incident was temporarily transferred to the Police on 14th February when the situation became critical at the Waterworks. It was transferred back to CC the following day.

- **Environment Agency** – The EA issued groundwater flood alerts and provided updates on groundwater and weather outlook. They carried out constant monitoring of groundwater, rainfall, river

flows and soil moisture deficits. Short-term risk assessment maps were prepared for decision makers. The EA's monitoring increased to additional boreholes. Flood ambassadors assisted with communicating with the public. Staff assisted with clearing blockages, providing advice as well as pumps and temporary flood defence structures.

- **Sutton and East Surrey Water** – SESW worked closely with CC, LFB and the Environment Agency in the protection effort at the Waterworks, erected defences and installed pumps. They developed plans for an alternative drinking water supply.
- **Thames Water** – TWUL supported SESW with personnel and equipment to protect the Waterworks and attended sites of foul flooding.
- **Transport for London** – TfL worked with CC to manage floodwater affecting the highway and assets. Helped provide sandbags and pumps.

Overall, given the scale of the event and number of agencies involved, it is felt by CC that the response worked well in protecting the communities in Croydon under very challenging circumstances. The number of flooded properties was low considering the size of the flood and this is thought to be due to early mobilisation of pumps and multi-agency working. Effective new relationships were formed between agencies and a multi-agency solution cell is continuing to address how the risks can be managed in the future at a regional scale.

Opportunities for improvement have been discussed by partner agencies with a focus around improving channels of communication between organisations and clarifying or formalising decision-making structures in these types of events. Information sharing and improved awareness with non-emergency partners about established London Emergency Services Liaison Panel LESLP procedures were highlighted as an area to improve. In the future, it is agreed that improved understanding of groundwater change and trigger levels as well as increased measuring points would be beneficial.

Mitigation and Next steps

Historic evidence supports that the bourne has been rising and flooding this area for many centuries and is likely to continue to do so in the future. The risk can never be entirely removed from this source but there is a need to investigate new approaches to manage the risk in the best possible way.

Short to medium term management options have been identified to recover and restore the bourne following the flooding and prepare for the coming winter as much as possible. Actions include clearance, dredging and de-silting of channels and culverts, establishing more regular maintenance and inspection and working with Thames Water to agree a way forward on asset maintenance. This will include investigating influences on the problems at Dale Road.

In the longer term CC will be working with SCC to develop a catchment scale flood alleviation scheme as well as identifying and constructing suitable areas which could be used for flood water attenuation in the future. A breakdown of recommended actions and next steps in included in Section 7 of the main report. A key theme will be partnership approaches between agencies and improved communications with local residents about the risks and finding suitable solutions.

1 INTRODUCTION

1.1 The Flood Event

The period from December 2013 to January 2014 was the wettest two month period on record in the South London area[1], with 213mm of rainfall recorded in January 2014[2]. 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 ('the 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.

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.

1.1 Why has this flood been investigated?

Croydon Council (CC) is the Lead Local Flood Authority (LLFA) for the area, and within its role as LLFA, it has a responsibility to record and report flood incidents, as detailed in Section 19 of Part 3 of the Flood and Water Management Act (FWMA).

FLOOD AND WATER MANAGEMENT ACT 2010

Part 1: Flood and Coastal Erosion Management

3. Supplemental powers and duties

19. Local authorities: investigations

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

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

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

(2) Where an authority carries out an investigation under subsection (1) it must:

(a) publish the results of its investigation, and

(b) notify any relevant risk management authorities.

[1] Environment Agency (2014) Groundwater flooding: Caterham Bourne, Environment Agency contribution to multi-agency response, June 13 2014

[2] Environment Agency rain gauge data for Caterham Bourne catchment, inclusive data range from 1st January to 31st January 2014.

CC has developed a draft Flood Investigation Protocol which outlines the process that will be followed to determine the need for investigation.

Each flood event is assessed on a case by case basis, considering all factors such as the source of flooding and the number and type of receptors (homes, businesses and critical infrastructure) which are considered as thresholds, to determine the need for an investigation. The protocol provides guidance to aid decision-making and threshold levels are used as a guide only and remain under review. The key thresholds from the draft protocol are listed in Table 1.1.

Table 1.1: Flood Investigation Protocol Threshold Exceedance

Key thresholds	Threshold exceeded?
There has been a fatality or serious injury as a direct result of flooding.	No fatalities or serious injuries as a result of the flood event.
Depth greater than 0.10m over ground floor threshold of a residential property ***or*** more than 3 residential properties flooded.	19 confirmed and 12 unconfirmed residential properties flooded. Small number over ground floor threshold
Flooding has prevented the operation of the critical infrastructure for more than 2 hours.	Critical Infrastructure was affected by flooding for more than 2 hours, Kenley Water Treatment Works (WTW) and A22.
More than 3 commercial properties been affected by flooding ***or*** the flooding is deemed to have caused significant economic disruption.	Four confirmed and four unconfirmed commercial properties flooded.
It is unclear which Risk Management Authority (RMA) is responsible ***or*** whether the appropriate duties have been carried out.	Some inconsistencies exist with regards to asset ownership.
The weight of public interest justifies the need for investigation (to be decided internally after review).	Not required.

As this flood event resulted in flooding of residential and commercial property as well as serious disruption to critical infrastructure, an investigation is required. This report constitutes that investigation.

1.2 Aims and Objectives

This report aims to meet the requirements of FWMA, as well as provide a useful reference for the effective future management of this source of flooding in Croydon through:

- Detailing the flooding incident,
- Analysing the flood history of the area,
- Identifying the responsibilities of RMAs and confirming the actions which were carried out,
- Identifying successful response measures and lessons learned,

- Recommending the next steps.

1.3 Data Collection and Review

Data relating to flood incidents and emergency response was requested from the following organisations for input to this investigation:

- Croydon Council (CC),
- Surrey County Council (SCC)
- EM Highways Services(contractors working for CC),
- Environment Agency (EA),
- Transport for London (TfL),
- London Fire Brigade (LFB),
- Sutton and East Surrey Water (SESW),
- Metropolitan Police (MPS),
- Thames Water Utilities Ltd (TWUL).
- Network Rail (NR)

1.4 Duties and Responsibilities

1.4.1 *Risk Management Authorities*

Under the definition of Section 6(13) of the FWMA, the RMAs with responsibilities on this occasion were as follows:

a) **Environment Agency**

b) **Lead Local Flood Authority** – CC and SCC

c) **Water Company** – TWUL,

d) **Highway Authority** – CC, SCC and TfL.

Additionally, emergency response roles were carried out by:

- LFB (major incident emergency response in Croydon)
- Surrey Fire and Rescue (SF&R) (responding to general emergency within Surrey)
- MPS and Surrey Police (SP),
- NHS London (NHS-L), London Ambulance Service (LAS), and Croydon Health Service (CHS),
- Tandridge District Council (TDC) – emergency works in Whyteleafe and Woldingham, Surrey.

As significant landowners around the bourne, responses were also carried out by:

- Network Rail (NR),
- SESW.

The legal duties of these organisations are summarised below.

1.4.2 *Croydon Council*

As a LLFA, the FWMA[3] requires that CC lead the management of local flood risk from surface water, groundwater and ordinary watercourses within the London Borough of Croydon. Duties include investigation of significant flood events, maintaining a register of structure and features influencing flood risk and developing a Local Flood Risk Management Strategy for Croydon.

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

As a Highways Authority, the Highways Act 1980[4] requires that CC (and SCC and TfL where applicable) ensure that highways are drained of surface water and where necessary maintain all drainage systems.

CC is a Category 1 Responder under the Civil Contingencies Act 2004[5] and therefore has a responsibility, along with other organisations for developing emergency plans, contingency plans and business continuity plans to help reduce, control or ease the effects of an emergency.

1.4.3 *Surrey County Council*

The Caterham Bourne rises in Tandridge District, within the County of Surrey. As a LLFA, the FWMA requires that SCC lead management of local flood risk from surface water, groundwater and ordinary watercourses within Surrey. Duties include investigation of significant flood events, maintaining a register of structure and features influencing flood risk and developing a Local Flood Risk Management Strategy for Surrey. SCC is also a Category 1 Responder under the Civil Contingencies Act 2004.

1.4.4 *Environment Agency*

The EA has permissive powers to carry out maintenance work on Main Rivers[6] under Section 165 of the Water Resources Act (1991)[7].

The FWMA outlines that the EA has powers to designate structures and features that affect flooding in order to safeguard assets that are relied upon for flood risk management. Once a feature is designated, the owner must seek consent from the authority to alter, remove or replace it (FWMA Schedule 1, Section 1). The EA is also a Category 1 Responder under the Civil Contingencies Act 2004.

[3] Flood and Water Management Act (2010) http://www.legislation.gov.uk/ukpga/2010/29/contents
[4] Highways Act (1980) http://www.legislation.gov.uk/ukpga/1980/66/contents
[5] Civil Contingencies Act (2004)http://www.legislation.gov.uk/ukpga/2004/36/contents
[6] Main Rivers are watercourses shown on the statutory main river maps held by the Environment Agency, the Department of Environment, Food and Rural Affairs (in England) and the Welsh Assembly Government (in Wales). They can include any structure or appliance for controlling or regulating the flow of water into, in or out of the channel.
[7] Water Resources Act (1991): http://www.legislation.gov.uk/ukpga/1991/57/contents

1.4.5 *Thames Water*

Under the FWMA, TWUL is responsible for managing the risks of flooding from surface water, foul and/or combined sewer systems where the sewer flooding is wholly or partly caused by an increase in the volume of rainwater (including snow and other precipitations) entering or otherwise affecting the system.

TWUL has a duty to provide and maintain a system of public sewers so that the areas for which they are responsible are effectually drained (Water Industry Act, 1991[8]). Since the late 1970s, and with the publication of Sewers for Adoption[9] in 1980, sewer systems have typically been designed and constructed to accommodate a rainfall event with a 1 in 30 probability of occurrence in any given year (3.3% AEP) or less. Therefore, rainfall events with a rainfall probability of greater than 3.3% AEP would be expected to result in surcharging of some of the sewer system.

TWUL are a Category 2 responder under the Civil Contingencies Act 2004 and therefore has the responsibility to co-operate and share information with Category 1 responders (e.g. LFB, MPS, CC, SCC) to inform multi-agency planning frameworks.

1.4.6 *Transport for London*

Transport for London are responsible for the effectual drainage of surface water from adopted roads along red routes by ensuring that drains, including kerbs, road gullies and ditches and the pipe network which connect to the sewers, are maintained.

TfL are a Category 2 responder under the Civil Contingencies Act 2004 and therefore has the responsibility to co-operate and share information with Category 1 responders (e.g. LFB, MPS, CC, SCC) to inform multi-agency planning frameworks.

1.4.7 *Riparian Owners*

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

Section 25 of the Land Drainage Act (1991)[10] outlines that where the flow of a watercourse is obstructed; the riparian owner is responsible to resolve the condition. Section 28 of the Land Drainage Act (1991) outlines the responsibility of the riparian owner to undertake maintenance of their watercourse if it is impeding the flow of water.

