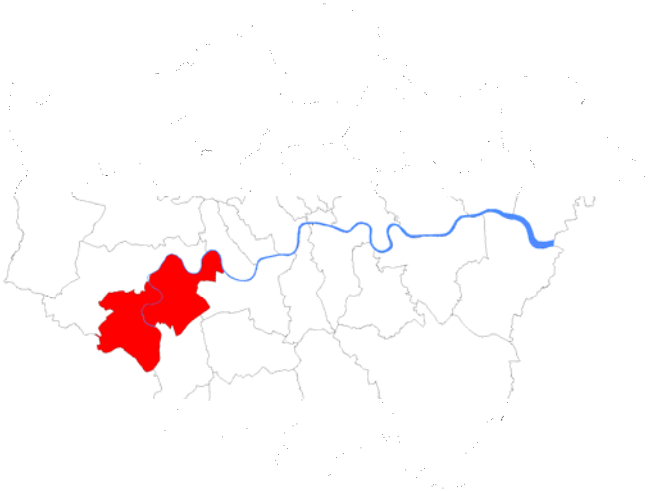
SURFACE WATER MANAGEMENT PLAN

DRAIN LONDON



LONDON BOROUGH OF RICHMOND UPON THAMES

GREATERLONDONAUTHORITY

Thames Water

LONDON COUNCILS

Environment Agency

LONDON BOROUGH OF RICHMOND UPON THAMES

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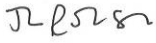
Jon Robinson	URS/Scott Wilson Approver		22.06.2011

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RELATED DOCUMENTS

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Executive Summary

This document forms the Surface Water Management Plan (SWMP) for the London Borough of Richmond upon Thames delivered as part of the Tier 2 package of works of the Drain London Project. This document is a plan which outlines the preferred surface water management strategy for the London Borough of Richmond upon Thames including consideration of flooding from sewers, drains, groundwater and runoff from land, small watercourses and ditches that occurs as a result of heavy rainfall.

The SWMP builds upon previous work undertaken in the Borough including a pilot study SWMP (August 2009) and has been undertaken following a four Phase approach; Phase 1 – Preparation; Phase 2 – Risk Assessment; Phase 3 – Options; and Phase 4 – Implementation and Review.

Phase 1 Preparation

Phase 1 builds upon work formerly undertaken during Tier 1 of the Drain London Project (as well as the Pilot Study SWMP completed in 2009) to collect and review surface water data from key stakeholders and build partnerships between stakeholders responsible for local flood risk management. As part of this Phase of work the London Borough of Richmond upon Thames has forged partnerships with the Environment Agency, Thames Water and with neighbouring London Boroughs in south west London. This will enable them to work in partnership; share resources and best practice and help enable each local authority to discharge their responsibilities as Lead Local Flood Authority under the Flood and Water Management Act 2010.

Phase 2 Risk Assessment

As part of the Phase 2 – Risk Assessment, pluvial modelling has been undertaken across the entire Borough for five specified return periods, using a uniform methodology agreed by the Drain London Programme Board for the whole of the Greater London Authority area. The results of this modelling have been used to identify Local Flood Risk Zones (LFRZs) within the Borough, where flooding affects houses, businesses or infrastructure. Those areas identified to be at more significant risk have been delineated into Critical Drainage Areas (CDAs) representing one or several LFRZs as well as the contributing catchment area and features that influence the predicted flood extent.

Within the London Borough of Richmond upon Thames, seven CDAs have been identified; these are listed in Table 0.1 below. A further two CDAs are located across the boundary with the London Borough of Hounslow and the Royal Borough of Kingston upon Thames and will need to be jointly managed to implement the potential options and management of surface water flood risk in these locations.

When compared to adjacent Borough's the extent and depths of future flood risk identified through pluvial modelling across the London Borough of Richmond upon Thames is relatively small. Typically water is shown to pool at topographical low points, primarily behind or underneath railway embankments where depths reached are sometimes greater than 0.5m. Pluvial modelling has shown linkages with the fluvial system, particularly the Beverley Brook in the east and the River Crane in the west. Local geology and sometimes limited capacity within the Thames Water combined sewer network also contribute to the complex and interlinked mechanisms of flooding within CDAs.

Analysis of the number of buildings at risk of flooding has been undertaken for the rainfall event with a 1% AEP (1 in 100 annual exceedence probability). A review of these statistics coupled with local knowledge of the study area identifies that the following CDAs are at greatest risk of flooding in terms of the number of receptors at risk (*Note: The size of CDA greatly influences results*);

Table 1 Critical Drainage Areas at greatest risk in London Borough of Richmond upon Thames

CDA ID & Name	Infrastructure			Households		Commercial	
	Essential	Highly Vulnerable	More Vulnerable	Non-Deprived	Non-Deprived (Basements)	All	Basements
Group8_004 Richmond Centre	7	1	23	5566	664	575	239
Group8_006 Teddington	3	1	8	2076	147	258	124
Group8_003 Strawberry Hill	1	2	14	1967	56	141	31
Group8_001 Twickenham	1	0	3	1417	8	44	7
Group8_002 St Margaret's	0	0	2	927	174	43	23
Group8_007 Hampton Wick	1	0	1	442	9	15	6
Group8_005 Petersham	0	0	0	55	1	4	1

Phase 3 Options Assessment

There are a number of opportunities for measures to be implemented across the Borough to tackle surface water flood risk. Ongoing maintenance of the drainage network and small scale improvements are already undertaken as part of the operations of the Borough. In addition, opportunities to raise community awareness of the risks and responsibilities for residents should be sought, and the London Borough of Richmond upon Thames should seek to implement a Communication Plan to assist with this process.

One Policy Area has been delineated for the whole Borough. This Policy Area describes generic measures that can be implemented thorough the establishment of a policy position such as the widespread use of water conservation measures including water butts and rainwater harvesting technology, use of soakaways, permeable paving and green roofs. In addition, there are Borough-wide opportunities to raise community awareness

For each CDA identified within the Borough, site-specific measures have been identified that could help alleviate surface water flooding. These measures were subsequently shortlisted to identify a potential preferred option for each CDA.

While property counts have been used to summarise risk across the Borough, local knowledge has been used to confirm that the **Teddington CDA_006** is an area where investment into drainage infrastructure should be made as a matter of priority. Potential mitigation measures include property level protection and larger schemes including increasing capacity of the pipe network at Broad Street. Both of these options should be further assessed by the London Borough of Richmond upon Thames in collaboration with Thames Water.

Phase 4 Implementation & Review

Phase 4 establishes a long-term Action Plan for the London Borough of Richmond upon Thames to assist in their role under the FWMA to lead in the management of surface water flood risk across the Borough. The purpose of the Action Plan is to; Outline the actions required to implement the preferred options identified in Phase 3; Identify the partners or stakeholders responsible for implementing the action; Provide an indication of the priority of the actions and a timescale for delivery; and, Outline actions required to meet the requirements for London Borough of Richmond upon Thames as LLFA under the FWMA 2010.

NORTH

London Borough of Hounslow

London Borough of Wandsworth

London Borough of Merton

Royal Borough of Kingston upon Thames

Surrey County Council

Beverley Brook

River Crane

River Thames

Group8_001
Group8_002
Group8_003
Group8_004
Group8_005
Group8_006
Group8_007
Group8_008
Group8_009
Group8_010
Group8_011
Group8_012
Group8_013
Group8_014
Group7_001
Group7_002
Group7_004
Group7_005

0 1 2km

- Borough Administrative Boundary
- Critical Drainage Area
- Permanent Water Body
- Main River
- Ordinary Watercourse
- Culverted Watercourse

Flood Depth

- <0.1m
- 0.1m to 0.25m
- 0.25m to 0.5m
- 0.5m to 1.0m
- 1.0m to 1.5m
- >1.5m

Notes

1. This map only shows the predicted likelihood of surface water flooding (this includes flooding from sewers, drains, small watercourses and ditches that occurs in heavy rainfall) for defined areas, and due to the coarse nature of the source data used, are not detailed enough to account for precise addresses.
2. Users of this map should refer to section 3.2 of the Surface Water Management Plan for a complete description of limitations and accuracy of the flood/hazard extents shown.
3. This map provides a strategic overview of surface water flood risk and may be subject to further analysis in the future.

London Borough of Richmond upon Thames

LONDON BOROUGH OF RICHMOND UPON THAMES

Surface Water Management Plan

Scale at A3	Date	Drawn by	Approved by
1:45,000	20/07/11	A.HARRIS	J.ROBINSON

Surface Water Depth (m)
1 in 100 Chance of rainfall event occuring in any given year (1% AEP)

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Drain London Programme Board Members

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FIGURE 1

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Glossary

Term	Definition
AEP	Annual Exceedance Potential 1% AEP = 1 in 100 annual probability of occurrence 1.5% AEP = 1 in 75 year annual probability of occurrence 3.3% AEP = 1 in 30 year annual probability of occurrence
Aquifer	A source of groundwater comprising water bearing rock, sand or gravel capable of yielding significant quantities of water.
AMP	Asset Management Plan
Asset Management Plan	A plan for managing water and sewerage company (WaSC) infrastructure and other assets in order to deliver an agreed standard of service.
AStSWF	Areas Susceptible to Surface Water Flooding
Catchment Flood Management Plan	A high-level planning strategy through which the Environment Agency works with their key decision makers within a river catchment to identify and agree policies to secure the long-term sustainable management of flood risk.
CDA	Critical Drainage Area
CFMP	Catchment Flood Management Plan
CIRIA	Construction Industry Research and Information Association
Civil Contingencies Act	This Act delivers a single framework for civil protection in the UK. As part of the Act, Local Resilience Forums must put into place emergency plans for a range of circumstances including flooding.
CLG	Government Department for Communities and Local Government
Climate Change	Long term variations in global temperature and weather patterns caused by natural and human actions.
Critical Drainage Area	Areas of significant flood risk, characterised by the amount of surface runoff that drains into the area, the topography and hydraulic conditions of the pathway (e.g. sewer, river system), and the receptors (people, properties and infrastructure) that may be affected.
Culvert	A channel or pipe that carries water below the level of the ground.
Defra	Department for Environment, Food and Rural Affairs
DEM	Digital Elevation Model
DG5 Register	A water-company held register of properties which have experienced sewer flooding due to hydraulic overload, or properties which are 'at risk' of sewer flooding more frequently than once in 20 years.
DTM	Digital Terrain Model
EA	Environment Agency
FCERM	Flood and Coastal Erosion Risk Management (Environment Agency)
FMfSW	Flood Map for Surface Water
Flood defence	Infrastructure used to protect an area against floods as floodwalls and embankments; they are designed to a specific standard of protection (design standard).
Flood Risk Area	An area determined as having a significant risk of flooding in accordance with guidance published by Defra and WAG.
Flood Risk Regulations	Transposition of the EU Floods Directive into UK law. The EU Floods Directive is a piece of European Community (EC) legislation to specifically address flood risk by prescribing a common framework for its measurement and management.
Floods and Water Management Act	Part of the UK Government's response to Sir Michael Pitt's Report on the Summer 2007 floods, the aim of which is to clarify the legislative framework for managing surface water flood risk in England.
Fluvial Flooding	Flooding resulting from water levels exceeding the bank level of a main river
FRR	Flood Risk Regulations
GIS	Geographical Information System
GLA	Greater London Authority
IDB	Internal Drainage Board

Term	Definition
Indicative Flood Risk Areas	Areas determined by the Environment Agency as indicatively having a significant flood risk, based on guidance published by Defra and WAG and the use of certain national datasets. These indicative areas are intended to provide a starting point for the determination of Flood Risk Areas by LLFAs.
IUD	Integrated Urban Drainage
LB	London Borough
LDF	Local Development Framework
Lead Local Flood Authority	Local Authority responsible for taking the lead on local flood risk management
LiDAR	Light Detection and Ranging
LLFA	Lead Local Flood Authority
Local Resilience Forum	A multi-agency forum, bringing together all the organisations that have a duty to cooperate under the Civil Contingencies Act, and those involved in responding to emergencies. They prepare emergency plans in a co-ordinated manner.
LPA	Local Planning Authority
LRF	Local Resilience Forum
Main River	A watercourse shown as such on the Main River Map, and for which the Environment Agency has responsibilities and powers
NRD	National Receptor Dataset – a collection of risk receptors produced by the Environment Agency
Ordinary Watercourse	All watercourses that are not designated Main River, and which are the responsibility of Local Authorities or, where they exist, IDBs
Partner	A person or organisation with responsibility for the decision or actions that need to be taken.
PFRA	Preliminary Flood Risk Assessment
Pitt Review	Comprehensive independent review of the 2007 summer floods by Sir Michael Pitt, which provided recommendations to improve flood risk management in England.
Pluvial Flooding	Flooding from water flowing over the surface of the ground; often occurs when the soil is saturated and natural drainage channels or artificial drainage systems have insufficient capacity to cope with additional flow.
PPS25	Planning and Policy Statement 25: Development and Flood Risk
Resilience Measures	Measures designed to reduce the impact of water that enters property and businesses; could include measures such as raising electrical appliances.
Resistance Measures	Measures designed to keep flood water out of properties and businesses; could include flood guards for example.
Risk	In flood risk management, risk is defined as a product of the probability or likelihood of a flood occurring, and the consequence of the flood.
Risk Management Authority	As defined by the Floods and Water Management Act
RMA	Risk Management Authority
Sewer flooding	Flooding caused by a blockage or overflowing in a sewer or urban drainage system.
SFRA	Strategic Flood Risk Assessment
Stakeholder	A person or organisation affected by the problem or solution, or interested in the problem or solution. They can be individuals or organisations, includes the public and communities.
SuDS	Sustainable Drainage Systems
Sustainable Drainage Systems	Methods of management practices and control structures that are designed to drain surface water in a more sustainable manner than some conventional techniques.
Surface water	Rainwater (including snow and other precipitation) which is on the surface of the ground (whether or not it is moving), and has not entered a watercourse, drainage system or public sewer.
SWMP	Surface Water Management Plan
TfL	Transport for London
TWUL	Thames Water Utilities Ltd
WaSC	Water and Sewerage Company

Table of Contents

Appendices

Figures

The following figures are included within the body of the report. Additional figures are included within Appendix D.

1. Introduction

1.1 What is a Surface Water Management Plan?

1.1.1 A Surface Water Management Plan (SWMP) outlines the preferred surface water management strategy in a given location. In this context surface water flooding describes flooding from sewers, drains, groundwater, and runoff from land, ordinary watercourses and ditches that occurs as a result of heavy rainfall.

1.1.2 This SWMP study has been undertaken as part of the Drain London Project[1] in consultation with key local partners who are responsible for surface water management and drainage in the London area. These include the Greater London Authority, Thames Water, the Environment Agency, Network Rail and Transport for London. The Partners have worked together to understand the causes and effects of surface water flooding so that they can agree the most cost effective way of managing surface water flood risk in the long term.

1.1.3 This document also establishes a starting point for a long-term action plan to manage surface water and will influence future capital investment, maintenance, public engagement and understanding, land-use planning, emergency planning and future developments.

1.2 Background

1.2.1 In May 2007 the Mayor of London consulted on a draft Regional Flood Risk Appraisal (RFRA). One of the key conclusions was that the threat of surface water flooding in London was poorly understood. This was primarily because there were relatively few records of surface water flooding and those that did exist were neither comprehensive nor consistent. Furthermore the responsibility for managing flood risk is split between Boroughs and other organisations including Transport for London, London Underground, Network Rail the Environment Agency and Thames Water. Relationships between surface water flooding and other sources of flood risk were also found to be unclear. To give the issue even greater urgency it is widely expected that heavy rain storms will increase in frequency with climate change.

1.2.2 The Greater London Authority, London Councils, Environment Agency and Thames Water commissioned a scoping study to test these findings and found that this was an accurate reflection of the situation. The conclusions were brought into sharp focus later in the summer of 2007 when heavy rainfall resulted in extensive surface water flooding in parts of the UK such as Gloucestershire, Sheffield and Hull causing considerable damage and disruption. It was clear that a similar rainfall event in London would have resulted in major disruption. The Pitt Review examined the flooding of 2007 and made a range of recommendations for future flood management, most of these have been enacted through the FWMA 2010.

1.2.3 DEFRA recognized the importance of addressing surface water flooding in London and fully funded the Drain London project. The Drain London project is delivered through 3 'Tiers' as shown in Figure 1-1 and Table 1-1. This SWMP is part of the Tier 2 package of works.

[1] Further information on the Drain London Project can be found here http://www.london.gov.uk/drain-london

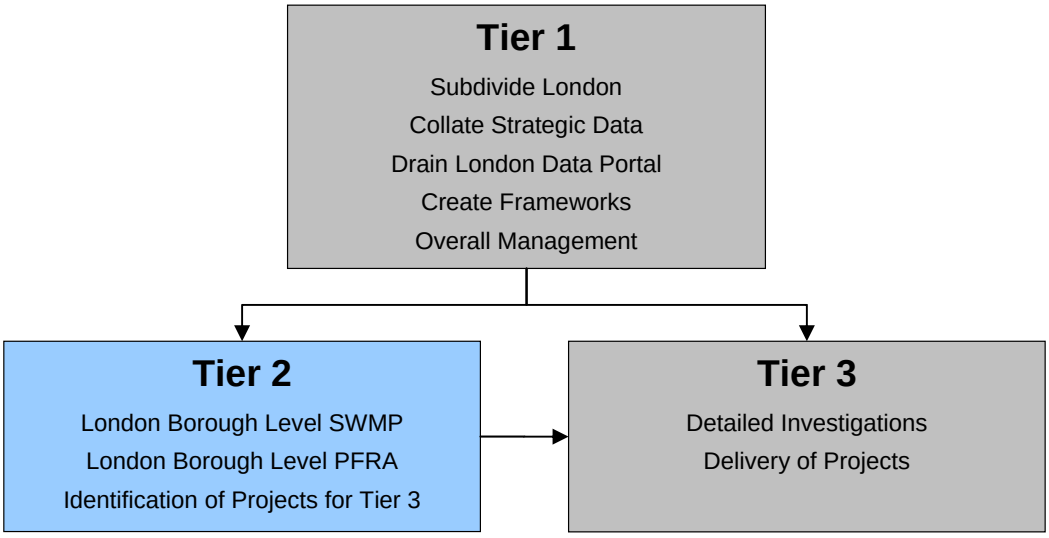

Figure 1-1 Drain London Project 'Tier' Structure

Table 1-1 Drain London Project 'Tier' Structure

Tier	Summary
Tier 1	a) A high level strategic investigation to group the 33 separate Boroughs into a smaller number of more manageable units for further study under Tiers 2 and 3 in order to develop and refine a SWMP for each. b) Development of a web based 'Portal' to provide data management, data storage and access to the various data sets and information across the 'Drain London Forum' (DLF) participants and to Tier 2 & 3 consultants. c) Provide programme management support for the duration of the Drain London project, including Tiers 2 and 3.
Tier 2	a) Delivery of 33 Borough-level **SWMP**s to identify Local Flood Risk Zones (LFRZ) and Critical Drainage Areas (CDAs). b) Creation of 33 Borough-level **Action Plans** including capital and maintenance actions and programmes of work for each partner/stakeholder as well as actions required to meet the responsibilities as LLFA required by the FWMA 2010. c) Preparation of 33 Borough-level **Preliminary Flood Risk Assessments** to meet the requirements of the Flood Risk Regulations 2009 on LLFAs. d) List of prioritised Critical Drainage Areas for potential further study or capital works in Tier 3 using the Drain London Tier 1 **Prioritisation Matrix**.
Tier 3	a) Detailed investigations into high priority Critical Drainage Areas to further develop and prioritise mitigation options. b) Development of cross-organisational action plans that include a costed list of identified flood risk management mitigation measures and community level flood plans.

1.2.4 As described in Table 1-1, Tier 2 of the Drain London project involves the preparation of SWMPs for each London Borough. Through the subsequent enactment of the Flood Risk Regulations 2009 (FRR2009), Boroughs are also required to produce Preliminary Flood Risk

Assessments (PFRA). The Drain London project brief has therefore been adjusted to deliver both a PFRA and an SWMP for each London Borough. The London Borough of Richmond upon Thames PFRA was completed and issued to the Environment Agency in June 2011. These documents will form an evidence base and provide a major step in meeting Borough requirements as set out in the FWMA. Another key aspect of the Act is to ensure that Boroughs work in partnership with other Local Risk Authorities. Drain London assists this by creating sub-regional partnerships as set out in Figure 1-2.

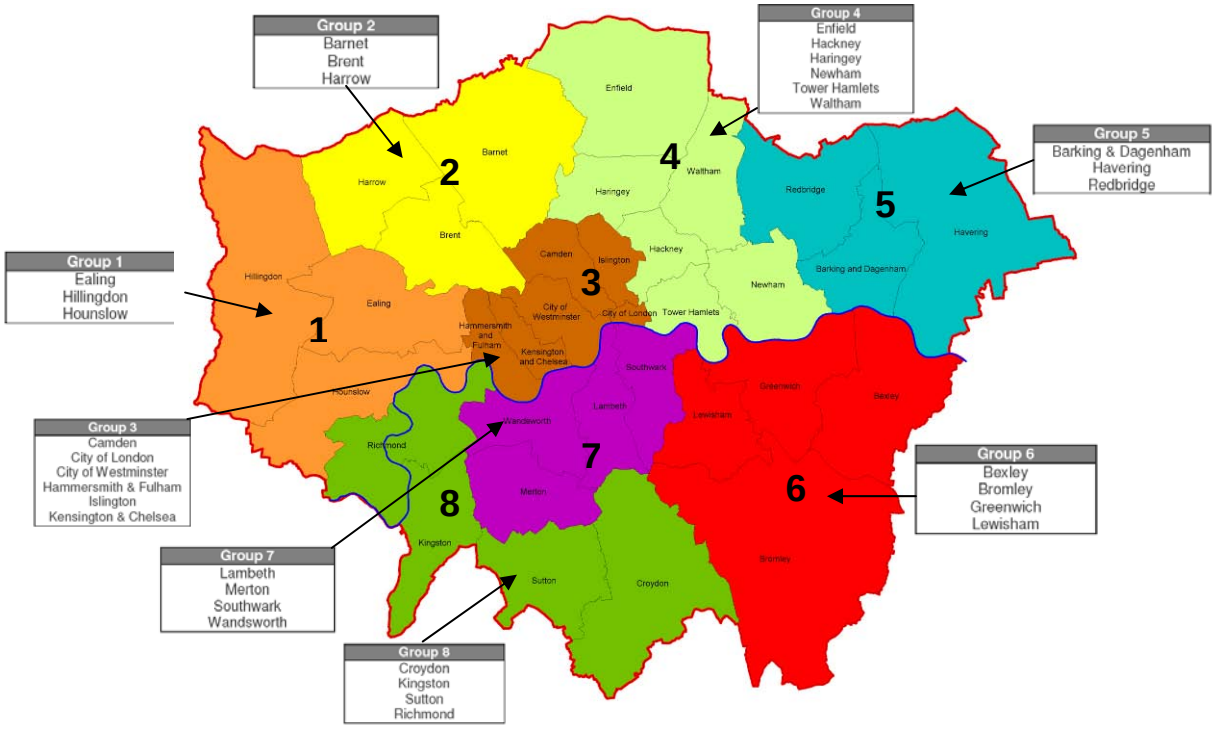

Figure 1-2 Drain London sub-regional partnership

1.3 OBJECTIVES

1.3.1 The key objectives of the SWMP are summarised as follows:

PHASE I – PREPARATION

- Meet specific needs for a SWMP in the London Borough of Richmond upon Thames and determine the local project drivers (further details below);
- Build upon the existing Richmond upon Thames Strategic Flood Group to facilitate a collaborative culture of data, skills and resource sharing between key drainage stakeholders;
- Use the Flood Group and SWMP to create closer coordination between Boroughs to enable future cross boundary working opportunities.

PHASE II – RISK ASSESSMENT

- Undertake a suitable modelling approach to enable a robust understanding of surface water flood risk in and around the study area, taking into account the challenges of climate change, population and demographic change and increasing urbanisation in London;
- Identify, define and prioritise Critical Drainage Areas (Section 3.2), including further definition of existing local Flood Risk Zones (Section 3.2.2) and mapping new areas of potential surface water flood risk;
- Communicate flood risks to relevant bodies both within the Borough and to the wider South London Strategic Flood Group (including members from the Environment Agency and Thames Water).

PHASE III – OPTIONS

- Make holistic and multifunctional recommendations for surface water management which improve emergency and land use planning and enable better surface water flood risk and drainage infrastructure investments;
- Undertake engagement with stakeholders to raise awareness of surface water flooding, identify flood risks and assets and agree mitigation measures and actions;
- Advise on 'early actions' or practical solutions that can be implemented;
- Advise on the potential for Integrated Drainage Strategies for strategic development sites.

PHASE IV – IMPLEMENTATION AND REVIEW

- Deliver outputs to enable a real change on the ground rather than just reports and models, whereby partners and stakeholders take ownership of their surface water flood risk and commit to delivery and maintenance of the recommended mitigation measures and actions;
- Prepare an Action Plan;
- Facilitate preliminary discussions relating to wider issues of future flood risk management including each Councils responsibility as LLFA for the Councils to then take forward with local stakeholders.

1.3.2 London Borough of Richmond upon Thames specific aims and objectives were discussed at meetings held throughout the development of the SWMP. The Borough had been part of a first edition completed in August 2009 and therefore had a good understanding of Flood Risk Zones across their Borough. This meant that the key requirements of the SWMP were more clearly stated including:

- Mapping of surface water flood depths across the whole Borough using one technique so that the Borough wide risk can be clearly assessed and compared to historic records of flooding;
- Guidance on the potential costs and impacts of mitigation measures within the Borough;

- Advice on planning policy measures;
- Using the SWMP to facilitate collaborative working with adjacent Boroughs and stakeholders;
- Guidance on roles and responsibilities moving forward under their new role as LLFA.
- Information on potential funding for future flood risk mitigation schemes.