Riparian owners must let water flow through their land without obstruction and must accept flood flows through their land. Riparian owners have no duty in common law to improve the drainage capacity of a watercourse. Further information can be found in the EA's document *Living on the Edge* (2012)[11].

1.4.8 *Local Residents*

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

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[8] Water Industry Act (1991): http://www.legislation.gov.uk/ukpga/1991/56
[9] The Sewers for Adoption guide was first issued in 1980 by WRc. Since then the document has become the standard for the design and construction of sewers to adoptable standards in England and Wales. It acts as a guide to assist developers in preparing their submission to a sewerage undertaker before they enter into an Adoption Agreement under Section 104 of the Water Industry Act 1991
[10] Land Drainage Act (1991): http://www.legislation.gov.uk/ukpga/1991/59/contents
[11] Environment Agency (2012) Living on the edge – A guide to your rights and responsibilities of riverside ownership. http://www.environment-agency.gov.uk/homeandleisure/floods/31626.aspx

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

1.4.9 ***London Fire Brigade and Surrey Fire and Rescue***

The Fire Service is a Category 1 Responder under the Civil Contingencies Act 2004 and therefore has a responsibility, along with other organisations for developing emergency plans, contingency plans and business continuity plans to help reduce, control or ease the effects of an emergency.

1.4.10 ***Metropolitan Police and Surrey Police***

The Police are a Category 1 Responder under the Civil Contingencies Act 2004 and therefore has a responsibility, along with other organisations for developing emergency plans, contingency plans and business continuity plans to help reduce, control or ease the effects of an emergency.

1.4.11 ***Tandridge District Council***

TDC are a Category 1 Responder under the Civil Contingencies Act 2004 and therefore has a responsibility, along with other organisations for developing emergency plans, contingency plans and business continuity plans to help reduce, control or ease the effects of an emergency.

2. BACKGROUND

The London Borough of Croydon is located within Greater London, and is one of the largest London Boroughs. It is bounded to the north by London Boroughs of Merton and Lambeth, to the east by London Borough of Bromley, to the west by London Borough of Sutton and to the south by Surrey.

2.1 The Catchment

The Caterham Bourne is an ephemeral watercourse, meaning it flows intermittently usually after periods of heavy or prolonged rainfall, and is predominantly dry at other times. Historically, it is recorded to flow heavily approximately every 7 years, although smaller flows can be observed more frequently. The bourne rises in Surrey within the district of Tandridge. The source location is reported to vary with three valley flow paths leading towards the Wapses Lodge roundabout on the A22 in Surrey (see Figure 2.2). The EA map the start of the designated main river at Wapses lodge[12], where the three flow paths combine.

The route of the bourne flows in a North West direction through Whyteleafe and into Croydon, roughly following the course of the A22, through Kenley to Purley Cross in Croydon. The bourne then flows within a culvert, flowing north east under Brighton Road to the balancing pond at the Purley Oaks depot. The bourne continues to flow in a northerly direction, mostly within culverts, eventually joining the River Wandle at Waddon (Figure 2.1).

[12]Environment Agency. Flood Map for Planning (Rivers and Sea) http://maps.environment-agency.gov.uk/wiyby/wiybyController?topic=floodmap&layerGroups=default&lang=_e&ep=map&scale=7&x=534523.8854166673&y=158842.2708333329

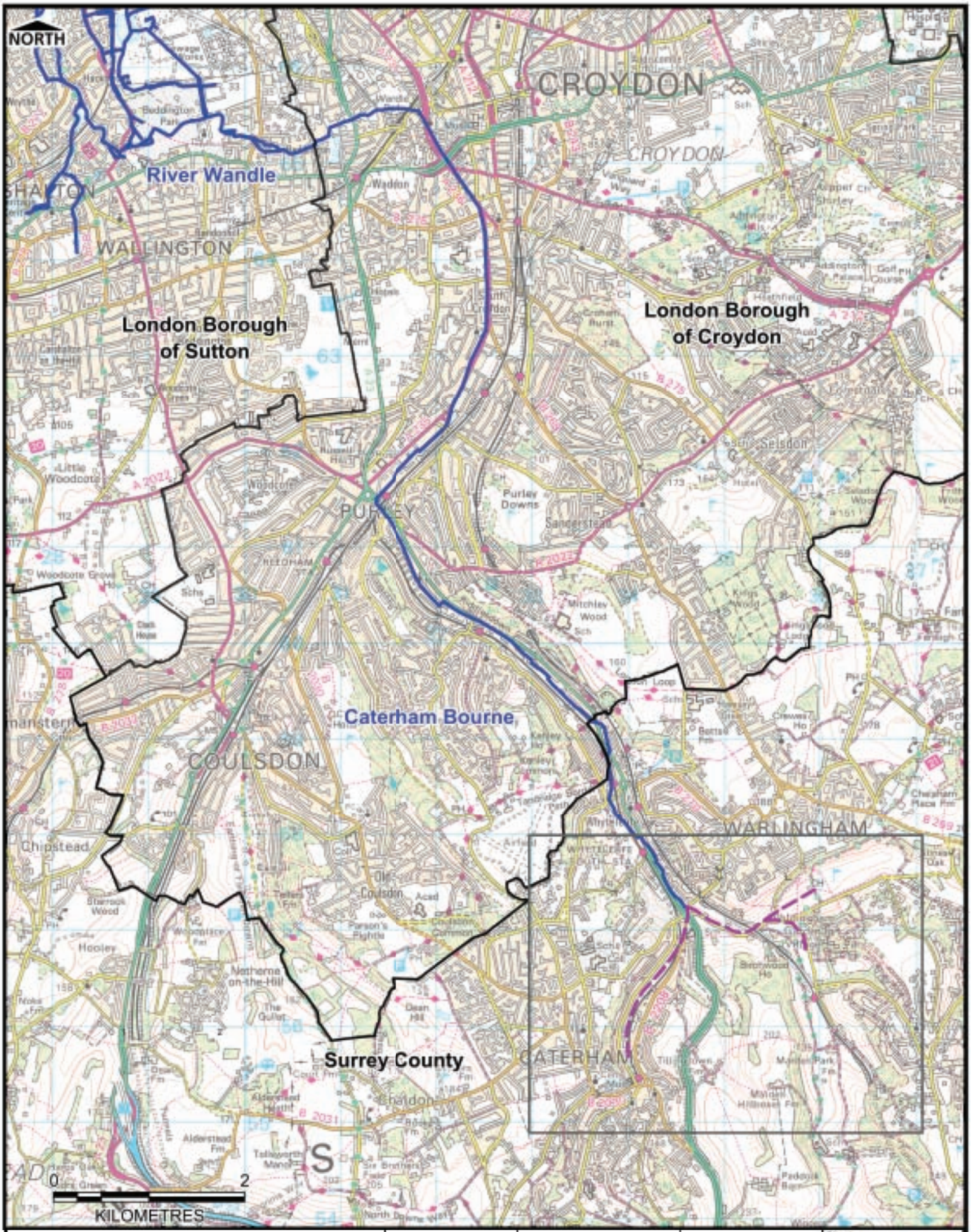

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FIGURE 2.1

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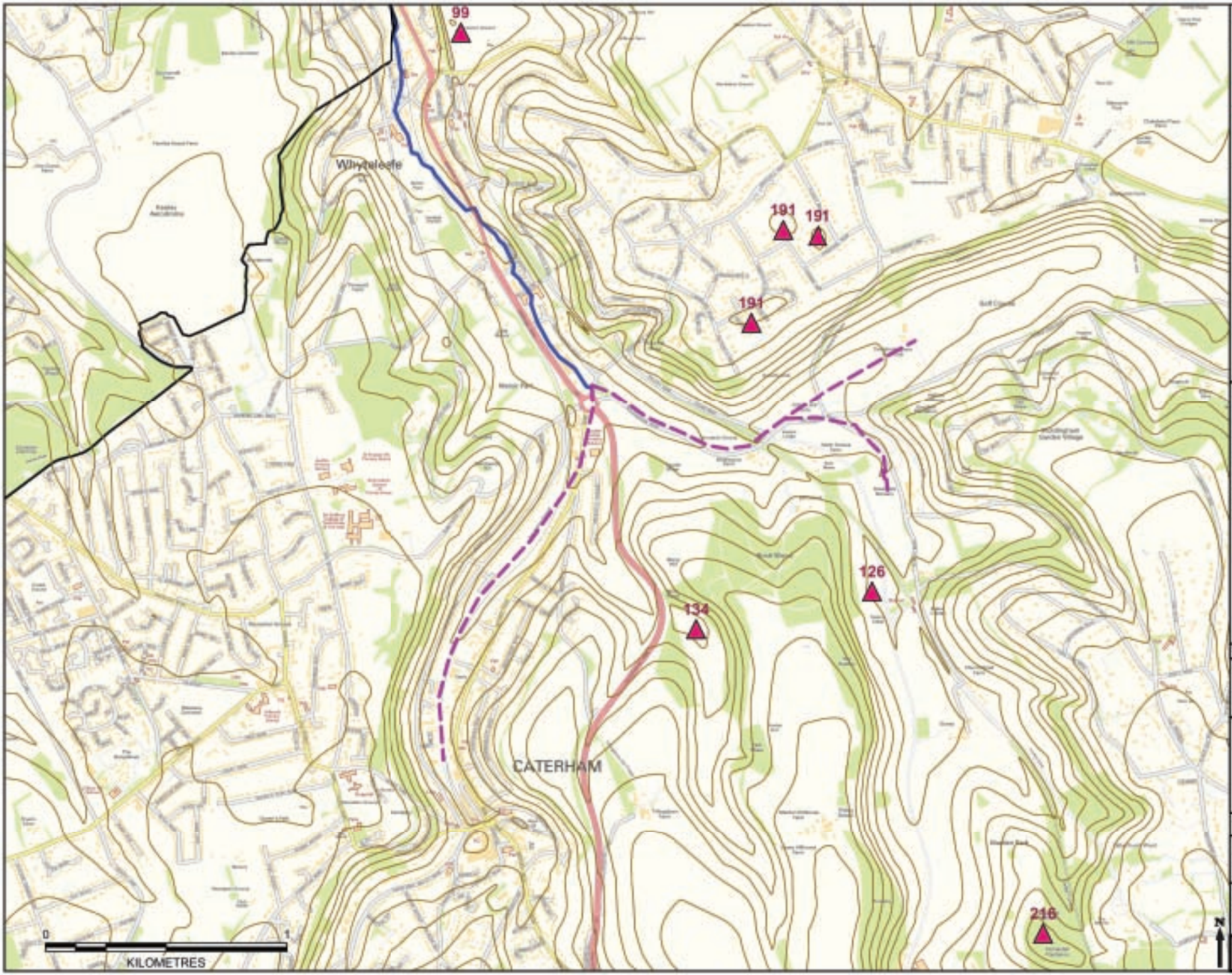

Legend

- Administrative Boundary
- Caterham Bourne
- Potential Flow Paths
- OS Spot Height
- OS Contour Line

Drawing Status: FINAL

Drawing Title:

DETAILED FLOW PATHS

LONDON BOROUGH OF CROYDON FLOOD INVESTIGATION

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Scale at A3	Date	Drawn: CB
1:20,000	August 2014	Approved: AR

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FIGURE 2.2

Figure 2.3: Groundwater emergence paths in Woldingham, February 2014

2.1.1 *Topography and Land Use*

The topography of the Caterham Bourne catchment is characterised by steep slopes and valleys in the south of the London Borough of Croydon and North West Surrey. The route of the A22 through Caterham, Whyteleafe and on to Purley is located in a natural valley, as is Brighton Road (A23). This has the potential to exacerbate flooding due to rapid runoff rates from the steep slopes and accumulation of runoff on the road.

There is park land and rural areas to the south of the catchment area, near Warlingham and Whyteleafe and development is focused alongside the A22, in the valley. The catchment becomes more urbanised at Purley and northwards along the A23 to Croydon.

2.1.2 *Geology and Soils*

The bedrock geology in the catchment is made up of undifferentiated chalk formations, including the Lewes Chalk Formation, Seaford Chalk Formation, Newhaven Chalk Formation and Culver Chalk Formation[13]. The Holywell Chalk and New Pitt Chalk formations are located at the bottom of the valley in Whyteleafe, along the A22. Chalk is highly permeable and the EA Aquifer Designation maps[14] indicate that the bourne catchment overlies a 'Principal Bedrock' aquifer.

The superficial deposits of Clay with Flint are located on top of the A22 valley and Head deposits of gravel, sand, silt and clay are located in the valley itself. Hackney Gravel Member deposits consist of sand and gravel, and overly the chalk at Purley and along the A23 valley to Croydon.

[13] http://www.bgs.ac.uk/data/mapViewers/home.html
[14] Environment Agency. 2014. What's in Your Backyard? 'Aquifer Designation' maps. Available at www.environment-agency.gov.uk/wiyby

The permeability of the soils in the catchment area is very high, with free draining shallow lime-rich soil in the valleys and slightly acid loamy soils on the top of slopes[15].

2.2 History of Flooding from Caterham Bourne in Croydon

Official records of flooding from the bourne are patchy, but local history group 'the Bourne Society'[16] document references to floods dating back many centuries and support reports of the bourne being 'in flood' approximately every 7 years. Urbanisation and development of the valley in more recent history has influenced the flow of the bourne with much of the route becoming culverted. Reported surcharging culverts and manholes in recent decades have demonstrated such activities have altered the risk rather than removed it. A search of the data register held by CC has produced a number of anecdotes attributing flooding to the bourne dating from the 1960s (Table 2.1), although this should not be considered a complete record.

The last major flood from high groundwater causing the bourne to flood is recorded in the winter of 2000 and 2001. Exceptional rainfall had fallen through 1999 and 2000 and water emerged alongside Woldingham Road in November 2000[17]. Water rose flooding the A22 up to 2 feet deep through December 2000 and January 2001, combining with foul sewer surcharging and leading to closure of the A22 for over a month.

Table 2.1: Historic Flood Records for Caterham Bourne (Source: Croydon Council Records)

Date	Recorded Incident
June & August 1967	Reference to bourne culvert surcharging in Whytecliffe Road and Brighton Road.
July 1976	Bourne culvert surcharged in Dale Road, flooding 1m deep.
August 1981	Reported bourne surcharging in Dale Road with flooding outside Lister Court. Flooding reported at Rose and Crown, outside Kenley water works and along Godstone Road.
February & August 1988	Flooded basements on Brighton road attributed to 'Bourne water'. Foul sewer reported surcharging into the bourne near Mosslea Road, Whyteleafe. Flooded timber yard on Godstone road near bridge.
October 2000 to March 2001	Closure of A22 for around a month due to bourne flooding and foul sewer surcharging.
July 2007	Property flooding reported at Bourne Park Close due to blocked trash screen.

[15] National Soil Resources Institute. 2014. Soilscapes. Cranfield University. Available at www.landis.orguk/soilscapes/
[16] http://www.bournesociety.org.uk/bournesoc/index.php
[17] Bourne Again! The rising of the Bourne in 2000-2001, The Bourne Society's Local History Records (41) (2001) http://www.bournesociety.org.uk/bournesoc/component/content/article/5-bourne-celebration/93-bourne-again.htm

3. FLOOD MECHANISMS: FEBRUARY – MARCH 2014

3.1 Antecedent Conditions

December 2013 was the sixth wettest December on record across the UK, with the South London region receiving more than 200% of the average rainfall amount for December. This was followed by the wettest January recorded since 1910 southern England[18]. The EA reported this two-month period as the wettest on record in the Kent and the South London area. Figure 3.1 illustrates how the national rainfall from December 2013 to January 2014 compared to the average and Table 3.1 outlines rainfall measured in the Caterham Bourne catchment compared to average monthly readings before and after the flood event.

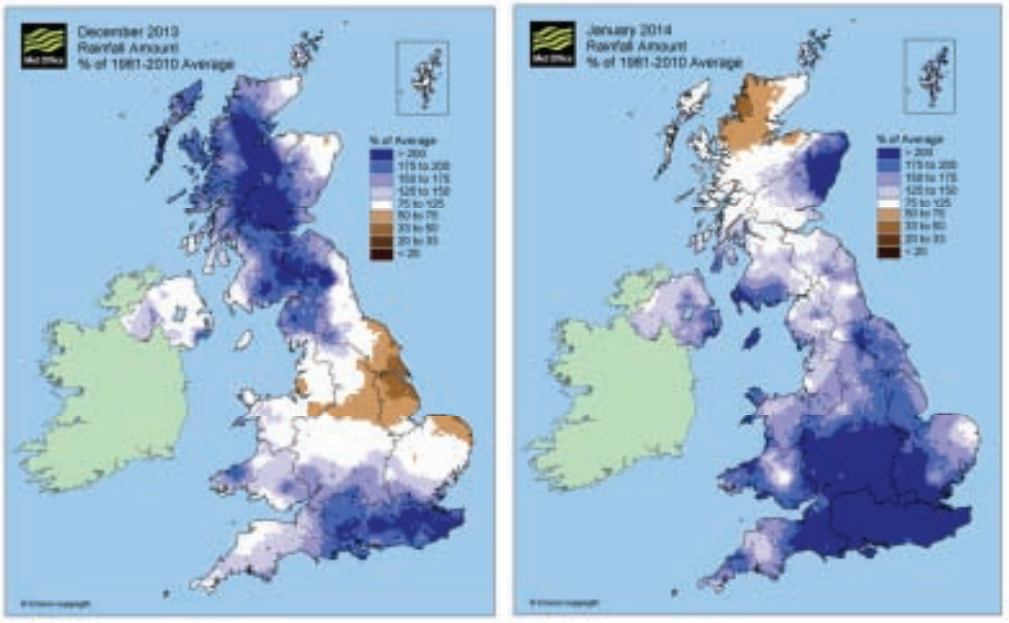


Figure 3.1: Rainfall for December 2013 and January 2014, showing the distribution of rainfall anomalies as a % of the long-term average from 1981-2010[18]

Table 3.1: Recorded Rainfall Data during Winter of 2013/14 from Godstone Gauge (Source: Environment Agency and Met Office)

Month	Total Rainfall (mm) recorded at Godstone Gauge	Met Office average monthly rainfall 1981-2010 at Kenley (mm)[19]
December 2013	156.4	84.1
January 2014	212.6	80.3
February 2014	123.2	59.5
March 2014	25.4	57.9

[18] MET Office (2014) The Recent Storms and Floods in the UK. Available at http://www.metoffice.gov.uk/research/news/2014/uk-storms-and-floods
[19] http://www.metoffice.gov.uk/public/weather/climate/gcpgqgu1r

3.2 Flood Warnings

The EA has a strategic overview for all sources of flooding including groundwater. They supply information in the form of monitored groundwater levels. The bourne and surrounding area has experienced historic groundwater flooding, and therefore the EA provides a groundwater alert service.

As a result of the heavy rainfall, groundwater levels rose rapidly throughout December 2013 and January 2014, and the EA issued a Groundwater Flood Alert for the areas of Whyteleafe, Kenley and Purley (the Bourne) on the 8th January 2014.

3.3 Sources of Flooding

As noted above, exceptionally high rainfall in December 2013 and January 2014 caused groundwater to rise rapidly and this is the predominant source of flooding during this event. However the catchment is complex particularly as the bourne moves into the more urbanised parts of Croydon, where further sources contribute to flooding. Table 3.2 breaks down some of the sources identified in the 2014 floods.

Table 3.2: Sources of Flooding

Type	Description	Role in 2014 Floods
Groundwater	Groundwater flooding occurs as a result of water rising up from the underlying aquifer or from water flowing from springs. This tends to occur after much longer periods of sustained high rainfall and can be sporadic in both location and time often lasting longer than a fluvial or surface water flood.	• The dominant source of flooding during this flood event following record rainfall in December 2013 and January 2014, led to the emergence of springs and flooding of gardens and basements. Also influenced fluvial, sewer and surface water flooding, • Exceptionally high groundwater levels in the underlying chalk as a result of the heavy prolonged rainfall experienced across the region led to: o The bourne rising, leading to high flows downstream in the Wandle catchment (fluvial), o The ingress of rising groundwater into the foul sewer network (sewer), • Saturated soil and extreme pressure on the surface water drainage network (surface water).

Table 3.2: Sources of Flooding		
Surface Water	Usually occurs when high intensity rainfall generates runoff which flows over the surface of the ground and ponds in low lying areas, before the runoff enters a watercourse or sewer.	• Heavy and prolonged periods of rainfall led to surface water runoff which exceeded the immediate capacity of the surface water drainage network in multiple locations, • This was further exacerbated by the lack of infiltration due to already saturated soil caused by high groundwater levels, • A combination of flooding from groundwater and heavy rain caused debris and silt to block up some of the drainage infrastructure limiting capacity further, • Extreme pressure on the surface water drainage network as a result of emergency pumping exceeding capacity.
Fluvial	Flooding resulting from water levels exceeding the bank level of a main river, resulting in watercourses overflowing or bursting their banks.	• Although this flood is largely considered a groundwater flood by the EA, the Caterham Bourne is a designated main river from Wapses Lodge roundabout in Surrey to little Roke Road in Kenley, • Although large sections of the bourne are culverted, the open sections experienced more 'fluvial' type flooding with the large flows of water overwhelming banks at Bourne View, Harris academy and the Kenley Cricket ground, • Structural assets such as trash screens caused water to back up as the high flows brought new debris combined with household waste items to block them up, • Some culverts along the bourne did not have sufficient capacity to convey the large volumes of flow, causing manholes to surcharge or water to back up and overflow upstream.