1.4 STUDY AREA

1.4.1 The London Borough of Richmond upon Thames covers an area of 5,095 hectares[2] in South West London and is the only London Borough which is situated both north and south of the River Thames. It is bounded by the Borough of Hounslow to the northwest, Hammersmith and Fulham to the north, Wandsworth to the east and the Royal Borough of Kingston upon Thames to the south east. The River Thames lies on its southern boundary where the Borough borders Elmbridge within Surrey County Council.

TOPOGRAPHY & LAND USE

1.4.2 The Borough is dissected by the River Thames which meanders in a south-north direction. Elevations to the east of the river peak within Richmond Park at levels of 50 mAOD to 60 mAOD with lower elevations of between 1 mAOD and 6 mAOD experienced around the River Thames fluvial floodplain. Elevations to the west of the river peak on the western boundary of the Borough in the vicinity of Whitton where levels reach approximately 16 mAOD to 18 mAOD; they then fall towards the east and the River Thames floodplain in Strawberry Hill and Hampton Wick. This topography results in some steep slopes within the Borough especially in Richmond town centre which can form flow paths for surface water runoff and subsequently pluvial flooding at lower elevations. Local topography is illustrated in Figure 1.4.1.

1.4.3 The main town centre is Richmond; there are four district centres at Twickenham, Teddington, East Sheen and Whitton as well as many smaller centres. The Borough is characterised by large open spaces including historic landscapes such as Richmond and Bushy Parks and the Old Deer Park. The character of the Borough has led to the designation of 72 conservation areas and over 1100 listed buildings.

1.4.4 As an outer London Borough the transport facilities are well developed with the A316 (great Chertsey Road) and A205 (South Circular Road) trunk roads (part of the Transport for London network) crossing the Borough. The rail network is well served with overland (Waterloo and North London Lines) and underground (District Line) rail links. Heathrow airport is located to the north west of the Borough and generates large volumes of traffic which pass though the Borough. Figure 1.4.2 illustrates local land uses.

Figure 1.4.1 – LiDAR Topographic Survey
Figure 1.4.2 – Land Use Areas

[2] London Borough of Richmond upon Thames Local Development Framework, Core Strategy, Adopted April 2009

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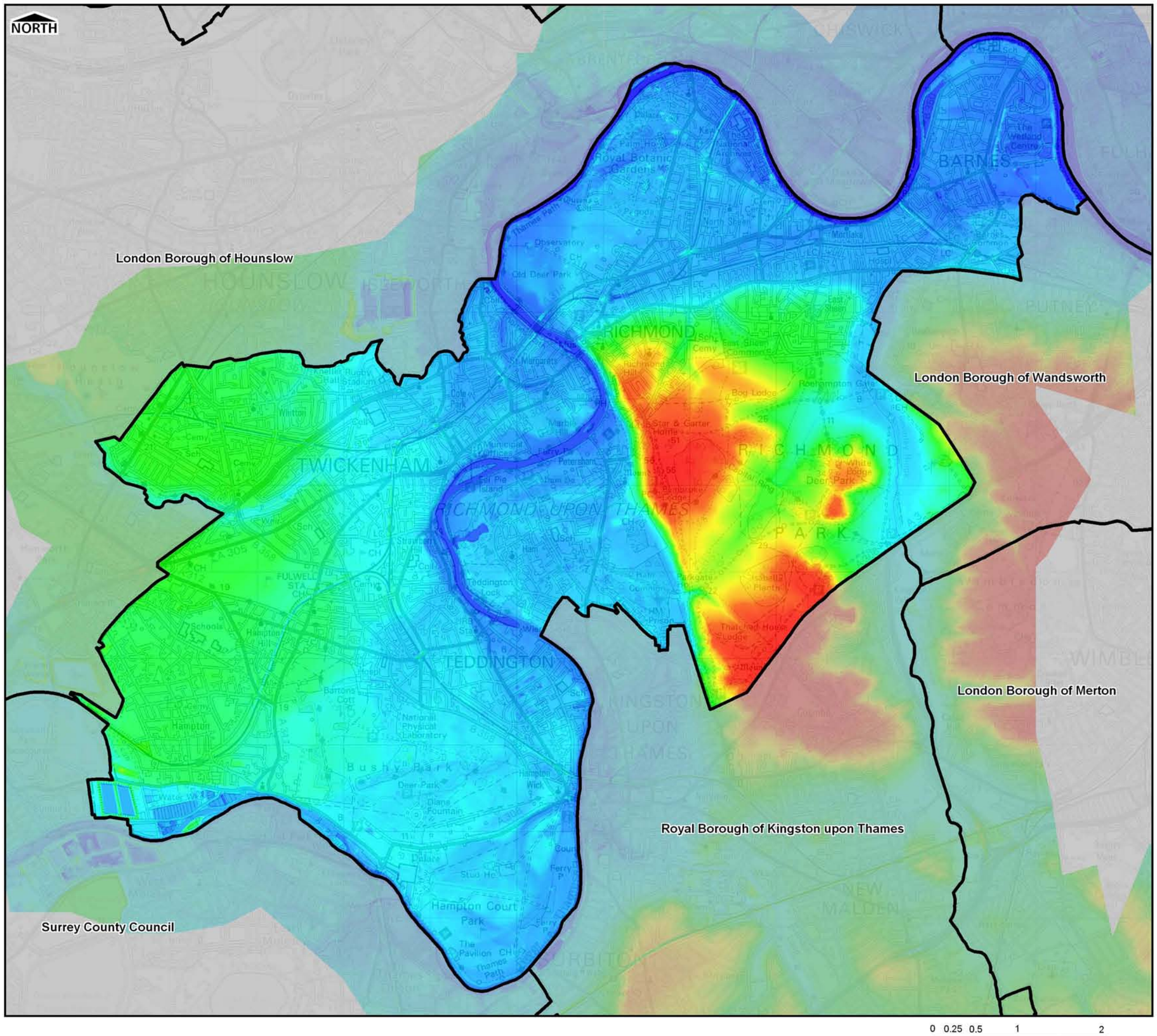

THIS DRAWING MAY BE USED ONLY FOR THE PURPOSE INTENDED

Legend

- Borough Administrative Boundary
- m AOD
  - 0
  - 10
  - 20
  - 30
  - 40
  - 55

Notes

London Borough of Richmond upon Thames

LONDON BOROUGH OF RICHMOND UPON THAMES

Surface Water Management Plan

Scale at A3	Date	Drawn by	Approved by
1:45,000	20/07/2011	D.SKILTON	E.CRAVEN

LiDAR Topographic Survey

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CAPITA SYMONDS Flood Risk Management
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6 - 8 Greencoat Place
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SW1P 1PL

Drain London Programme Board Members

Environment Agency · Thames Water · LONDON COUNCILS · GREATER LONDON AUTHORITY

FIGURE 1.4.1

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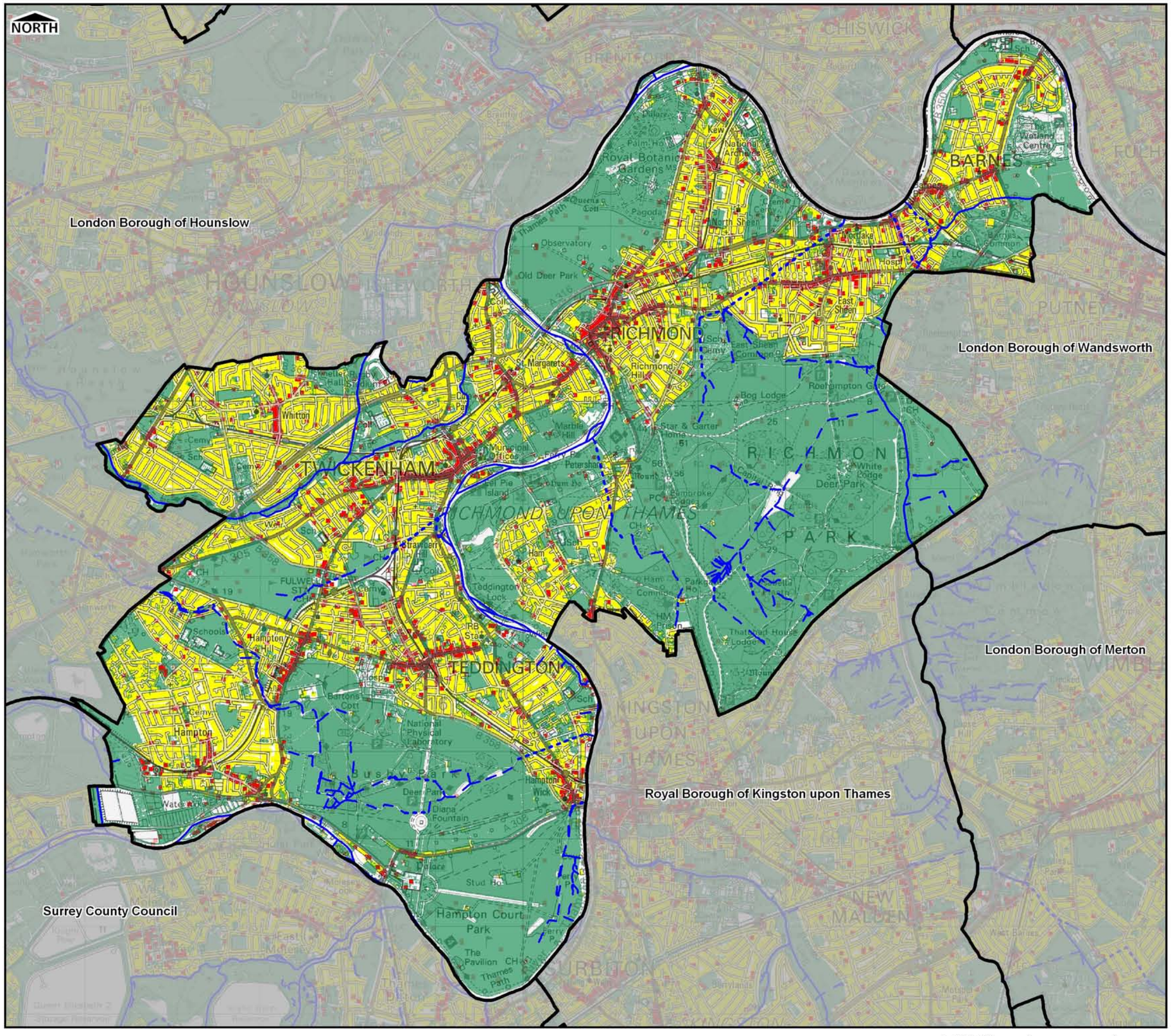

THIS DRAWING MAY BE USED ONLY FOR THE PURPOSE INTENDED

Legend

- Borough Administrative Boundary
- Residential (Derived from EA NRD Dataset)
- Commercial / Industrial (Derived from EA NRD Dataset)
- Open Land & Park Land (Derived from OS Master Mapping)
- Main River
- Ordinary Watercourse
- Culverted Watercourse

Notes

London Borough of Richmond upon Thames

LONDON BOROUGH OF RICHMOND UPON THAMES

Surface Water Management Plan

Scale at A3	Date	Drawn by	Approved by
1:45,000	20/07/2011	D.SKILTON	E.CRAVEN

Land Use Areas

Consultants
CAPITA SYMONDS Flood Risk Management
Scott Wilson
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6 - 8 Greencoat Place
London
SW1P 1PL

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FIGURE 1.4.2

History of Surface Water Flooding in Richmond upon Thames

1.4.5 According to national research undertaken by Defra[3], Richmond upon Thames is ranked the 36th settlement in England most susceptible to surface water flooding, with as many as 9,100 properties estimated to be at risk.

1.4.6 The London Borough of Richmond upon Thames was in places severely affected in July 2007 by surface water flooding. The Met Office reported rainfall intensities in excess of 25mm/hr at many locations in the south and west with daily totals exceeding 100mm (compared to a monthly average rainfall of 44mm for July in the period 1971 to 2000).

1.4.7 This short duration high intensity storm led to substantial overland flow and ponding of surface water in low lying areas. Drainage systems were overwhelmed in several locations across the Borough most notably in Teddington where commercial properties were affected by bow-wave wash from vehicles and basement properties on Richmond Hill were also flooded. In addition, widespread damage was caused to schools, commercial properties and disruption was experienced on the transport systems connecting the Borough with central London.

1.4.8 Following the July 2007 flood event, a list of all locations affected was compiled using street scene staff, council volunteers and members of the public. Across the Borough approximately 200 properties (businesses and homes) in approximately 30 streets sustained damage. Ten schools reported damage with sewer surcharging being sighted as the primary cause.

1.4.9 The event was documented via a Surface Water Flooding Scrutiny Task Group Report which has informed the Borough moving forward in tackling issues raised at the time.