Table 3.2: Sources of Flooding		
Sewer Flooding	Flooding from the sewer system may occur if: (a) a heavy rainfall event exceeds the capacity of the sewer system / drainage system, (b) interaction with groundwater within the sewer system / drainage system, (c) the system becomes blocked by debris or sediment and/or, (d) the system surcharges due to high water levels in receiving watercourses.	• Heavy and prolonged periods of rainfall led to surface water runoff which exceeded the capacity of the drainage network, • Significant pumping was required to prevent closure of the Kenley Water Treatment Works and to avoid property flooding. This led to greater volumes of water entering the sewer system as routes were sought to get water away from the risk area, • Rising groundwater entered the foul sewer network, causing manholes to overflow and surcharge raw sewage internally and externally, particularly around Bourne Park and further upstream in Whyteleafe.
Artificial Sources	Artificial sources include any water bodies not covered under other categories and typically include canals, lakes and reservoirs.	• Only one waterbody in affected area considered to be artificial - Purley Oaks Pond, • The pond was significant during the flood. Believed to be a relief area for the surface water sewer, it began to fill to dangerously high levels. Flow was not exiting the pond as it should due to blockages and a malfunctioning pump, • Significant pumping was undertaken by the LFB to move water manually back into the drainage system downstream amid fears the system may back up and flood Purley, • The pond overtopped on one occasion on 14th February 2014 causing some shallow highway flooding.

3.4 Monitored Groundwater Conditions

Weekly situation groundwater reports produced by the EA for the South London Boroughs include hydrographs illustrating the groundwater levels at EA groundwater observation boreholes (OBH). Figure 3.2 illustrates the rapid rise in groundwater in the Caterham Bourne area. The coloured section gives average data and shows how the groundwater normally behaves. The black line shows the rising levels experienced in early 2014 and the red dotted line shows the 2000/2001 groundwater levels (the last recorded major flood from the bourne).

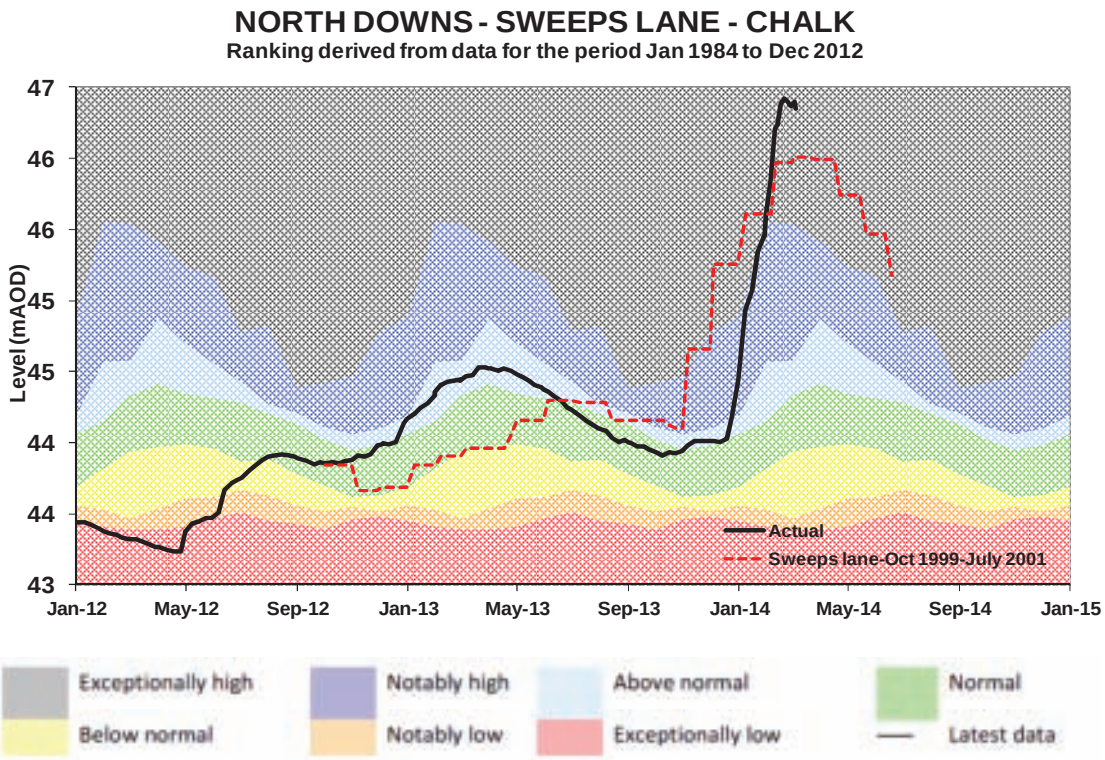


Figure 3.2: Hydrograph at the Sweeps Lane OBH indicating groundwater patterns in the Caterham Bourne area (Source: Environment Agency)

The EA monitored several OBHs in the Caterham Bourne catchment throughout the period. The Woldingham OBH (OSNGR 535230, 156940) and Purleybury OBH (OSNGR 532150, 162150) were monitored and provided groundwater level data in the upper (south) and lower (north) reaches of the bourne catchment respectively. Manual readings were also taken at a number of locations including the site of the former Rose and Crown Pub on Godstone Road

Figure 3.3 shows the groundwater level recorded at both OBHs, alongside readings from the Rose and Crown and demonstrates the rapid rise in water levels in the upper reaches of the catchment at Woldingham, where the water level rose by approximately 22.7m (26%) over the 32 day period from 23rd December 2013 to 23rd January 2014. The increase in groundwater level further down the catchment at the Rose and Crown and Purley Oaks was more prolonged, increasing by approximately 12m (16%) over 50 day period between 22nd December 2013 and 10th February 2014 at the Rose and Crown and approximately 9.2m (19%) over the 63 day period from 15th December 2013 to 15th February 2014 at Purley Oaks.

All three locations indicate elevated groundwater levels remained high throughout the period, up to and beyond March 2014. Whilst groundwater flooding subsided, the bourne continued to flow significantly until late April 2014. Some flow was observed alongside the Kenley Cricket Club during a site visit in July 2014, although upstream sections were dry through Bourne View Meadow.

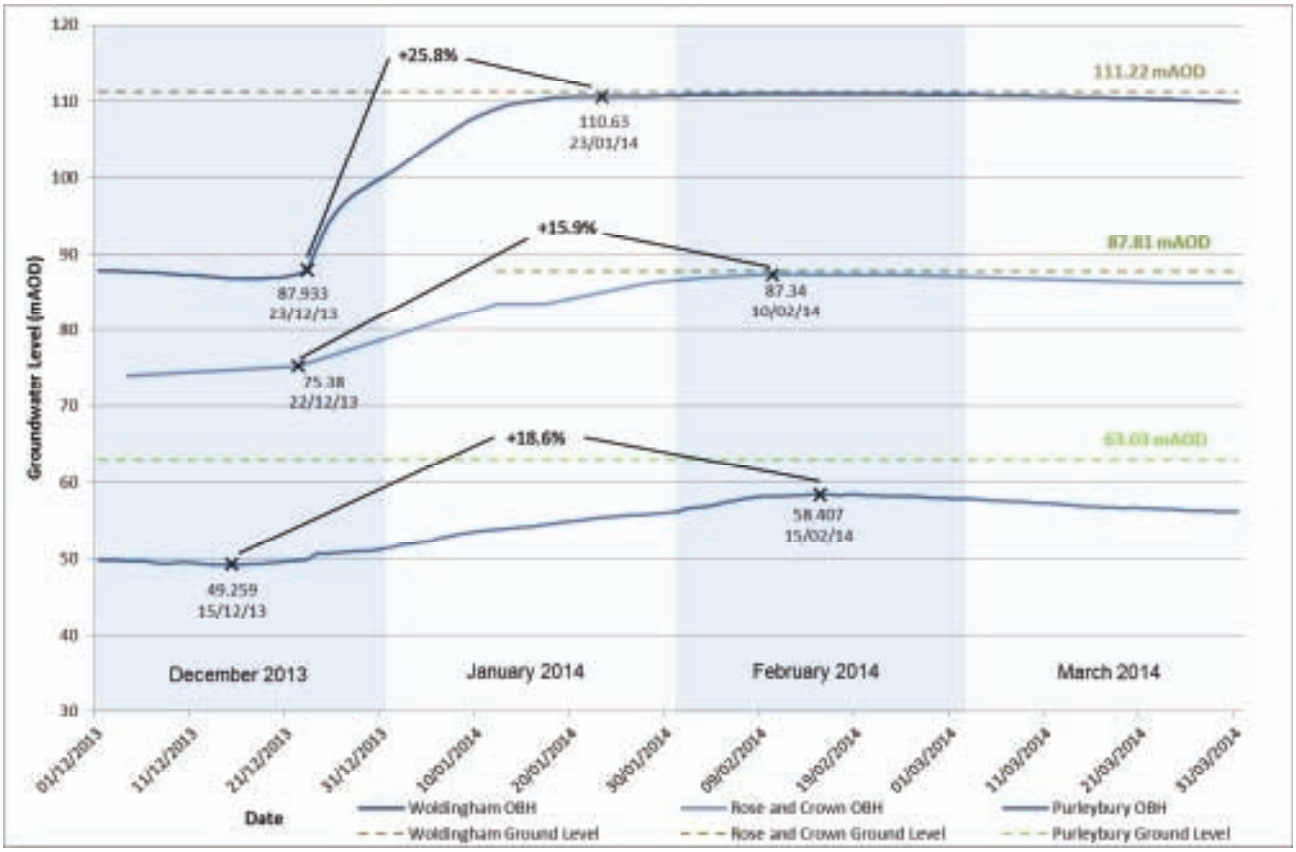


Figure 3.3: Groundwater Levels measured at the Rose and Crown, Woldingham OBH and Purleybury OBH

The ground levels identified in Figure 3.3 are associated with the ground elevation at each of the boreholes. At these sites the data suggests that although close to the surface, the groundwater levels did not exceed ground level. It should be noted that the groundwater and ground level is as recorded at the borehole, and these will vary across the catchment. Therefore, whilst the borehole observations indicate that groundwater levels did not exceed ground level at these locations, there were reports of groundwater emergence at other non-monitored locations across the Caterham Bourne catchment during Winter 2013 / 14.

4. THE FLOOD EVENT: LOCATIONS OF FLOODING

Due to the complexity and extent of this flood event, this section breaks down some of the events by location to give an overview of what happened and when. Table 4.2 to Table 4.9 highlight some key locations in Croydon which either flooded or were significant to the relief and management effort.

4.1 Property Flooding

Known affected residential areas in Croydon are detailed in Table 4.1. With some exceptions, affected properties largely suffered from basement or garden flooding as a result of the very high groundwater levels. This kind of flooding can be extremely difficult to prevent particularly with the incredibly wet conditions preceding these events. It is considered that the early declaration of an emergency and rapid mobilisation of emergency services to a significant pumping operation made a substantial contribution to preventing many more properties from flooding over the ground floor threshold.

Table 4.1: Property flooding during February and March 2014 (source: Environment Agency and Croydon Council)

Area	Reported impacts
Purley Park Road	Garden flooding from high groundwater.
Bourne Park Close Godstone Road Dale Road	Garden flooding from high groundwater. Road flooding from surcharging bourne culvert and relief pumping.
Lansdown Road Godstone Road Purley Down Road Brighton Road	Basement flooding from high groundwater.
Foxley Hill Road	Property flooding from bourne water surcharging from culvert in Dale Road

Additionally a row of commercial businesses between the Kenley Hotel and Westbourne Florist on Godstone Road suffered some internal flooding as the road filled with water.

4.2 Multi-agency response

Rapidly rising groundwater posed numerous threats to people, property and infrastructure which required multiple agencies and authorities working together. Pumping operations, sandbagging and flood barrier construction were carried out by LFB, Environment Agency, and CC with significant support from the Army.

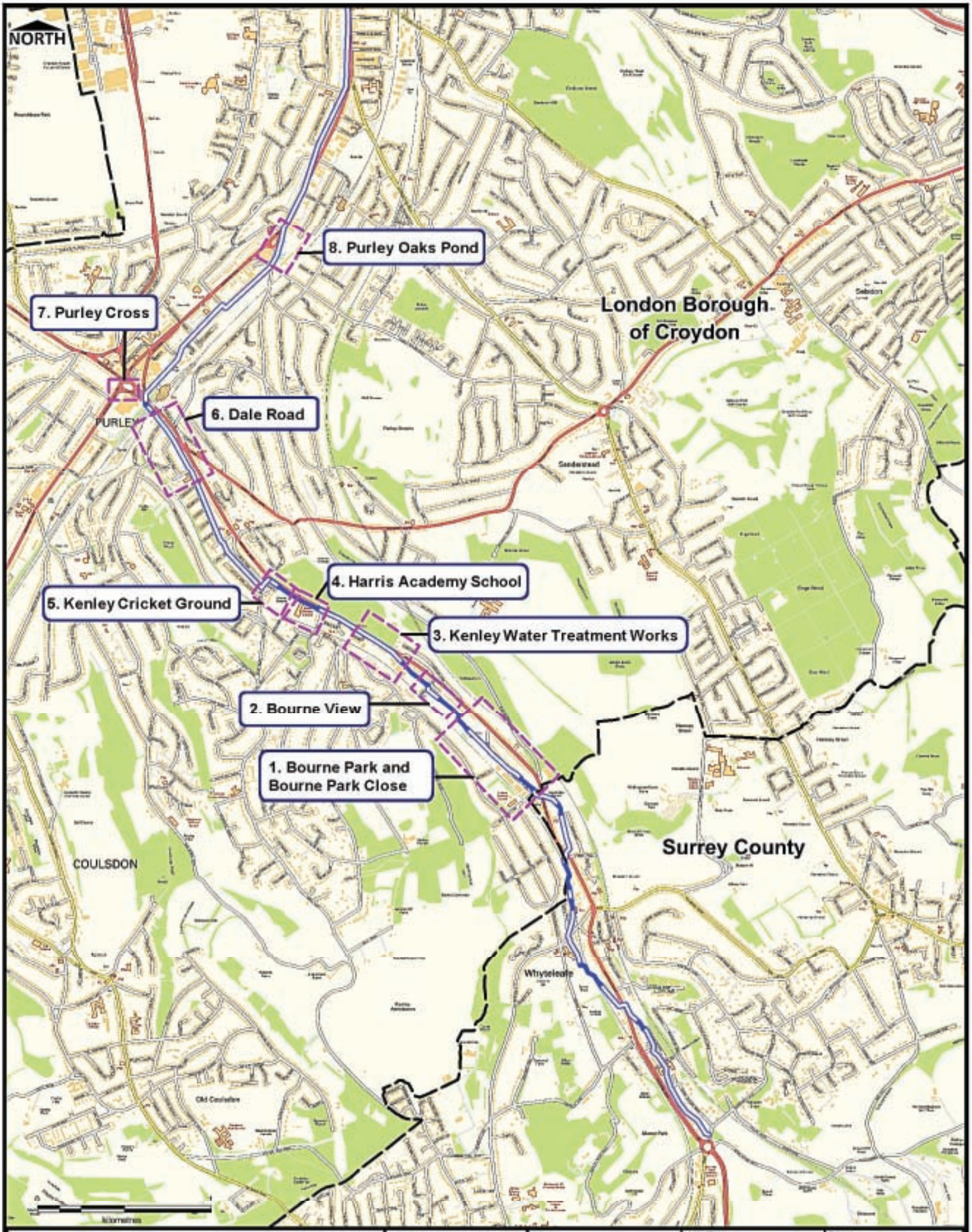
Fast decisions needed to be made with limited information about the mechanisms controlling the fluctuations in flow and emergency measures being carried out at the Tandridge end of the

catchment. Emergency response followed procedures laid out in the The London Emergency Services Liaison Panel LESLP Major Incident Procedure Manual[20].

4.3 Strategic Locations

This section details some of the location-specific impacts and management measures which were particularly significant during the flood event. Figure 4.1 indicates these locations within the London Borough of Croydon.

[20] The London Emergency Services Liaison Panel (2012) Major Incident Procedure Manual: Eigth Edition, May 2012 http://www.leslp.gov.uk/



LEGEND

- LB Croydon boundary
- Main River
- Culverted Watercourse
- Area of Interest

Notes: This map has been produced using the Environment Agency Detailed River Network data

Purpose of Issue: FINAL REPORT CATERHAM BOURNE S19 INVESTIGATION

Revision Details

Scale at A4: 1:20,000

Drawn: CB | Checked: AH

Approved: JR | Date: October 2014

Job Title: LONDON BOROUGH OF CROYDON FLOOD INVESTIGATION

Drawing Title: STRATEGIC LOCATIONS

Client: CROYDON www.croydon.gov.uk

URS

Drawing Number: FIGURE 4.1

Rev: 02

Table 4.2: Bourne Park and Bourne Park Close

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- Groundwater springs observed emerging from property on higher ground east of Bourne Park Close. Resident cut a trough to direct water down to the Caterham Bourne channel,
- High groundwater entered the sewer system causing manholes to surcharge foul water in a number of locations,
- Gardens along Bourne Park Close were surrounded by rising groundwater mixed with surcharging foul sewer,
- Commercial site off Bushey close was flooded with surface and foul water combined,
- The foul sewer was also surcharging into the Bourne Park recreation area.

Open section of bourne flowing NW out of culvert at Bourne Park, February 2014

Silted culvert in Bourne Park following flood, July 2014

New fencing around gardens flooded by foul sewage in Bourne Park Close, July 2014

Aerial view of foul flooding in Bourne Park 14th February 2014

Table 4.3: Bourne View Flood Storage Area

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- Bourne View has a history of property flooding when the Bourne rises,
- Following the floods of 2000/01 a permanent flood storage area (FSA) and bund was constructed on a former allotment site alongside an open section of the bourne,
- Properties in Bourne View were provided with sandbags early and experienced some garden flooding from high groundwater but no internal flooding,
- The FSA functioned well as an alleviation measure in 2014. The water levels fluctuated daily and there was some concern it could become too full and overtop,
- The trash screen located before the bourne becomes culverted under Bourne View had to be regularly cleared to keep the Bourne flowing including removal of household waste items,
- The bourne has 2 sharp 90º changes as it enters the FSA. When the flow was very high, it flooded straight out of the bank, rather than following the channel. This may have been a measure originally put in to slow down flow before reaching Kenley WTW.

Bourne View flood storage area already filling up on January 18th 2014

Bourne View on 9th February 2014

Fly tipping at Bourne View culvert on 18th January 2014

Water flowing from the bourne into the FSA on 9th February 2014

Table 4.4: Kenley Water Treatment Works

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- Following flooding in 2000/1, SESW put in a new culvert in the previously open section between Bourne View and Kenley WTW,
- High flows in the bourne in February 2014 caused water to surcharge out of the culverted watercourse,
- Flooding from the bourne threatened to close down the WTW which supplies drinking water to 47,000 homes,
- Relief efforts were focussed on pumping water away from the works via pipes along Godstone Road, initially to the open section at the cricket club, then subsequently all the way to Purley Cross to an open section north of the railway line (see Box 4.8),
- It was estimated by gold command that if the works shut down, it would take 2-3 hours for the cone of depression to fill and thereafter an Olympic size pool of water would appear every couple of hours – potential for catastrophic flooding in Purley and Kenley.

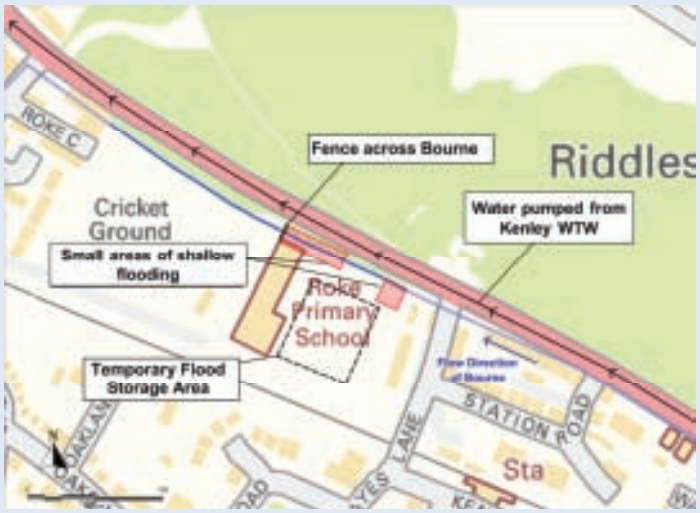
Surcharging bourne culvert

Demountable flood defences protecting the WTW

Floodwaters by main building at WTW in February 2014

Aerial view of waterworks showing defences erected to protect infrastructure and pipes leading off down the A22 in February 2014

Table 4.5: Harris Academy, Kenley (formerly Roke Primary)



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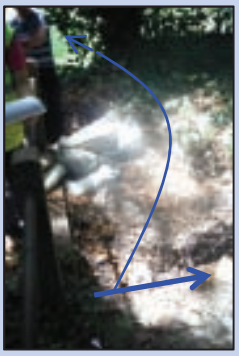
- The bourne overtopped causing some shallow flooding in the corner of the field and behind the main school building,
- The watercourse is poorly maintained here and requires de-silting and bank reinforcement,
- Pumping efforts were impeded due to a wall constructed by the school since the 2001 flood,
- The school was closed for several weeks during the flooding with children diverted to alternative schools,
- Temporary structures were erected around the school field to create an emergency FSA in the event of Kenley WTW shutting down, but it did not need to be used,
- A boundary fence between the school and cricket ground was found to impede flow and was partially removed,
- Significance of flooding here was reduced as a result of the pumping upstream at Kenley WTW.

Fence across the bourne causing blockage

Part of fence removed to aid flow (post flood)



Overtopping at culvert

Temporary flood storage barriers set up around the school field

Temporary flood storage barriers set up around the school field

Table 4.6: Kenley Cricket Ground

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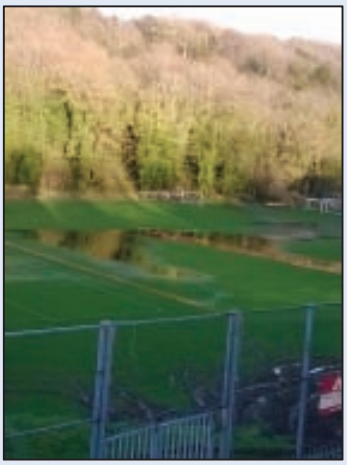
- Shallow flooding in cricket ground due to overtopping of the bourne and high groundwater,
- A sand bag wall was erected at the bottom of the north west sloping cricket ground,
- Flooding of the field was fairly shallow,
- A vented chamber to the foul sewer was observed along the western side of the field,
- Sewers were surcharging on Little Roke Road onto the highway only,
- Some surcharging from the bourne culvert where the route takes a sharp right angle turn between Lower Road and Little Roke Avenue but not considered significant.