1.4.10 Under UKCIP02, predictions for future rainfall up to 2050 are for up to 15% more winter precipitation. Heavier winter precipitation is expected to become more frequent with 0.25-0.75 more days of 'intense' rainfall (i.e. over 20mm). The risk of exceedance of the urban drainage system and surface water flooding in the Borough is therefore likely to increase into the future unless steps are taken to manage and mitigate this form of flooding.

Cross Boundary Interactions with neighbouring Local Authorities

1.4.11 As shown in Figure 1-2, the London Borough of Richmond upon Thames shares boundaries with LLFAs in Group 7, Group 3 and Group 1 as well as Surrey County Council which lies outside of the Greater London Authority study area.

1.4.12 The London Borough of Richmond upon Thames has well established links with the Royal Borough of Kingston upon Thames with joint studies being commissioned in the past. The Drain London project has provided opportunity for this partnership to expand to include collaborative working with the London Boroughs of Sutton, Croydon Wandsworth and Merton. A summary of cross-boundary interactions with these LLFAs is provided below:

Interactions with the Royal Borough of Kingston upon Thames (Group 8)

1.4.13 Overland flow from Richmond Park flows in a south westerly direction to topographical lows sitting within the Royal Borough of Kingston upon Thames. As a result, CDA_008 identified within the Royal Borough of Kingston upon Thames SWMP includes a small area of the London Borough of Richmond upon Thames. Cross boundary flows from this source should

[3] National Rank Order of Settlements Susceptible to Surface Water Flooding, Defra 2009

be discussed at future Flood Group meetings.

Interactions with the London Borough of Hounslow (Group 1)

1.4.14 Interactions with the London Borough of Hounslow are limited to the north western boundary of the London Borough of Richmond upon Thames as the north eastern boundary is defined by the River Thames. There are few significant cross boundary flows identified by pluvial modelling with the exception of the path of the River Crane, a designated Environment Agency main river which flows in a northerly direction into the Borough of Hounslow. On-going work relating to the maintenance and management of this watercourse will be led by the Environment Agency but will require buy-in from both Boroughs. CDA_001 includes some cross boundary flows with Hounslow. The London Borough of Richmond upon Thames is identified as the lead authority but liaison with the London Borough of Hounslow should be sought when discussing mitigation measures.

Interactions with the London Borough of Hammersmith and Fulham (Group 3)

1.4.15 There are no surface water interactions with the London Borough of Hammersmith and Fulham as the River Thames forms the boundary between the two Boroughs.

Interactions with the London Borough of Wandsworth (Group 7)

1.4.16 The chief interaction between the London Borough of Richmond upon Thames and the London Borough of Wandsworth is the Beverley Brook, an Environment Agency main river which flows along the boundary of the two Boroughs to its confluence with the River Thames.

Interactions with Surrey County Council

1.4.17 The River Thames forms the southern boundary of the London Borough of Richmond upon Thames and Surrey County Council. Therefore there are no surface water cross boundary flows at this location.

FUTURE URBANISATION & DEVELOPMENT

1.4.18 The London Borough of Richmond upon Thames Unitary Development Plan (UDP) was adopted in March 2005 and outlines the Councils broad vision for future development. This will remain until superseded by the Local Development Framework which is currently being produced (this first of the suite of documents, the Core Strategy was adopted in April 2009).

1.4.19 The Core Strategy outlines the importance of the large expanses of protected open space within the Borough which needs to be balanced with the need to provide more housing, employment, retail and leisure space. The protection of the core green space areas means that future housing targets can only be met through the allocation of brownfield areas within the Borough.

1.4.20 These plans for urbanisation and redevelopment within the Borough may present a challenge to the existing drainage systems. However, it also affords a crucial opportunity to address long-standing issues and problems relating to surface water flooding and pressure points on the drainage system through strategic improvements and upgrades to the existing drainage systems.

1.5 INTERACTIONS BETWEEN SOURCES OF FLOODING

1.5.1 In the context of SWMPs, surface water flooding incorporates flooding from sewers, drains,

groundwater, and runoff from land, small watercourses (often referred to as ordinary watercourses) and ditches occurring as a result of heavy rainfall. These sources may operate independently or through a more complex interaction of several sources.

1.5.2 An initial overview of the flooding issues in the London Borough of Richmond upon Thames reveals areas that are affected by multiple sources of flood risk and complex interactions between urban watercourses, direct surface water ponding, overland flow paths and the surface water sewer system. One such example is the Teddington CDA which is susceptible to surcharging of the surface water drainage system as well as direct surface water flooding from rainfall which contributes to overland flow-paths.

1.5.3 The SWMP approach will seek to ensure that all sources and mechanisms of surface water flood risk are assessed and that solutions are considered in a holistic manner so that measures are not adopted that reduce the risk of flooding from one source to the detriment of another.

1.5.4 While fluvial flood risk is not modelled in this study, its influence can't be ignored as when receiving watercourses are in flood or under high tide conditions, surface water drainage outfalls may become blocked causing surface water flooding elsewhere. Fluvial flood risk caused by fluvial systems within the Borough is well understood and has been documented in the London Borough of Richmond upon Thames Strategic Flood Risk Assessment, 2009. For the purposes of this study, fluvial watercourses have been represented as being at 'bank full' please refer to Appendix C for pluvial modelling methodology.

Map D3 – Fluvial Flood Zones (Appendix D)

1.6 Linkages with Other Plans

1.6.1 The increased focus on flood risk over recent years is an important element of adaptation to climate change and has led to the creation of a number of new documents. It is important that the SWMP is not viewed as an isolated document and links with other strategic and local plans outlined below:

Regional Flood Risk Appraisal (RFRA)

1.6.2 This is produced by the Greater London Authority and gives a regional overview of flooding from all sources. The RFRA will be updated in 2012 to reflect the additional information on local sources of flood risk (surface water, groundwater and ordinary watercourses) provided by the Drain London study. This may also generate new policies that could be incorporated into the London Plan when it is reviewed.

Thames Catchment Flood Management Plan (CFMP)

1.6.3 The Thames Catchment Flood Management Plan was published in 2008 by the Environment Agency and sets out policies for the sustainable management of flood risk across the whole of the Thames catchment over the long-term (50 to 100 years) taking climate change into account. More detailed flood risk management strategies for individual rivers or sections of river may sit under these.

1.6.4 The CFMP emphasises the role of the floodplain as an important asset for the management of flood risk, the crucial opportunities provided by new development and regeneration to manage risk, and the need to re-create river corridors so that rivers can flow and flood more

naturally.

1.6.5 This Plan will be periodically reviewed, approximately five years from when it was published, to ensure that it continues to reflect any changes in the catchment. There are links to Drain London where there are known interactions between surface water and fluvial flooding

PRELIMINARY FLOOD RISK ASSESSMENT (PFRA)

1.6.6 These are required as part of the Flood Risk Regulations (2009) which implement the requirements of the European Floods Directive (2009). Drain London has produced a PFRA for each London Borough to give an overview of all local sources of flood risk. In London PFRAs will benefit from an increased level of information relating to surface water from the Drain London SWMPs. Boroughs will need to review these PFRAs every 6 years as a requirement of their responsibilities as LLFA (see Section 1.7).

SURFACE WATER MANAGEMENT PLANS (SWMP)

1.6.7 Drain London is producing a SWMP for each London Borough. They provide much improved probabilistic 2-dimensional modelling and data when compared to National Scale data made available by the Environment Agency. In addition they contain an Action Plan that has been developed in conjunction with both the Borough and relevant other Risk Management Authorities. The SWMP data, actions and associated policy interventions will need to feed directly into the operational level of the Borough across many departments, in particular into spatial and emergency planning policies and designations and into the management of local authority controlled land.

STRATEGIC FLOOD RISK ASSESSMENTS (SFRA)

1.6.8 Each local planning authority is required to produce a SFRA under Planning Policy Statement 25 (PPS25). This provides an important tool to guide planning policies and land use decisions. Current SFRAs have a strong emphasis on fluvial flooding from main rivers and the sea and are relatively weak in evaluating flooding from other local sources including surface water, groundwater and ordinary watercourses. The information from Drain London will improve this understanding.

LOCAL DEVELOPMENT DOCUMENTS (LDD)

1.6.9 LDDs including the Core Strategy and relevant Area Action Plans (AAPs) will need to reflect the results from Drain London. This may include policies for the whole Borough or for specific parts of Boroughs, for example Critical Drainage Areas. There may also be a need to review Area Action Plans where surface water flood risk is a particular issue. The updated SWMP will assist with this as will the reviewed RFRA and any updated London Plan policies. In producing Opportunity Area Planning Frameworks, the GLA and Boroughs will also examine surface water flood risk more closely.

LOCAL FLOOD RISK MANAGEMENT STRATEGIES (LFRMS)

1.6.10 The FWMA 2010 requires each LLFA to produce one of these by December 2012 (See Section 1.7). Whilst Drain London will not actually produce these, the SWMPs, PFRAs and their associated risk maps will provide the necessary evidence base to support the development of LFRMS. No new modelling is anticipated to be required to produce these strategies.

1.6.11

1.6.12 Figure 1-3 illustrates how the CFMP, PFRA, SWMP and SFRA link to and underpin the development of a Local Flood Risk Management Strategy.

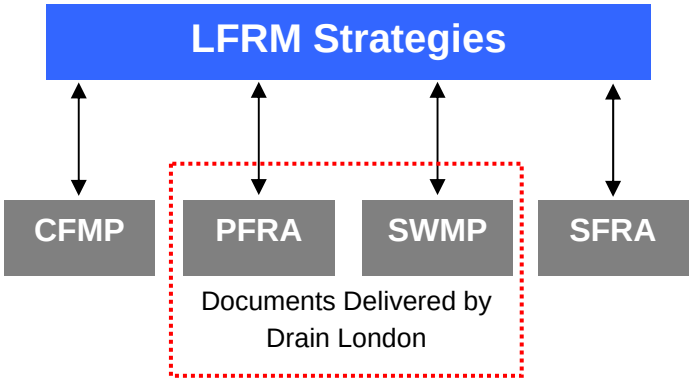

Figure 1-3 Linkages between Flood Risk Management Documents

1.7 EXISTING LEGISLATION

1.7.1 The FWMA 2010 presents a number of challenges for policy makers and flood and coastal risk management authorities identified to co-ordinate and deliver local flood risk management (surface water, groundwater and flooding from ordinary watercourses). 'Upper Tier' local authorities have been empowered to manage local flood risk through new responsibilities for flooding from surface and groundwater.

1.7.2 The FWMA reinforces the need to manage flooding holistically and in a sustainable manner. This has grown from the key principles within Making Space for Water (Defra, 2005) and was further reinforced by the summer 2007 floods and the Pitt Review (Cabinet Office, 2008). It implements several key recommendations of Sir Michael Pitt's Review of the summer 2007 floods, whilst also protecting water supplies to consumers and protecting community groups from excessive charges for surface water drainage.

1.7.3 The FWMA must also be considered in the context of the EU Floods Directive, which was transposed into law by the Flood Risk Regulations 2009 (the Regulations) on 10 December 2009. The Regulations requires LLFAs to provide three main types of assessment / plan:

1) Preliminary Flood Risk Assessments (maps and reports for Sea, Main River and Reservoirs flooding) to be completed by LLFA and the Environment Agency by the 22 December 2011. Flood Risk Areas, at potentially significant risk of flooding, will also be identified. Maps and management plans will be developed on the basis of these flood risk areas.

2) Flood Hazard Maps and Flood Risk Maps. The Environment Agency and LLFAs are required to produce Hazard and Risk maps for Sea, Main River and Reservoir flooding as well as 'other' relevant sources by 22 December 2013.

3) Flood Risk Management Strategies. The Environment Agency and LLFAs are required to produce Flood Risk Management Strategies for Sea, Main River and Reservoir flooding as well as 'other' relevant sources by 22 December 2015.

1.7.4 Figure 1-4 below illustrates how this SWMP fits into the delivery of local flood and coastal risk management, and where the responsibilities for this lies.