Cricket Ground in February 2014

Culvert and Trash Screen downstream of Cricket Ground in January 2014

Flooding to the Cricket Ground in January 2014

The bourne flowing alongside the Cricket Ground in January 2014

Table 4.7: Dale Road and Foxley Hill Road

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- Most significant flooding occurred in Dale Road,
- Approximately 56 properties were evacuated in this area,
- Depth of flooding was approximately 1m deep,
- A number of blocks of flats and surrounding parking and gardens were affected,
- The bourne culvert becomes smaller dropping from 900mm to 450mm. It is also a low point where a number of flow paths meet,
- The LFB pumped water intensively out of Dale Road to Purley Cross,
- Car park alongside the church was prepared to be used as a temporary FSA if evacuation plan were activated,
- The evacuation plan was temporarily commenced on 14th February 2014 when water levels became critical at the Waterworks. On this day, high floodwater flowed from Dale Road towards Foxley Hill Road leading to flooding of ground floor properties at Liddell Court.

Response officers building sandbag walls in Dale Road in February 2014

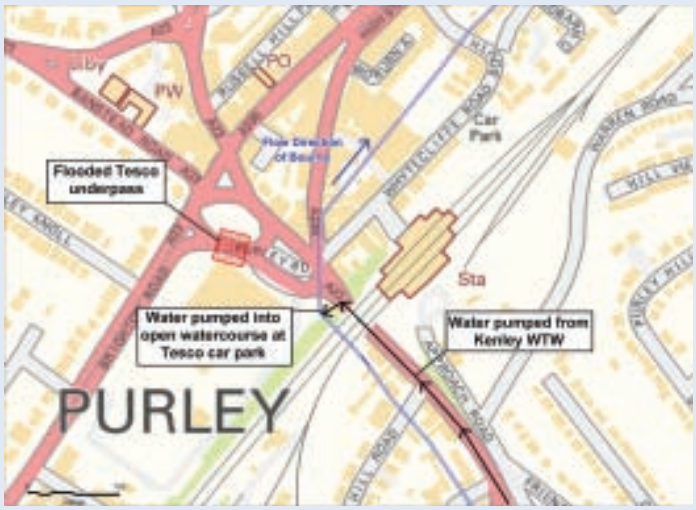
Dale Road on 14th Febraury 2014

LFB evacuations by boat in Dale Road (February 2014)

Church car park, emergency FSA

Flooding at rear of Liddell Court on Foxley Hill Road, February 2014

Table 4.8: Purley Cross



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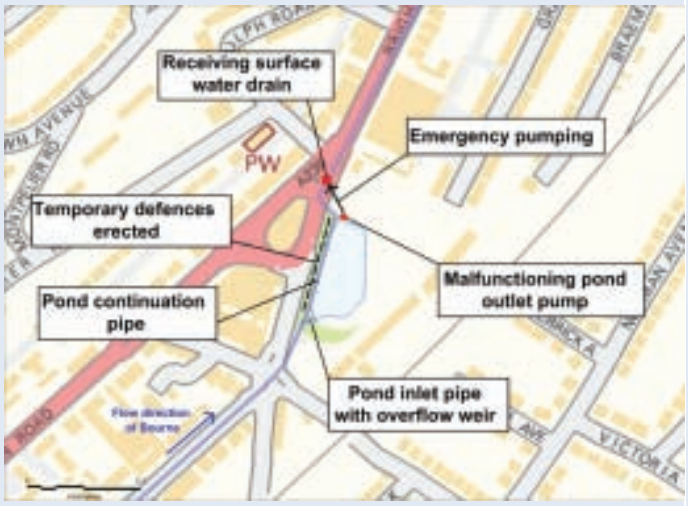
- Water being pumped out from Dale Road was diverted to a short open section of the bourne north of the railway line,
- The pedestrian underpass beneath Purley Cross roundabout was used as a temporary balancing pond to help manage the risk to Purley town centre and relieve pressure on Purley Oaks Pond further downstream,
- Water eventually drained away from the underpass through the existing system,
- Flooding of gardens and basements was reported to Croydon Council on Whytecliffe Road where the culverted route of the bourne continues north.

Inundation of the underpass at Purley Cross as a management measure to alleviate downstream flows towards Purley Oaks in February 2014

Water pumped from Dale Road and WTW around to an open section of the Bourne, north of the railway line in February 2014

Water pumping into the bourne north of the railway line

Table 4.9: Purley Oaks Pond



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- The balancing pond at Purley Oaks quickly began to fill as flow in the bourne increased,
- Flows were fluctuating from upstream for a variety of reasons which were difficult to predict,
- There was uncertainty regarding how the pond should be functioning. It was determined that the pond was not draining as it was meant to and pumping operations were required to pump water out and back into the downstream drainage system,
- The pond overtopped onto the highway on one occasion on the 14th February 2014 causing shallow flooding,
- Temporary defences were erected along the western edge of the pond,
- There are inconsistencies at this site over ownership of assets between TWL and CC,
- It was later discovered the outlet pump was not functioning properly due to a missing power connection.

Balancing pond full during flood in February 2014

Culvert inlet to balancing pond after flood in July 2014

Pump provided by EM (CC contractor) used at Purley Oaks pond

Sump area at north end of pond (July 2014)

5. THE FLOOD EVENT: RISK MANAGEMENT AUTHORITY RESPONSE

During February 2014 and March 2014, there was a significant multi-agency response following emergency declaration by CC. This report aims to understand the responses of the agencies and RMAs during the flood and highlight any lessons learnt.

As discussed in Section 1.4; the RMAs with duties related to this flood event under FWMA were:

- The Environment Agency,
- Croydon Council,
- Surrey County Council,
- Thames Water,
- Transport for London.

Additionally, emergency response roles were carried out by:

- London Fire Brigade and Surrey fire and Rescue ,
- Metropolitan Police and Surrey Police,
- NHS London, Local Ambulance Service and Croydon Health Service

5.1 Mobilising the Response.

Following declaration of an emergency on 6th February 2014, CC set up a Borough Emergency Control Centre (BECC) which monitored the situation 24 hours a day for 20 days. Gold Command was established by CC to determine a framework with emergency services dealing with the incident. Gold Meetings were held daily with representatives from the EA, LFB, MPS, LAS, SESW, TfL, and TDC.

Figure 5.1 illustrates a high-level time-line of events as produced by CC's Emergency Planning team. A more detailed record of incident progression as discussed by Gold Command is detailed in Appendix B.

5.2 Risk Management Authorities Response: Summarised Actions

Box 5.1 to Box 5.8 summarise actions carried out by the respective RMAs and some Category 1 responders. These boxes are not an exhaustive account, but are intended to be a summary of a complex multi-agency initiative. They are based largely on information provided by each authority combined with some observations from CC.

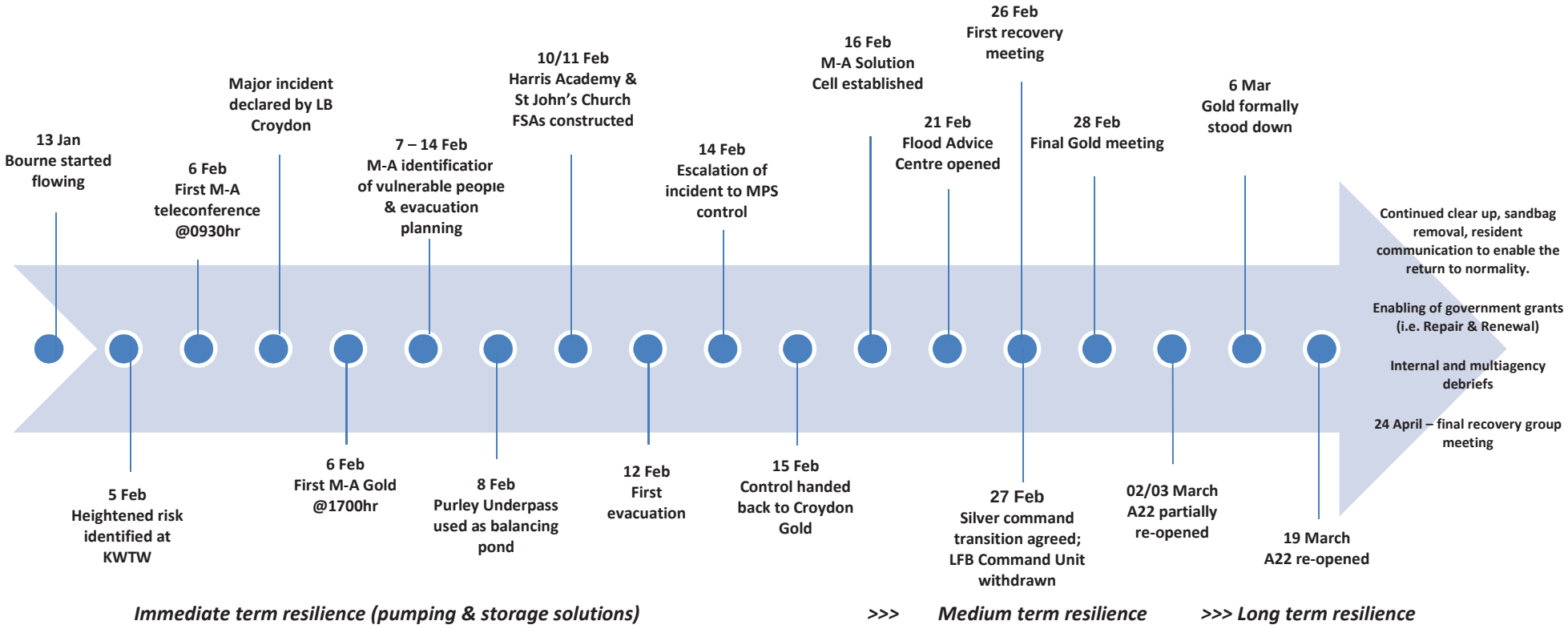

Figure 5.1: Key Events Timeline (source: Croydon Council)

Box 5.1: Croydon Council Actions

- Observed and monitored flow of the bourne as it started to flow in January 2014. Instructed contractors to check and clear trash screens twice a day. Flow was initially contained under usual watercourse management,
- Declared major incident on 6th February 2014, BECC set up at the council to coordinate the emergency response from 7th February 2014. Daily multi-agency Gold Command meetings were then held at the council offices until 28th February 2014,
- 24 hour monitoring of the situation continued for 20 days until 28th February 2014,
- Identified vulnerable communities and number of properties at risk in worst case scenario of shut down of the WTWs,
- 22,500 sandbags were deployed with the help of emergency services, armed forces and contractors to protect homes and businesses,
- Diversion plan was established due to essential closure of the A22. Bus routes diverted in conjunction with TfL,
- Effective communication networks were set up with other agencies to update website, Facebook and Twitter feeds,
- Developed a robust evacuation plan for when the trigger level was reached at the Kenley waterworks, which included construction of temporary FSAs at Harris Academy, Bourne Park, car park at the church in Dale Road,
- Mobilised extra resources to support the BECC and assist with resident liaison on the ground,
- Gold Command formally stood down on 6th March 2014.