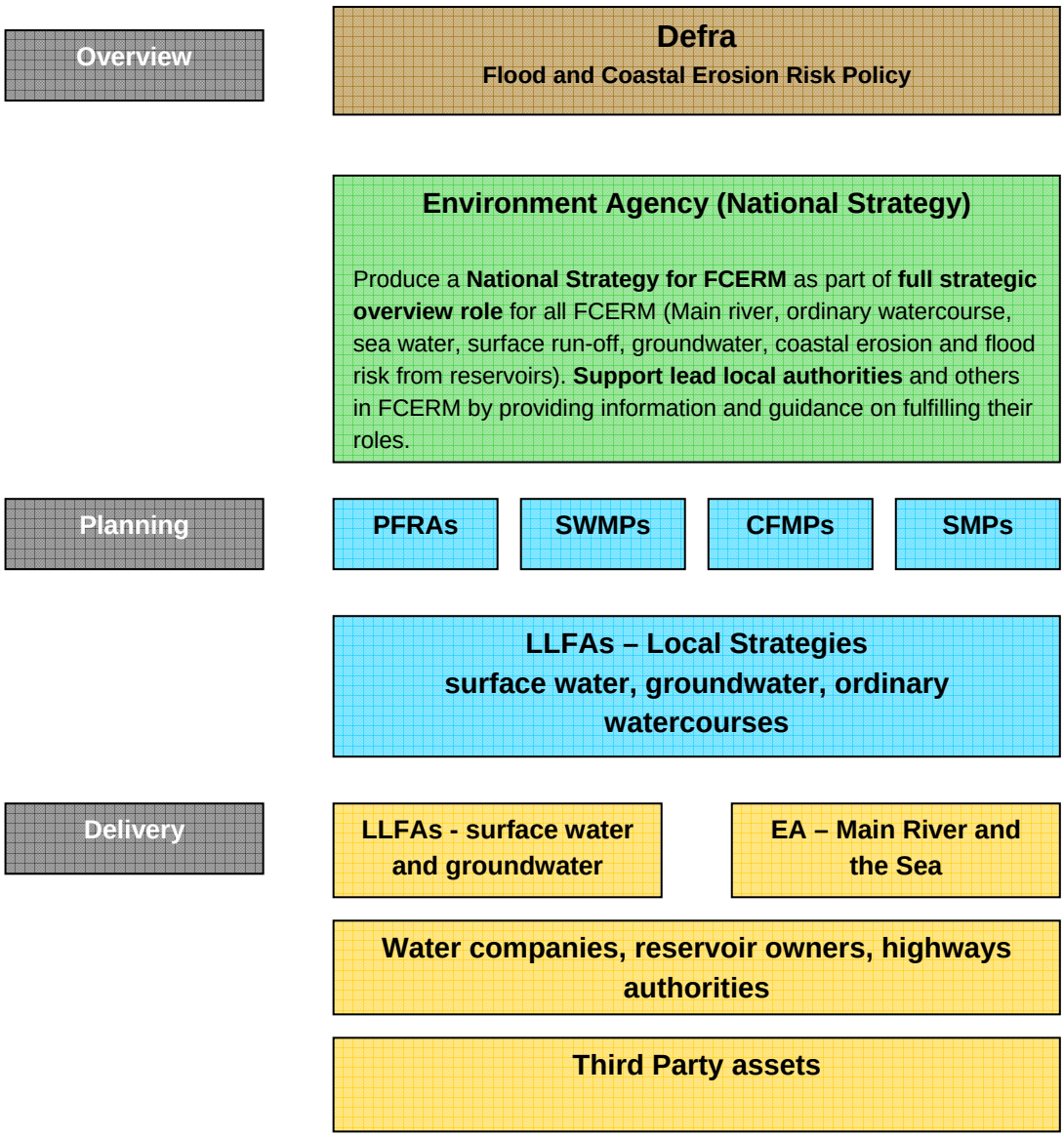

Figure 1-4 Requirements and responsibilities for the delivery of local flood and coastal risk management

1.7.5 Aside from forging partnerships and coordinating and leading on local flood management, there are a number of other key responsibilities that have arisen for LLFAs from the FWMA 2010, and the Flood Risk Regulations 2009. The preparation of the SWMP and PFRA for London Borough of Richmond upon Thames as part of the Drain London Project will enable the Council to strengthen its understanding of these responsibilities and how they can be fulfilled by the Borough. These responsibilities include:

- **Investigating flood incidents** – LLFAs have a duty to investigate and record details of significant flood events within their area. This duty includes identifying which authorities have flood risk management functions and what they have done

or intend to do with respect to the incident, notifying risk management authorities where necessary and publishing the results of any investigations carried out.

- **Asset Register** – LLFAs also have a duty to maintain a register of structures or features which are considered to have an effect on flood risk, including details on ownership and condition as a minimum. The register must be available for inspection and the Secretary of State will be able to make regulations about the content of the register and records.

- **SuDS Approving Body** – LLFAs are designated the Sustainable Drainage Systems (SuDS) Approving Body (SAB) for any new drainage system, and therefore must approve, adopt and maintain any new SuDS within their area. This responsibility is anticipated to commence from April 2012.

- **Local Flood Risk Management (LFRM) strategies** – LLFAs are required to develop, maintain, apply and monitor a strategy for local flood risk management in its area. The LFRM strategy will build upon information such as EA national risk assessments and will use consistent risk based approaches across different local authority areas and catchments.

- **Works powers** – LLFAs have powers to undertake works to manage flood risk from surface runoff and groundwater, consistent with the LFRM strategy for the area.

- **Designation powers** – LLFAs, as well as district councils and the Environment Agency 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.

1.8 PEER REVIEW

1.8.1 It is essential for the Drain London Project that SWMPs are consistent and comparable across Greater London. This is to facilitate:

- Fair, transparent and rapid allocation of funds to identified high priority flood risk areas within London;

- Collaborative working practices between stakeholders; and

- Building of local capability (Council officers and consultants doing work in the future will be able to make use of outputs regardless of who produced them for each Borough).

1.8.2 To ensure consistency and comparability between London Borough SWMPs produced, a Peer Review process has been used. The process involved the four consultant teams working on the Drain London SWMPs independently reviewing each others work. This has ensured that all outputs result from a consistent technical approach, are of a high technical quality and are communicated in the specified formats. The peer review report for this SWMP has been completed by Jacobs/JBA to ensure that any knowledge gained during the first edition SWMP report is included within this study. The peer review is included in Appendix F.

2. Phase 1: Preparation

2.1 PARTNERSHIP

2.1.1 Under the FWMA and the Flood Risk Regulations 2009, all Unitary Authorities including the London Borough of Richmond upon Thames are designated 'Local Lead Flood Authority' (LLFA). As such, the London Borough of Richmond upon Thames is responsible for leading local flood risk management, including establishing effective partnerships within their local authority as well as with external stakeholders such as the Environment Agency, Thames Water Utilities Ltd, Transport for London, Network Rail and others e.g. landowners.

2.1.2 In areas of multiple sources of flood risk and complicated interactions between different sources of flooding, there are often multiple water or drainage regulators, owners and maintainers. It is essential that all relevant partners with responsibility for making decisions and taking actions are involved in plans for flood risk management from the outset. One of the aims of the SWMP for London Borough of Richmond upon Thames is to strengthen the partnership between these organisations and ensure inclusivity through all Phases of this study and future flood risk management in the Borough.

2.2 SOUTH WEST LONDON STRATEGIC FLOOD GROUP

2.2.1 The London Borough of Richmond upon Thames has been working closely with neighbouring Boroughs to forge partnerships with respect to local flood risk management as part of the preparation of SWMPs for all 33 London Boroughs.

2.2.2 As a result, the **South West London Strategic Flood Group** which reports to the Regional Flood Defence Committee through Councillor Osborne at Royal Borough of Kingston has been established.

2.2.3 The flood group is divided into a Strategic Management Group which is responsible for making overall decisions about flood risk management such as severe weather incident management, operational maintenance, future flood risk investments and planning; and the Operational Management Group which serves as the 'day-to-day' flood risk group delivering the flood risk system operations and maintenance on the ground.

2.2.4 The South West London Strategic Flood Group was set up during the Drain London project; it meets every 3 months (first meeting held on the 29th March 2011) and will continue with the aim of ensuring collaborative working across relevant stakeholders as described above.

2.2.5 Responsibility for flood risk management at the London Borough of Richmond upon Thames is shared across several departments; however Jon Freer, Assistant Director of Environment (Development & Street Scene) takes on the overall lead on local flood risk management activities within the Council and is representing the Borough on the South West London Strategic Flood Group (structure outlined in Figure 2-1 and Table 2-1 below)

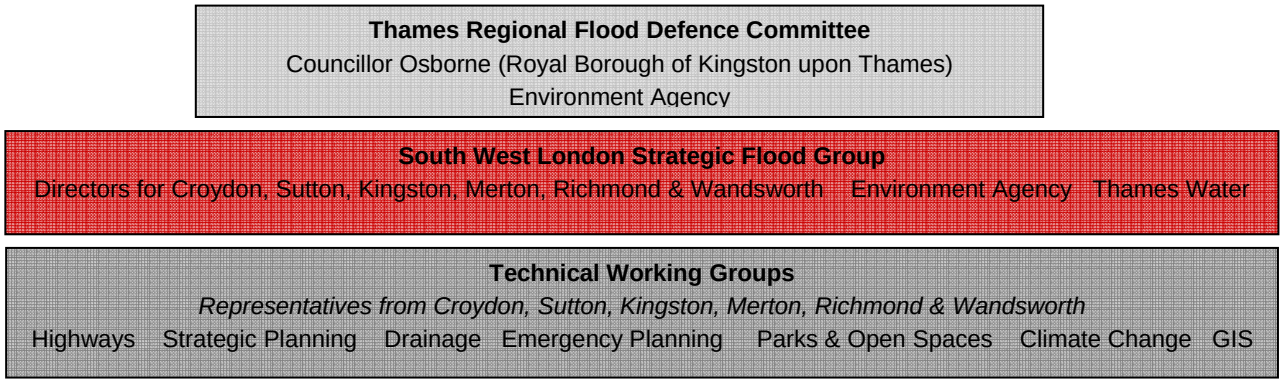

Figure 2-1 Organogram of South West London Flood Partnership

2.2.6 A summary of roles and responsibilities is shown in Table 2-1.

Table 2-1 Flood Group Members and Roles

Tier 1 - Strategic Management Group			
Organisation	**Name**	**Title**	**Role**
London Borough of Sutton	Chris Reid	Head of Environmental Sustainability	Overall lead on local flood risk management activities within the Council.
Royal Borough of Kingston upon Thames	Roy Thompson Jay Judge	Director of Place & Regeneration Strategic Projects Manager	Mr Thompson has the ownership and responsibility for delivery of the FWMA. Mr Judge will be the lead officer, sitting on the Areas Strategic Flood Group.
Richmond upon Thames	Jon Freer	Assistant Director of Environment	Overall lead on local flood risk management activities within the Council.
London Borough Croydon	TBC. Short term contact: David Carlisle	Project Officer, Spatial Planning Team	Currently responsibility for flood risk management is shared across four departments. Discussions are currently underway to determine future governance arrangements.
London Borough of Merton	Mario Lecordier	Traffic and Highways Services Manager	Overall lead on local flood risk management activities within the Council.
London Borough of Wandsworth	Adam Hutchins John Stone	Head of Forward Planning and Transportation	Overall lead on local flood risk management activities within the Council.
Thames Water	Mark Dickinson/ David Harding	Performance Manager, Asset Management	Share data on the performance of Thames Water assets within the administrative area.
Environment Agency	David Bedlington/Ivan Parr	Technical Specialist	Overview role for Inland Flooding, provide guidance on methodology, share best practice and provide data.
Tier 2 - Technical & Operational Management Group			
Organisation	**Name**	**Title**	**Role**
London Borough of Sutton	Gerry McLaughlin	Drainage Engineer	Operational support. Operational maintenance
London Borough Croydon	David Carlisle	Project Officer, Spatial Planning Team	Linking SWMP and SFRA with Multi-Agency Flood Plan / Severe Weather Plan. Drain London primary contact.
Richmond upon Thames	Andrea Kertzberger	Planning Policy Officer	Linking SWMP and SFRA with Multi-Agency Flood Plan / Severe Weather Plan. Drain London primary contact.
Royal Borough of Kingston upon Thames	Rob Bell	Contingency Planning Manager	Linking SWMP and SFRA with Multi-Agency Flood Plan / Severe Weather Plan. Drain London primary contact.

2.3 DATA COLLECTION

2.3.1 The collection and collation of strategic level data was undertaken as part of the Tier 1 work and disseminated to Tier 2 consultants by the GLA. Data was collected from each of the following organisations:

- London Borough of Richmond upon Thames
- British Airports Authority
- British Geological Survey
- British Waterways
- Environment Agency
- Transport for London
- Greater London Authority
- Highways Agency
- London Underground
- Network Rail
- Thames Water

2.3.2 A comprehensive data set was passed onto Tier 2 consultants and in some cases additional supplemental data was provided by individual organisations.

2.4 DATA REVIEW

2.4.1 The following table provides a brief summary of key datasets used in the preparation of the SWMP. Further details regarding the datasets used as part of this SWMP are included in Appendix A.