Box 5.2: Surrey County Council Actions

- Worked with TDC and the Army to construct a series of emergency storage areas in the fields alongside Woldingham Road as water began to emerge from the elevated ground in January and February. These were later formalised into major attenuation structures which were used to control water discharged downstream,
- Constructed a flow control weir upstream of Wapses Lodge roundabout,
- Attended flood surgeries in Whyteleafe and Woldingham with TDC and other agencies to keep communities informed,
- Carried out emergency works in Whyteleafe on the demolition site where the culverted Bourne had been damaged,
- Operated a 24 hour highways/flood crew in Whyteleafe during the event,
- Established diversion routes to keep motorists away from flood waters,
- Attended all appropriate meetings with partner organisations during the event.

Box 5.3: Environment Agency Actions

- Issued first groundwater flood alert on 8th January 2014 and began to provide technical information to LLFAs (CC and SCC),
- Staff attended Bronze, Silver and Gold Command meetings to update on groundwater situation, weather forecast and outlook and providing technical advice on flood management,
- Provided weekly reports on groundwater situation form mid-January 2014 to late-April 2014 with comparisons to last event in 2000/01,
- Following liaison with SESW in early February 2014, permission was granted to increase abstraction from the boreholes at Kenley above the rates permitted in their abstraction license to assist in alleviating rising groundwater,
- Constant monitoring of rainfall, river flows, groundwater levels and soil moisture deficits,
- As event escalated, partner organisations were provided with more detailed briefings with indication of geographical areas at risk. Short term risk assessment maps developed to support decision makers,
- Adapted network and monitoring regime through period of high groundwater to improve accuracy and timing of response. Monitoring increased at 2 boreholes without telemetry,
- Weekly updates provided to CC detailing groundwater levels in the catchment,
- Flows were manually recorded in the bourne during the event,
- Flood data collectors were deployed to identify incidents of high groundwater and flooded properties to support partners in planning response,
- Briefings and advice published on website to inform the public about risks from groundwater flooding,
- Deployment of flood ambassadors who worked with council ambassadors to document flooding and provide contacts on the ground; assisting with leaflet dropping, door-knocking and communicating with the public,
- Where resources allowed, operatives were sent to clear blockages to assist council teams and provide specialist advice, provide pumps and temporary defences. 17 pumps and over 8km of pipes and 200m of temporary defences were provided.

Box 5.4: Thames Water Actions

- Supported SESW with Personnel, contractors and equipment to help protect waterworks,
- TWL attended Croydon Gold and Silver Commands to give updates on the status of assets and assist where possible,
- Attended sites of foul flooding in Bourne Park Close and Lower Road.

Box 5.5: Sutton and East Surrey Water Actions

SESW's Kenley WTWs (at Godstone Road) was under threat of shutting down due to flooding from the Bourne inundating the site.

- SESW worked closely with the CC, the LFB, the EA and other agencies to ensure flood defence work and efforts to remove the floodwater were coordinated as the inundation affected a wide area,
- Sandbag and other flood defences were placed around SESW's key assets on the site (operating buildings and plant) and pumps were installed to take water away from the site,
- SESW's network engineers developed plans for supplying customers from other treatment works in the event that the site was overwhelmed,
- SESW were heavily involved in both the Gold and Silver Command meetings during the whole event.

Box 5.6: Transport for London Actions

- TfL Highways Operations Manager attended Gold meetings and TfL Route Manager attended Silver Meetings. Both representatives worked in collaboration with CC to manage the floodwater and implement a temporary solution,
- TfL asset the Purley Cross Underpass was used as a temporary flood water storage area. The flood water levels were monitored 24/7 on an hourly basis by London Highways Alliance Contractor (EM Highways),
- London Highways Alliance Contractor's provided the following: 3,000 filled sand bags, 9,500 empty sand bags, 100 tonnes sharp sand and Pumps.

Box 5.7: London Fire Brigade Actions

On 6th February 2014 the LFB were notified that raising flood water in the Kenley area threatened to compromise the integrity of the Kenley WTW.

- The LFB implemented an operational plan to protect the local communities and this element of critical national infrastructure,
- High Volume Pumps were deployed to remove floodwater from the bourne, in the area around the WTW, to a point further downstream where the river had a greater capacity,
- Water was also pumped from the balancing pond at Purley Oaks into a separate drainage system,
- Simultaneously the LFB also engaged in numerous local area flood management activates to minimise the damage to property caused by the floodwater,
- These operations were maintained 24 hours a day between 6th February 2014 and 3rd March 2014.

Box 5.8: Metropolitan Police Actions

- The Police Borough Commander was notified of the major incident on 6th February
- Police responded to the flooding in the Kenley/Purley area on Friday 7th February 2014 in support of other emergency services and CC,
- Provided support to the ongoing emergency work, providing re-assurance for the local community and to work up a traffic plan in conjunction with TfL and CC Highways Dept. There was a dedicated police presence in the flooded area,
- On Friday 14th March 2014, the situation became critical at the Kenley Water Treatment Works and there was a transfer of overall responsibility and management of the ongoing major incident to the MPS at about 2200 hours and transferred back to the CC at 0700 hours the following morning Saturday 15th February 2014.

The role of police throughout this operation was to assist and support the other emergency services including the CC, SESW, TWL and the EA while discharging core policing responsibility and providing re-assurance to the local community. This involved the prevention of crime, protection of life and supporting a traffic plan to allow emergency work to take place while reducing the impact on local residents and the business community.

5.3 Lessons Learned in Emergency Response

Overall, it is felt by CC and the other primary responders that, given the scale of the event and number of agencies involved, the response worked well in protecting the communities in Croydon under difficult and unprecedented circumstances.

Representatives from the different organisations involved have since come together to break down the response and identify key lessons learnt for dealing with similar incidents in the future, which are detailed below and will be used to guide the next steps.

Key Successes

- The number of flooded properties was remarkably low considering the size of the flood thanks to early mobilisation of pumps and support,
- Other boroughs gave invaluable support to Croydon with officer resources supporting evacuation plans and running of the BECC,
- Declaration of a major incident assisted in awareness raising and people understanding the seriousness of the incident,
- A multi-agency solution cell, including neighbouring local authorities was formed to address issues across the catchment. The Gold group assisted with immediate solutions during the flooding and the silver group continues to develop legacy work to support a more efficient and consistent approach to groundwater management across the region,
- Best use was made of temporary attenuation areas to prevent property flooding (flooding of Purley underpass and Purley Oaks Pond),
- Effective relationships were formed between communication leads for main partner agencies.

Opportunities for improvement

- Coordination and information sharing between CC and SCC was problematic. Procedures in London are different to Surrey. Additionally SCC was dealing with multiple flood incidents across a large area,
- Improvements in clarity / sharing expectations for communications – improved explanation of command structure across different agencies e.g. Local Authority Liaison Officer (LALO) training,
- There were occasions where the interactions between some agencies' command structure was unclear, - potential for clarification on how organisations can interact most efficiently during an emergency,
- The CC / Surrey boundary is also the boundary between emergency response agencies which caused some problems and inefficiencies between police units – requirement to agree procedure for cross-boundary incidents, particularly where only a small area of Surrey is affected,
- There is a need to increase awareness of major incident procedures established in LESLP amongst non-emergency local partners and for earlier engagement with local partners if there is concern an incident may escalate,

- It took too much time to establish information on vulnerable communities through different organisations – NHS and health organisations need to be brought in earlier,
- GIS resources hindered quick identification of addresses at risk,
- Details of properties visited by EA officers were not always clearly communicated to CC officers coordinating the response – opportunity to improve efficiency of resident liaison,
- There was some confusion over channels of communication between Gold and Silver This impacted on individuals understanding of specific responsibilities associated with their role at this incident,
- The situation was unusual with CC leading the response; a role usually carried out by the police or fire brigade. There is a need to establish if this would be done the same way for similar emergencies in the future,
- Better definition of command structure early in the incident would help regional agencies like TWUL to be more effectively involved,
- There was heavy reliance on LFB pumps because the national flooding situation meant alternative equipment was difficult to source,
- At times there were challenges in disseminating up to date information particularly as things developed quickly,
- Some issues with consistency of measurements and communicating changes. A better understanding of trigger points in groundwater levels is required.

6. POTENTIAL MITIGATION OPTIONS

Historic evidence supports that the Caterham Bourne has been rising and flooding intermittently for many centuries. It is reasonable to expect therefore that it will continue to do so and new approaches are required to effectively manage the risk in the long term to reduce flooding threats to communities in Croydon and Tandridge. Future management needs to incorporate the most up-to date understanding of flood risks in Croydon and should take into account outputs from concurrent investigations particularly the Drain London modelling study investigating surface water management along the A23 to identify where multiple benefits can be achieved.

6.1 Option Development

In order to potentially reduce the risk from combined sources of flooding around the bourne, initial standalone and/or combined 'high level' mitigation options have been identified by CC based on the known flooding sources and mechanisms. As it has been identified that a key problem relates to disagreement in asset ownership, the authority to take forward these actions is not yet fully agreed.

Table 6.1: Short to Medium Term Management Options

Action	By Whom
• Clearance and dredging at Purley Oaks pond.	The asset owner (to be resolved between CC and TWUL).
• Ensure a working pump is installed at Purley Oaks Pond.	The asset owner (to be resolved between CC and TWUL).
• Carry out maintenance and investigate re-profiling of open sections of the bourne.	CC and SCC in partnership with the EA and riparian owners.
• Carry out de-silting and clearance of culverts and trash-screens following flood.	To be agreed, CC to lead.
• Developing a regular maintenance programme for trash screens and investigating improved access to assets.	CC lead in partnership with riparian owners.
• Development of a local community flood plan.	A joint initiative between local residents, CC, TDC and SCC.
• Engage with residents about the types of property level protection and pumping equipment they have.	CC.
• Working with TWUL to understand how foul sewer network can be upgraded in Kenley.	TWUL in partnership with CC.

Table 6.1: Short to Medium Term Management Options	
• Expanding capacity of Bourne View FSA.	CC.
• Improve understanding of trigger levels and indicators of the Bourne flowing.	CC, SCC and EA.
• Investigate ways in which water can be slowed and controlled through the catchment.	CC, SCC and EA.
• Implement multi-borough protocol and procedure to manage and coordinate resources, to include a trigger point escalation process.	CC, South London Borough partners, SCC, LFB, MPS

Table 6.2: Longer Term Mitigation Options
• Developing a catchment scale alleviation scheme in partnership with SCC.
• Investigating use of the Purley underpass as a permanent FSA.
• Investigating a new bunded FSA in Bourne Park.
• Evaluating and implementing more effective control of flow through culverted sections including options for expanding culvert in Dale Road.
• Investigating feasibility of groundwater management measures.

7. NEXT STEPS

7.1 Summary of Findings

The flooding during February 2014 and March 2014 was an exceptional event. The volumes of water and required response were considered significantly more severe than other incidents of the Caterham Bourne flooding in recent memory. The fact that only a small number of properties suffered internal flooding to the ground floor is largely attributed to the scale of the round-the-clock relief effort following declaration of an emergency. On the whole the partnership approach worked well in a high-pressure situation. RMAs, LFB, MPS and the Army worked hard to fulfil their duties and maintain public safety.

Some key lessons learnt have been documented and will feed into improving procedures to cope with future emergencies. A highlighted issue remains disagreement over asset responsibility, particularly between CC and TWUL which will form a central theme in the way forward. CC and TWUL have commenced discussions to start resolving these issues.

7.2 Way Forward

Table 7.1: Next Steps for Local Stakeholders

ID	Action	Details	Stakeholders Involved	Potential funding
01	Liaison	Under Section 19 (2) of the FWMA, CC should publish the results of the flood investigation and notify any relevant RMAs, stakeholders and residents.	CC	
02	Liaison / flood management	CC and SCC should pursue funding routes to develop a catchment scale flood alleviation scheme for the bourne.	CC, SCC, EA	FCRM GiA
03	Liaison	CC with neighbouring authorities should engage with local landowners and residents about shared responsibility and develop a long-term plan.	CC, TDC, SCC	
04	Recording/ liaison	The RMAs should work together to identify assets and ownership in the catchment. These should be incorporated into the relevant authority's maintenance schedules.	CC Highways, TfL, EA, TW	
05	Recording	CC and TDC should follow up with residents that reported flooding to acquire additional details of flooding (consequences, damage caused etc.) and to provide advice as to property level protection measures.	CC, TDC residents groups, EA	Repair and renewal grants
06	Liaison	CC should work with the EA to provide local homeowners with information on flood resilience measures.	CC, EA	
07	Liaison	CC, TDC and EA should encourage formation of a community flood group to specifically address the risks from the Bourne and aid regular communication about management and lowering risk.	CC, TDC, EA	
08	Liaison	CC Highways and TW should communicate more regularly about upgrades to the sewer network and planned improvements.	CC, TW	
09	Liaison / flood management	CC should incorporate findings from the concurrent Drain London modelling investigation into surface water flooding along the A23 to identify opportunities for alleviation measures with multiple benefits	CC, TW, TfL	
10	Liaison / Emergency Planning	Agree clearer chain of command in the event of a large scale major incident between CC and emergency responders, which is in line with the LESLP procedure.	CC, LFB, MPS, EA, SESW, TW	

Table 7.1: Next Steps for Local Stakeholders				
11	Liaison / Emergency Planning	Specific procedures should be reviewed, and if non-existent established, including chain of command when dealing with cross-boundary incidents.	MPS, CC, SCC, TDC	
12	Flood Management / Liaison	Investigate the options for future management in Dale Road including clarification of asset ownership and downstream implications of changing the culvert size.	CC, TW, EA	FCRM GiA
13	Maintenance / enforcement	Establish pre-winter maintenance regime for the Bourne assets in agreement with RMAs and riparian owners. CC should undertake regular surveys of watercourses to ensure riparian owners are maintaining their channels as required.	CC, TDC, EA, TW, SESW, riparian owners	
14	Liaison	CC, TDC and SCC should engage with Network Rail regarding planned maintenance to their assets along route of the Bourne.	CC, TDC, SCC, NR	
15	Liaison / Emergency Planning	Develop a management approach for future protection of the Kenley WTW, which does not increase risk to other parts of the catchment. WTW failure should be added to CC Risk Register.	SESW, EA, CC, TW	
16	Emergency Planning	CC should review GIS facility to ensure information about at risk communities is more easily available.	CC	
17	Flood Management	CC should investigate utilising Schedule 1 of FWMA, Designation of features to protect areas identified as essential for flood alleviation from future development.	CC, riparian owners. TfL	
18	Investigation	The RMAs should work together to determine potential options for the management of flood risk in the Caterham Bourne catchment. These should include those discussed in Section 6 of this report.	CC, TDC, SCC, EA, TW, SESW, TfL, NR	FCRM GiA
19	Liaison	CC and SCC should pursue opportunities for improved collaboration in joint emergency response through the solution cell.	CC, SCC	
20	Flood management	CC should incorporate the findings of this report to existing plans to identify priority areas for emergency response related to groundwater. This should be incorporated into the Multi-Agency Flood Plan.	CC	

APPENDIX A SUPPORTING FIGURES

Figure A1: Location of assets associated with open sections of the Caterham Bourne

LEGEND

- LB Croydon boundary
- Main River
- Culverted Watercourse
- 1A Flow Inlet/Trash Screen
- 1B Flow Outlet

Notes: This map has been produced using the Environment Agency Detailed River Network data.
All photos taken in July 2014 by URS except '6B & 7' and '5A' which were taken approx. February 2014 by Croydon Council officers

Purpose of Issue: FINAL REPORT CATERHAM BOURNE S19 INVESTIGATION

Revision Details:

THIS DRAWING IS TO BE USED ONLY FOR THE PURPOSE OF ISSUE THAT IT WAS ISSUED FOR AND IS SUBJECT TO AMENDMENT

Scale at A1: 1:15,000

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Job Title: LONDON BOROUGH OF CROYDON FLOOD INVESTIGATION

Drawing Title: KEY ASSET LOCATIONS

Client: CROYDON www.croydon.gov.uk

URS Infrastructure & Environment UK Ltd
Scott House
Alencon Link, Basingstoke
Hampshire, RG21 7PP
Telephone +44 (0)1256 310 200
URS

Drawing Number: FIGURE A.1

Rev: 02

APPENDIX B SUMMARY NOTES TAKEN FROM GOLD COMMMAND MEETING MINUTES

Appendix B: Summary notes taken from Gold Command meeting minutes

Please note that the information provided in this table is based on information recorded in the official minutes of the Gold Command Meetings that took place between 6th February and 3rd March 2014. Its completeness is therefore dependent on the notes taken at each meeting, and should not be relied on as an accurate account of all actions that took place during the flooding event.

Date	Summary
6th February 2014	**Major Incident Declared** The Caterham Bourne is flowing at full capacity, with sewer surcharging in **Tandridge,** whilst the situation at **Kenley WTW** is under control. **Purley Oaks Pond** is at maximum capacity.
7th February 2014	Six properties were evacuated in **Whyteleafe.** Groundwater emergence & sewer flooding on **Bourne Park Close** causes flooding to some properties, whilst water levels at **Bourne View** have dropped, but more rain forecast for the next 24 hours. The **A22** is closed due to the number of hoses laid.
8th February 2014	Heavy and persistent rain during 7th February increased the volume of water at **Purley Oaks Pond** and the pumps failed. Three pumps are to be installed. Localised flooding in **Purley** and on the railway. The situation at **Kenley WTW** is stable with sandbags and demountable flood defences provided, however surcharging is an issue.
9th February 2014	Pumping into the **Tesco Underpass** begins, whilst the **A22** remains closed.
10th February 2014	**Harris Academy School** is closed as a precaution, with the situation at **Kenley WTW** stable. Two pumps at **Purley Oaks Pond** working at full capacity to reduce levels in anticipation of forecasted rainfall over next 5 days.
11th February 2014	The situation is under control and it was agreed that as much progress as possible should be made over the next 24 hours to reduce water levels in preparation of more rain or loss of resources.
12th February 2014	Evacuations were carried out on **Dale Road** (Liberty Court and Nicholas Court), with 8 LFB appliances keeping the flood waters level.
13th February 2014	The situation is considered to be improving, with good capacity at **Purley Oaks Pond.** Flooding at **Dale Road** remains and Liddel Court is evacuated. Three HVP's are in operation to alleviate flooding and sandbags have been provided. The situation at **Kenley WTW** remains stable.
14th February 2014	Significant rainfall is predicted over the next 24-48 hours, with **Dale Road** still flooded. However, the situation is considered to be in a 'static state'.

Appendix B: Summary notes taken from Gold Command meeting minutes *Please note that the information provided in this table is based on information recorded in the official minutes of the Gold Command Meetings that took place between 6th February and 3rd March 2014. Its completeness is therefore dependent on the notes taken at each meeting, and should not be relied on as an accurate account of all actions that took place during the flooding event.*	
15th February 2014	Heavy rainfall experienced in the afternoon of 14th February (20mm compared to 17mm over previous 5 days). Water levels at **Kenley WTW** rose above critical level with pumping at maximum capacity. Control was escalated to London Gold at 21:00 and plans to evacuate 220 properties were in place. The temporary flood storage areas (ponds) were successfully utilised, and the decision to evacuate was reversed at 02:00. Only 9 properties in **Purley** were evacuated. **Significant escalation was narrowly averted.** Pumping at **Dale Road** also at capacity, but concern over equipment resilience and need to retain current level of resources is raised. 15 LFB appliances on site, 3 out of 4 HVPs operational and 4 mobile units.
16th February 2014	Control returned to Local Authority Gold at 07:00. The situation at all sites remains the same. **Dale Road** still flooded, with the Army laying sandbags. Significant groundwater pumping at **Kenley WTW** to lower the water table.
17th February 2014	Sewers on **Bourne Park Close** and **Bourne View** are still surcharging. Water levels at **Dale Road** have been significantly reduced, with 8 LFB appliances on site, and the **Tesco Underpass** now full.
18th February 2014	Heavier rain than expected was anticipated, but resilience at all sites remains good. Sewers at **Bourne Park Close** are still surcharging, preventing the clean up.
19th February 2014	Environment Agency pumps replace LFB HVP's at **Purley Oaks Pond, Dale Road and Kenley WTW.** Public Health advice to be distributed via leaflets at the One Stop shop. Water levels at **Kenley WTW** are low.
20th February 2014	Less rain forecast for the next 5 days, with most sites at 'Green' status. Flooding at **Dale Road** has increased slightly but is stable. Water levels at **Purley Oaks Pond** have increased slightly, but the cause is unknown. All pumping at the pond is now carried out by EA/LBC pumps. Demountable flood barriers installed at **Bourne Park** to control emerging groundwater.
21st February 2014	**Kenley WTW** at 'Green' status, **Dale Road** remains at 'Amber'. Reported that 22 properties on **Foxley Hill Road** were without power for 3 hours.

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22nd February 2014	No Gold Meeting.
23rd February 2014	No Gold Meeting.
24th February 2014	Investigation continues at **Dale Road** as to the exact cause of flooding. All sites remain at 'Green' status.
25th February 2014	Some rainfall today but resilience remains good. Forecasted rainfall is considered to be manageable. Water levels at **Dale Road** continue to drop and are stable at **Purley Oaks Pond** and **Kenley WTW.**
26th February 2014	No Gold Meeting.
27th February 2014	Despite significant rainfall this morning, resilience is still good. LFB have removed redundant hose and police resources will also be reduced, being sourced locally.
28th February 2014	Rainfall over the past 24 hours was lower than expected, with more settled weather forecast for the next week. Two LBC pumps installed at **Kenley WTW,** with pumping coordination handed over to Local Authority Silver Command. In **Tandridge,** 2 temporary dams and a balancing pond have been constructed, and a reduction in water levels has been noted.
1st March 2014	No Gold Meeting.
2nd March 2014	No Gold Meeting.
3rd March 2014	**Gold Command stood down.**