Table 2-2 Data Review

Supplier Organisation	Dataset	Description
London Borough of Richmond upon Thames	Historical Flooding Records	Historical records of flooding from surface water, groundwater and ordinary watercourses.
	Maintenance Regime	The council provided details of their local maintenance regime
	Local Climate Impact Profile Report	Report identifying the impacts and consequences of weather-related events, including surface water flooding.
	Strategic Flood Risk Assessment	The London Borough of Richmond upon Thames SFRA contains useful information on historic flooding, including local sources of flooding from surface water and groundwater.
	First Edition Surface Water Management Plan (August 2009)	The SWMP contained useful details of past flood records and site visits.
Environment Agency	Environment Agency Flood Map (Fluvial)	Shows the extent of flooding from rivers with a catchment of more than 3km^2 and from the sea.
	Flood Map for Surface Water	A second generation of surface water flood mapping which was released at the end of 2010.
	Groundwater Flooding Database	Mapping showing historic groundwater flood records
	Historic Flood Map	Attributed spatial flood extent data for flooding from all sources.
	Thames Estuary 2100	Environment Agency / Jacobs dataset of the

Supplier Organisation	Dataset	Description
	(TE2100) Groundwater Hazard Maps	Thames Estuary 2100 (TE2100) Groundwater Hazard Maps
	LiDAR Topographic Data	LiDAR Topographic Data
	National Receptors Dataset	A nationally consistent dataset of social, economic, environmental and cultural receptors including residential properties, schools, hospitals, transport infrastructure and electricity substations.
	Indicative Flood Risk Areas	National mapping highlighting key flood risk areas, based on the definition of 'significant' flood risk agreed with the Defra.
Greater London Authority	Ordnance Survey Mapping (1:10k, 1:50k, Mastermap)	Ordnance Survey Mapping for the Greater London Area for the 1:10k and 1:50k scale and Mastermap dataset.
Thames Water Utilities Limited	DG5 Register for Thames Water Utilities areas	DG5 Register logs and records of properties at risk of flooding from sewers. The dataset supplied provides those properties at risk at end of June 2010.
	Thames Water Sewer Network and Asset Location	The Thames Water Sewer network shows the location and size of the foul, combined, surface water and storm relief sewers across the Greater London area along with the locations for Sewage Treatment Works, Pumping Stations and Combined Sewer Overflows.
London Fire Brigade	Historical flooding call-out records	Records of all London Fire Brigade callouts for 'flooding' events since 2000. However, no flooding source is provided, so could be a result of water mains bursting as well as heavy rainfall / surface water flooding.
Network Rail	Areas Prone To Flooding	A list of areas prone to flooding across their South East Territory.
Transport for London (TfL)	Tfl Red Routes	Pdf of the TfL Red Routes for the Greater London area
	TfL Gullies	GIS dataset of the Tfl owned / managed gullies along the Red Routes for the Greater London area
	TfL Pumps	Location and pump regimes for Tfl owned / managed gullies in the Greater London area
London Underground	Flooding records – July 2007	Records relating to station closures (location and duration) on 20th July 2007 due to heavy rainfall.
British Geological Survey	Groundwater Flooding Susceptibility Map	GIS dataset of areas susceptible to groundwater flooding
Jacobs / JBA	Groundwater Emergence Maps (GEMs)	GIS dataset of areas of groundwater emergence (GEMs)
	Groundwater Flood Map	GIS dataset of groundwater flood map
	Increased Potential for Elevated Groundwater (iPEG)	GIS dataset of areas of increased potential for elevated groundwater (iPEG), produced using existing Environment Agency, BGS and Jacobs / JBA datasets, produced for the Greater London

Supplier Organisation	Dataset	Description
		area for the purpose of assessing groundwater flood risk as part of the Drain London project.

2.5 ASSET REGISTER

2.5.1 Section 21 of the FWMA 2010 sets a duty on each London Borough as LLFA (Section 1.7) to maintain a register of structures or features, and a record of information about each of those structures or features, which, in the opinion of the authority, are likely to have a significant effect on flood risk in its Borough. From the 6th of April 2011 all LLFAs have a duty to maintain a register. The legal characteristics of the register and record are outlined in Table 2-3 below:

Table 2-3 Asset Register Requirements

	Register	Record
a.	Must be made available for inspection at all reasonable times.	Up to the LLFA to decide if they wish to make it available for inspection
b.	Must contain a list of structures or features which in the opinion of the authority, are likely to have a significant effect on a local flood risk.	For each structure or feature listed on the register, the record must contain information about its ownership and state of repair.
c.	S.21 (2) of the Act allows for further regulations to be made about the content of the register and record. There is currently no plan to provide such regulations therefore their content should be decided on by the LLFA depending on what information will be useful to them.	
d.	There is no legal requirement to have a separate register and record although as indicated above, only the register needs to be made available for public inspection.	

2.5.2 Defra have provided each LLFA with templates to demonstrate what information should be contained in the asset register. Although these templates are not intended as a working tool, they provide a good example of how an asset register might be structured.

2.5.3 Populating and ensuring the ongoing maintenance of the asset register is outside the scope of the Drain London project and is the responsibility of each London Borough. The expectation from Defra is that LLFAs (London Boroughs) will utilise a risk-based approach to populate the register and record with those structures or features considered the most significant first. The register will then grow over time and be continually updated.

EXISTING ASSET MANAGEMENT ARRANGEMENTS

2.5.4 A review of the existing asset arrangements for London Borough of Richmond upon Thames has been undertaken using the following set of criteria.

Level 1 – The London Borough knows where their assets are, what they look like and what condition they are in. Register system may take the form of a spreadsheet or hard copy records.

Level 2 – The London Borough is aware of the 'Local Authority Flood Risk Asset Tool' currently being produced by the EA / Defra. Their register is GIS based (basic proprietary system only) or uses a highways based asset management system database. Their register captures information generally aligned with guidance provide by the Tool and the EA NFCDD system where practical. They know where their assets are and carry out reactive maintenance of significant structures as required.

Level 3 – The London Borough has a detailed understanding of Asset Registers as required by the FWMA 2010. Their register system accurately replicates the 'Local Authority Flood Risk Asset Tool' data standards and related NFCDD structures to an attribute level. Their register is GIS based (advanced proprietary or bespoke system) or is completely integrated with an existing asset management system. They know where their assets are and carry out periodic maintenance on the structures using a risk based priority system.

RECOMMENDATIONS

2.5.5 Appendix B provides a summary of the current status of the asset register for London Borough of Richmond upon Thames as well as recommendations for suggested actions that could be undertaken to meet the full Level 3 status as defined in Section 2.5.1.

2.6 PHASE 1 PREPARATION – CONCLUSIONS

2.6.1 Phase 1 of the SWMP has achieved the following:

- Established a sub-regional flood risk partnership structure for the London Boroughs of Richmond upon Thames, Wandsworth, Merton, Croydon, Sutton and Kingston (along with other key stakeholders), through the 'South West London Strategic Flood Group', to take forward and manage flood risk in the future;
- Collected and reviewed flood risk data and knowledge from key stakeholders and partner organisations;
- Set out recommendations for the London Borough of Richmond upon Thames' Asset Register, as required under the FWMA; and
- Set out the objectives and governance for the Phase 2 – Risk Assessment, Phase 3 – Options Assessment, and Phase 4 – Action Plan of the Richmond upon Thames SWMP.

3. Phase 2: Risk Assessment

3.1 INTERMEDIATE ASSESSMENT

3.1.1 The aim of the Phase 2 Risk Assessment is to identify the sources and mechanisms of surface water flooding across the study area which will be achieved through an intermediate assessment of pluvial flooding, sewer flooding, groundwater flooding and flooding from ordinary watercourses along with the interactions with main rivers and the sea. The modelling outputs will then be mapped using GIS software.

3.1.2 SWMPs can function at different geographical scales and therefore at differing scales of detail. Table 3-1 defines the three potential levels of assessment within a SWMP. This SWMP has been prepared at the 'Borough' scale and fulfils the objectives of a second level 'Intermediate Assessment'.

Table 3-1: SWMP Study Levels of Assessment [Defra 2010]

Level of Assessment	Appropriate Scale	Outputs
1. Strategic Assessment	Greater London	Broad understanding of locations that are more vulnerable to surface water flooding. Prioritised list for further assessment. Outline maps to inform spatial and emergency planning.
2. Intermediate Assessment	Borough wide	Identify flood hotspots which might require further analysis through detailed assessment. Identify immediate mitigation measures which can be implemented. Inform spatial and emergency planning.
3. Detailed Assessment	Known flooding hotspots	Detailed assessment of cause and consequences of flooding. Use to understand the mechanisms and test mitigation measures, through modelling of surface and sub-surface drainage systems.

3.1.3 As shown in Table 3-1 above, the intermediate assessment is applicable across a large town, city or Borough. In the light of historical flooding and the results from the over-arching national pluvial modelling suggesting that there are 9100 properties at risk across the Borough[4], it is appropriate to adopt this level of assessment to further quantify the risks.

3.1.4 The purpose of this intermediate assessment will be to further identify those parts of the Borough that are likely to be at greater risk of surface water flooding and which may require more detailed assessment. The methodology used for this SWMP is summarised below. Further detail of the methodology is provided in Appendix C.

3.1.5 2-Dimensional pluvial modelling (using TuFLOW software) has been undertaken following a Direct Rainfall Approach. Rainfall events of known probability are applied directly to the ground surface and water is routed overland to provide an indication of potential flow path

[4] National Rank Order of Settlements Susceptible to Surface Water Flooding Defra 2009

directions, velocities and areas where surface water are likely to pond.

3.1.6 The 2-Dimensional pluvial modelling has been supported by field visits and visual surveys undertaken in conjunction with the London Borough of Richmond upon Thames staff.

3.1.7 The outputs from the pluvial modelling are verified (where possible) against historic surface water flood records.

3.2 Risk Overview

Mapping of Surface Water Flood Risk

3.2.1 The mapping shown within this report is intended to identify broad areas which are more likely to be vulnerable to surface water flooding. This allows the London Borough of Richmond upon Thames and its partners to undertake more detailed analysis in areas which are most vulnerable to surface water flooding.

3.2.2 In addition, the mapping can also be used as an evidence base to support spatial planning to ensure that surface water flooding is appropriately considered when allocating land for future development. Furthermore, the map can also be used to assist emergency planners in preparing their Multi-Agency response plans.

3.2.3 It should be noted that these maps only show the predicted likelihood of surface water flooding (this includes flooding from sewers, drains, small watercourses and ditches that occurs in heavy rainfall in urban areas) for defined areas. Due to the coarse nature of the source data used, the maps are not detailed enough to define risk for individual addresses. Individual properties therefore may not always face the same probability of flooding as the areas that surround them.

3.2.4 There may also be particular occasions when flooding occurs and the observed pattern of flooding does not in reality match the predicted patterns shown on these maps. The maps reflect all the suitable and relevant data provided and have been produced using expert knowledge to create conclusions that are as reliable as possible. However, it is essential that users of these maps understand the complexity of the data and modelling utilised in their production and that they are also aware of the associated limitations and uncertainties in the mapping. The maps are not intended to be used in isolation.

3.2.5 The Borough Council and the Drain London Tier 1 and Tier 2 Consultants cannot be held responsible if maps are misused or misunderstood.

Summary of Definitions

3.2.6 Figure 3-1 provides a summary of the levels of assessment and terminology used throughout this SWMP; the following sections provide a definition of each. To avoid confusion and ensure clarity of scale, the hierarchy of definitions is summarised as follows, from smallest to largest:

1. Local Flood Risk Zone (managed at the local scale);
2. Critical Drainage Area (containing one or more Local Flood Risk Zones – managed at the local scale);
3. Policy Areas (containing one or more Critical Drainage Areas and covering the entire Borough);

4. Flood Risk Area (as defined by the EA / Defra Indicative Flood Risk Areas – an area approximately covering the entire Greater London Area and managed at a strategic scale).

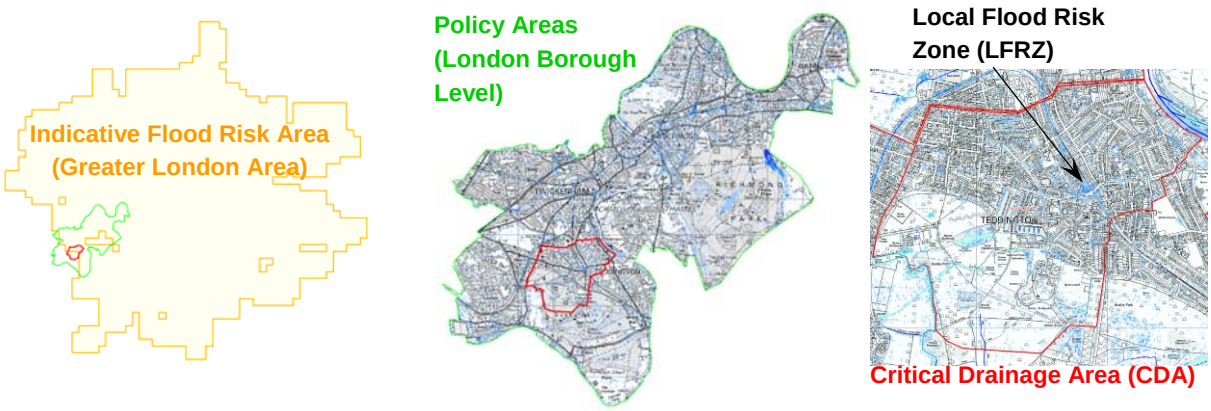

Figure 3-1 Example of Flood Risk Area, Policy Area, CDA and LFRZ

Local Flood Risk Zones (LFRZ)

3.2.7 For the purposes of the SWMP, a LFRZ as defined as:

'Discrete areas of flooding that affect houses, businesses or infrastructure'.

3.2.8 A LFRZ is defined as the actual spatial extent of predicted flooding at a single location. Related LFRZs can be grouped together as a Critical Drainage Area or left in isolation and considered within the larger Policy Areas.

Critical Drainage Areas (CDA)

3.2.9 A Critical Drainage Area (CDA) is defined as:

'a discrete geographic area (usually a hydrological catchment) where multiple and interlinked sources of flood risk (surface water, groundwater, sewer, main river and/or tidal) cause flooding in one or more Local Flood Risk Zones during severe weather thereby affecting people, property or local infrastructure.'*

3.2.10 CDA units are larger than LFRZs and denote an area or catchment where mitigation measures may be implemented to reduce flooding experienced in the flood risk zone. CDA units should be used for site specific detailed planning and capital works schemes and may contain one or more LFRZ.

3.2.11 It is noted, as discussed in Section 1.1, that the SWMP study only includes pluvial modelling of surface water flood risk. The influences of Main River and tidal flood risk will be considered as far as their potential to block surface water drainage outfalls and create surface water flooding elsewhere. Main River/tidal flood risk is not illustrated on SWMP pluvial risk mapping included in this report.

Policy Areas

3.2.12 A Policy Area is defined as:

> *'A discrete area within an administrative boundary where appropriate planning policy can be applied to manage flood risk.'*

3.2.13 Policy Areas contain one or more CDAs and cover the entire study area. Policy Areas are primarily based on hydrological catchments but may also accommodate geological concerns and other factors as appropriate. Policy areas may be used to provide guidance on general policy across the study area e.g. the use of soakaways in new development.

Indicative Flood Risk Areas

3.2.14 Indicative Flood Risk Areas are defined by the Environment Agency / Defra primarily for the purposes of the preparation of Preliminary Flood Risk Assessments. The Indicative Flood Risk Area covers the entire Greater London Areas and is managed at a strategic scale5.

3.3 SURFACE WATER FLOODING

MECHANISM OF FLOODING

3.3.1 Surface water flooding is caused as a result of high intensity rainfall, often short duration summer storms such as those experienced in Richmond upon Thames in July 2007. Water flows over the surface of the ground and ponds in low lying areas before entering watercourses or sewers. Surface water flooding may be exacerbated when receiving watercourses are full to capacity or where there are local issues with the drainage network including blockage, lack of gullies etc. Surface water flooding is also known as pluvial flooding.

3.3.2 No single organisation has overall responsibility for surface water flooding with different aspects of the drainage system falling to either The Highway Authority (in this case the London Borough of Richmond upon Thames Council), Thames Water, riparian owners and Transport for London (red routes including the A316).

PLUVIAL MODELLING

3.3.3 The Environment Agency commissioned national scale surface water modelling, resulting in the preparation of the Flood Map for Surface Water (FMfSW) which identified areas at risk of flooding during the 3.3% (1 in 30 annual probability) and 0.5% (1 in 200 annual probability) rainfall events.

Figure D1 – EA Flood Map for Surface Water (Appendix D)

3.3.4 In order to continue developing an understanding of the causes and consequences of surface water flooding in the study area, intermediate level hydraulic modelling has been undertaken for a suite of five rainfall event probabilities. This hydraulic modelling has been designed to provide additional information where local knowledge is lacking and forms a basis for future detailed assessments in areas identified as high risk.

3.3.5 A Direct Rainfall approach using Tuflow software has been selected whereby rainfall events

[5] Refer to the London Borough of Richmond upon Thames PFRA report for further details

of known probability are applied directly to the ground surface and is routed overland to provide an indication of potential flow path directions and velocities and areas where surface water will pond. A full methodology of the hydraulic modelling undertaken is included in Appendix C.

3.3.6 Figures 3.3.1 and 3.3.2 show the modelling results for London Borough of Richmond upon Thames for the rainfall event with a 1% AEP of occurring in any year. Figures for the other modelled return periods are included in Appendix D.

Figure 3.3.1 – Surface Water Flood Depth (1% AEP)
Figure 3.3.2 – Surface Water Flood Risk Hazard (1% AEP)

[Appendix D]
Figure D9 – Surface Water Flood Depth (3.3% AEP)
Figure D10 – Surface Water Flood Hazard (3.3% AEP)
Figure D11 – Surface Water Flood Depth (1.3% AEP)
Figure D12 – Surface Water Flood Hazard (1.3% AEP)
Figure D13 – Surface Water Flood Depth (1% AEP plus climate change)
Figure D14 – Surface Water Flood Hazard (1% AEP plus climate change)
Figure D15 – Surface Water Flood Depth (0.5% AEP)

3.3.7 A summary of the suggested use for each mapped output is provided in Table 3-2.

Table 3-2 Modelled Return Periods and Suggested Use

Modelled Return Period	Suggested use
3.3% AEP Probability of occurrence is 1 in 30 years Figure D9 & D10	Thames Water sewers are typically designed to accommodate rainfall event with a 3.3% AEP period or less. This layer will identify areas that are prone to regular flooding and could be used by highway teams to inform maintenance regimes.
1.3%AEP Probability of occurrence is 1 in 75 years Figure D11 & D12	In areas where the likelihood of flooding is 1.3% AEP insurers will not guarantee to provide cover to property should it be affected by flooding. This GIS layer should be used to inform spatial planning; if property cannot be guaranteed insurance, the development may not be viable.
1% AEP Probability of occurrence is 1 in 100 years Figure 3.3.1 & 3.3.2	Can be overlaid with Environment Agency Flood Zone 3 GIS layer to show areas at risk under the same event from both sources. Can be used to advise planning teams.
1% AEP + Climate Change Probability of occurrence is 1 in 100 years plus an allowance for climate change. Figure D13 & D14	PPS25 requires that the impact of climate change is fully assessed. Reference should be made to this flood outline by the spatial planning teams to assess the sustainability of developments.
0.5% AEP Probability of occurrence is 1 in 200 years Figure D15 & D16	To be used by emergency planning teams when formulating emergency evacuation plans from areas at risk of flooding.

THIS DRAWING MAY BE USED ONLY FOR THE PURPOSE INTENDED

NORTH

London Borough of Hounslow

London Borough of Wandsworth

London Borough of Merton

Royal Borough of Kingston upon Thames

Surrey County Council

Beverley Brook

River Crane

River Thames

Group8_001
Group8_002
Group8_003
Group8_004
Group8_005
Group8_006
Group8_007
Group8_008
Group8_009
Group8_010
Group8_011
Group8_012
Group8_013
Group8_014
Group7_001
Group7_002
Group7_004
Group7_005

0 1 2km

- Borough Administrative Boundary
- Critical Drainage Area
- Permanent Water Body
- Main River
- Ordinary Watercourse
- Culverted Watercourse

Flood Depth

- <0.1m
- 0.1m to 0.25m
- 0.25m to 0.5m
- 0.5m to 1.0m
- 1.0m to 1.5m
- >1.5m

Notes

1. This map only shows the predicted likelihood of surface water flooding (this includes flooding from sewers, drains, small watercourses and ditches that occurs in heavy rainfall) for defined areas, and due to the coarse nature of the source data used, are not detailed enough to account for precise addresses.
2. Users of this map should refer to section 3.2 of the Surface Water Management Plan for a complete description of limitations and accuracy of the flood/hazard extents shown.
3. This map provides a strategic overview of surface water flood risk and may be subject to further analysis in the future.

London Borough of Richmond upon Thames

LONDON BOROUGH OF RICHMOND UPON THAMES

Surface Water Management Plan

Scale at A3	Date	Drawn by	Approved by
1:45,000	20/07/11	A.HARRIS	J.ROBINSON

Surface Water Depth (m)
1 in 100 Chance of rainfall event occuring in any given year (1% AEP)

Consultants
CAPITA SYMONDS Flood Risk Management
Scott Wilson
URS / Scott Wilson
6 - 8 Greencoat Place
London
SW1P 1PL

Drain London Programme Board Members

Environment Agency · Thames Water · LONDON COUNCILS · GREATERLONDONAUTHORITY

FIGURE 3.3.1

Filepath: N:\Current Projects\D1347785 D1347786 DRAIN LONDON Tier 2\02 Group 8 (D1347786)\05 GIS

THIS DRAWING MAY BE USED ONLY FOR THE PURPOSE INTENDED

NORTH

London Borough of Hounslow

London Borough of Wandsworth

London Borough of Merton

Royal Borough of Kingston upon Thames

Surrey County Council

River Crane

River Thames

Beverley Brook

Group8_001
Group8_002
Group8_003
Group8_004
Group8_005
Group8_006
Group8_007
Group8_008
Group8_009
Group8_010
Group8_011
Group8_012
Group8_013
Group8_014
Group7_001
Group7_002
Group7_004
Group7_005

0 1 2km

- Borough Administrative Boundary
- Critical Drainage Area
- Permanent Water Body
- Main River
- Ordinary Watercourse
- Culverted Watercourse

Flood Hazard

- <0.75 Caution (Very low hazard)
- 0.75 - 1.25 Moderate (Danger for some)
- 1.25 - 2.0 Significant (Danger for most)
- <2.0 Extreme (Danger for all)

Notes

1. Flood Hazard has been defined based upon the joint EA and Defra R&D Technical Report FD2320 (January 2006).
2. Degree of flood hazard can be interpreted as follows:
- Caution: Flood zone with shallow flowing water or deep standing water
- Moderate: Flood zone with deep or fast flowing water. Dangerous for children, the elderly and the infirm
- Significant: Flood zone with deep fast flowing water. Dangerous for most people.
- Extreme: Flood zone with deep fast flowing water. Dangerous for all (including emergency services)
3. This map provides a strategic overview of surface water flood risk and may be subject to further analysis in the future.

London Borough of Richmond upon Thames

LONDON BOROUGH OF RICHMOND UPON THAMES

Surface Water Management Plan

Scale at A3	Date	Drawn by	Approved by
1:45,000	20/07/11	A.HARRIS	J.ROBINSON

Surface Water Flood Hazard Rating
1 in 100 Chance of rainfall event occuring in any given year (1% AEP)

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SW1P 1PL

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FIGURE 3.3.2

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HISTORICAL SURFACE WATER FLOODING

3.3.8 The London Borough of Richmond upon Thames has provided records of roads and broad locations which experienced flooding during the July 2007 floods[6]. These incidents have been mapped over the pluvial modelling results in Figure D2 (Appendix D).

Figure D2 – Surface Water Flood Depth (1% AEP) & Recorded Surface Water Flood Incidents

3.4 ORDINARY WATERCOURSE FLOODING

MECHANISMS OF FLOODING

3.4.1 Ordinary watercourse flooding includes flooding from small open channels and culverted urban watercourses. These small channels often receive most of their flow from inside the urban area and perform an urban drainage function.

3.4.2 As part of this study, no information has been provided by the London Borough of Richmond upon Thames regarding ordinary watercourse flooding in the study area. The Detailed River Network (DRN) has been provided by the Environment Agency and identifies a number of watercourses, as shown in Figure 3.4.1.

Figure 3.4.1 – EA Main Rivers, Ordinary Watercourses Flood Zones & Fluvial Flood Incidents

3.4.3 As part of the pluvial modelling, inclusion has been made for an assessment of flooding from ordinary watercourses. The presence of ordinary watercourses has been defined using the DNR dataset provided by the Environment Agency and the ground levels have been determined using the LiDAR topographic data. It is therefore considered that the pluvial flooding maps include an indication of the extent of flooding from ordinary watercourses.

RESPONSIBLE ORGANISATIONS

3.4.4 The Environment Agency has responsibility over flooding from designated Main Rivers, however the responsibility for maintenance of small open channels and culverted urban watercourses which are not designated as 'main river' falls to the London Borough of Richmond upon Thames and riparian owners who own land on either bank i.e. Richmond Council is only responsible for ordinary watercourses where land on either bank is in council ownership, or where historical agreements have been made.

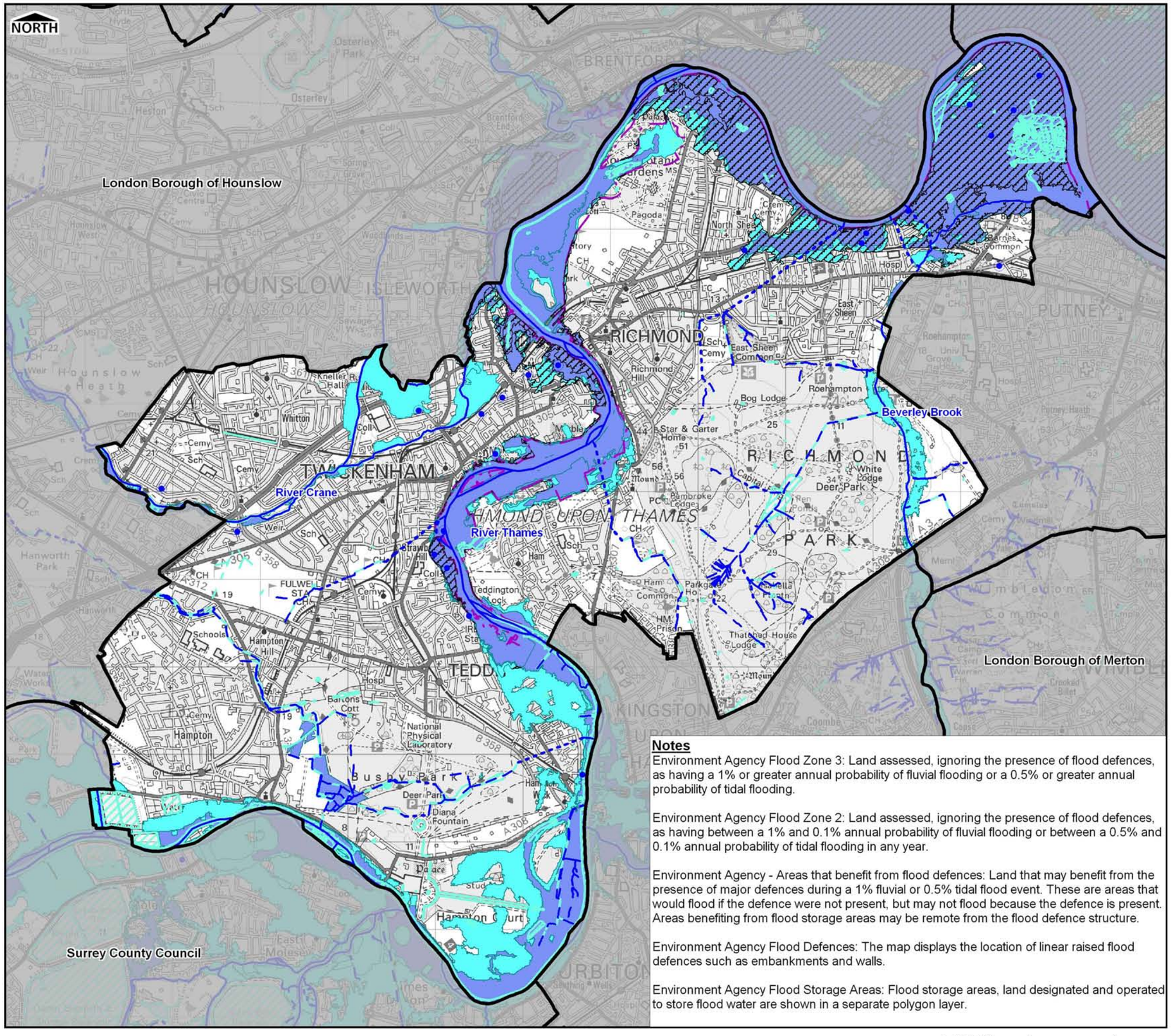
3.4.5 Responsibilities as riparian owner are to:

- Pass flow on without obstruction, pollution or diversion affecting the rights of others;
- To accept flows through your land even if caused by inadequate capacity downstream;
- Maintain the bed and banks of the watercourse (including trees and shrubs growing on the banks) and for clearing any debris, natural or otherwise even if it did not originate from your land;

[6] London Borough of Richmond upon Thames Surface Water Flooding Scrutiny Task Group June 2008

- Watercourses and their banks must not be used for the disposal of any form of garden or other waste;
- Failure in carrying out these responsibilities could result in possible civil action;

3.4.6 Local Authorities have certain permissive powers to undertake flood defence works and powers for enforcement under the Land Drainage Act 1991 and Public Health Act on watercourses which have not been designated as main rivers. The London Borough of Richmond upon Thames should discuss and re-confirm their policy on enforcement of the Land Drainage Act in relation to ordinary watercourses and riparian owners especially when dealing with issues relating to lack of maintenance.



Notes

Environment Agency Flood Zone 3: Land assessed, ignoring the presence of flood defences, as having a 1% or greater annual probability of fluvial flooding or a 0.5% or greater annual probability of tidal flooding.

Environment Agency Flood Zone 2: Land assessed, ignoring the presence of flood defences, as having between a 1% and 0.1% annual probability of fluvial flooding or between a 0.5% and 0.1% annual probability of tidal flooding in any year.

Environment Agency - Areas that benefit from flood defences: Land that may benefit from the presence of major defences during a 1% fluvial or 0.5% tidal flood event. These are areas that would flood if the defence were not present, but may not flood because the defence is present. Areas benefiting from flood storage areas may be remote from the flood defence structure.

Environment Agency Flood Defences: The map displays the location of linear raised flood defences such as embankments and walls.

Environment Agency Flood Storage Areas: Flood storage areas, land designated and operated to store flood water are shown in a separate polygon layer.

THIS DRAWING MAY BE USED ONLY FOR THE PURPOSE INTENDED

Legend

- Borough Administrative Boundary
- Flood Zone 2
- Flood Zone 3
- Main River
- Ordinary Watercourse
- Culverted Watercourse
- Permanent Water Bodies
- Areas Benefiting from Flood Defences
- Flood Storage Areas
- Defences
- Fluvial Flood Incidents

London Borough of Richmond upon Thames

LONDON BOROUGH OF RICHMOND UPON THAMES

Surface Water Management Plan

Scale at A3	Date	Drawn by	Approved by
1:45,000	20/07/2011	D.SKILTON	E.CRAVEN

Environment Agency Flood Map and Fluvial Flooding Incidents

Consultants
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URS / Scott Wilson
6 - 8 Greencoat Place
London
SW1P 1PL

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FIGURE 3.4.1

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3.5 GROUNDWATER FLOODING

MECHANISMS OF FLOODING

3.5.1 Groundwater flooding occurs as a result of water rising up from the underlying aquifer or from water flowing from abnormal springs. This tends to occur after much longer periods of sustained high rainfall, and the areas at most risk are often low-lying where the water table is likely to be at shallow depth. Groundwater flooding is known to occur in areas underlain by principal aquifers[7], although increasingly it is also being associated with more localised floodplain sands and gravels.

3.5.2 Groundwater flooding tends to occur sporadically in both location and time, and tends to last longer than fluvial, pluvial or sewer flooding. Basements and tunnels can flood, buried services may be damaged, and storm sewers may become ineffective, exacerbating the risk of surface water flooding. Groundwater flooding can also lead to the inundation of farmland, roads, commercial, residential and amenity areas.

3.5.3 It is also important to consider the impact of groundwater level conditions on other types of flooding e.g. fluvial, pluvial and sewer. High groundwater level conditions may not lead to widespread groundwater flooding. However, they have the potential to exacerbate the risk of pluvial and fluvial flooding by reducing rainfall infiltration capacity, and to increase the risk of sewer flooding through sewer / groundwater interactions.

3.5.4 The need to improve the management of groundwater flood risk in the UK was identified through Defra's Making Space for Water strategy. The review of the July 2007 floods undertaken by Sir Michael Pitt highlighted that at the time no organisation had responsibility for groundwater flooding. The FWMA 2010 identified new statutory responsibilities for managing groundwater flood risk, in addition to other sources of flooding and has a significant component which addresses groundwater flooding

3.5.5 Based on the hydrogeological conceptual understanding of the London Borough of Richmond upon Thames study area, the potential groundwater flooding mechanisms that may exist are:

3.5.6 Claygate Member outcrop area in Richmond Park: Water levels within the outcropping Claygate Member (and overlying Black Park Gravel Member) will be perched on top of the London Clay Formation aquiclude. This means that basements / cellars and other underground structures in this area may be at risk from groundwater flooding following periods of prolonged rainfall, increased utilisation of infiltration SUDs and / or artificial recharge from leaking pipes.

3.5.7 Superficial aquifers along the River Thames, River Crane and Beverley Brook: groundwater flooding may be associated with the Alluvium, Head and, in particular, River Terrace Deposits, where they are in hydraulic continuity with surface watercourses. Stream levels may rise following high rainfall events but still remain "in-bank", and this can trigger a rise in groundwater levels in the associated superficial deposits. The properties at risk from this type of groundwater flooding are probably limited to those with basements / cellars, which have been constructed within the superficial deposits.

3.5.8 Superficial aquifers in various locations: a third mechanism for groundwater flooding is also associated with the Head and River Terrace Deposits (gravel and sand) where they are not

[7] Aquifers allow significant groundwater movement

hydraulically connected to surface watercourses. Perched groundwater tables can exist within these deposits, developed through a combination of natural rainfall recharge and artificial recharge e.g. leaking water mains. The properties at risk from this type of groundwater flooding are probably limited to those with basements / cellars.

3.5.9 Impermeable (silt and clay) areas down slope of superficial aquifers in various locations: a forth mechanism for groundwater flooding may occur where groundwater springs / seepages form minor flows and pond over impermeable strata where there is poor drainage (artificial or natural).

3.5.10 Artificial ground in various locations: a final mechanism for groundwater flooding may occur where the ground has been artificially modified to a significant degree. If this artificial ground is of substantial thickness and permeability, then a shallow perched water table may exist. This could potentially result in groundwater flooding at properties with basements, or may equally be considered a drainage issue. Areas mapped by the BGS as containing artificial ground are shown in Figures 1 and 2. It is noted that the artificial deposits are mostly over the River Terrace Deposits and may either form a continuous aquifer with these superficial deposits, or provide a low permeability cap, depending on the composition of the artificial ground.

EVIDENCE OF GROUNDWATER FLOODING

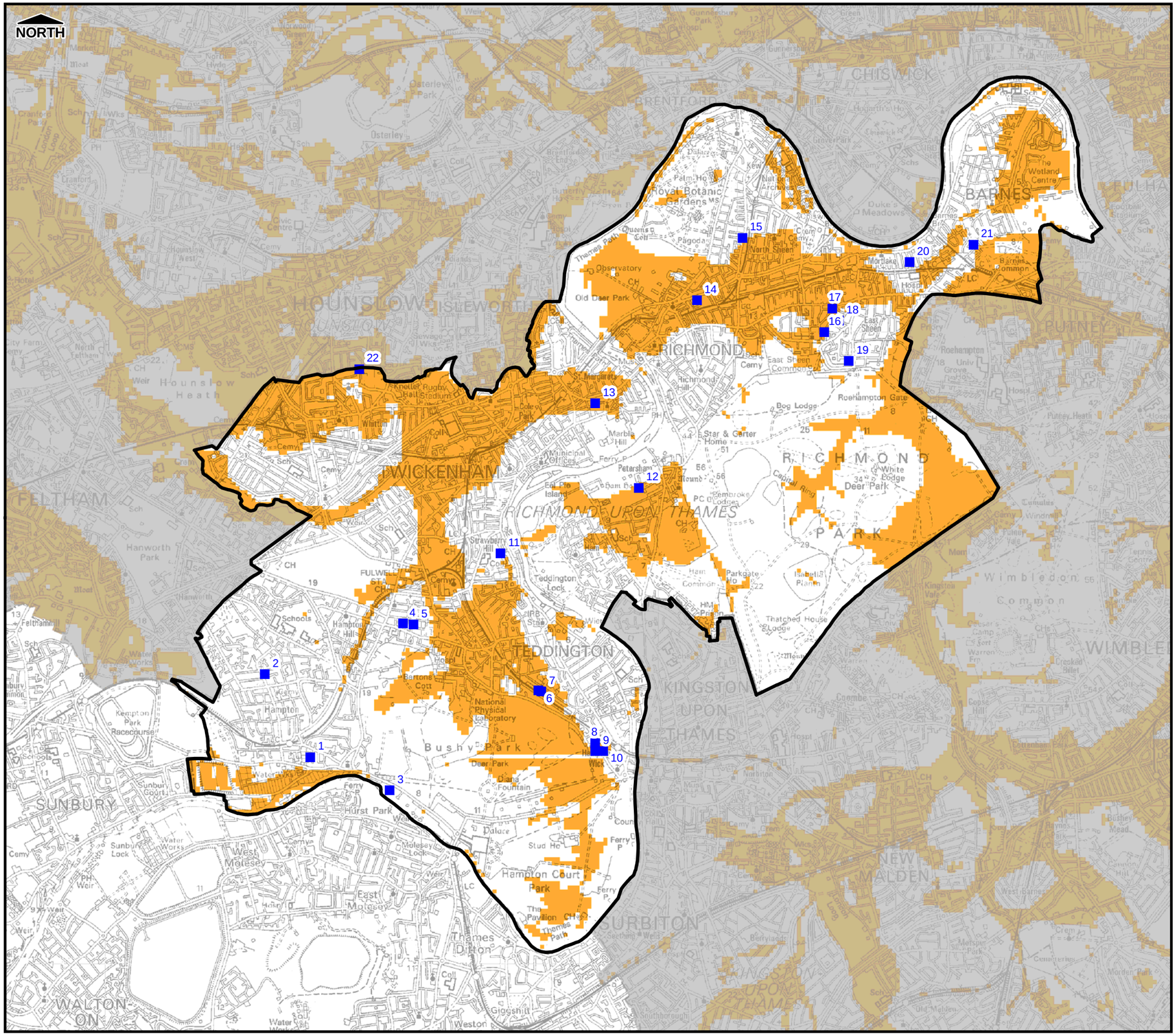
Figure 3.5.1 – Increased Potential for Elevated Groundwater (iPEG) Dataset & Historic Groundwater Flood Incidents

3.5.11 Figure 3.5.1 shows the location of a number of groundwater flooding incidents between 2000 and 2010 within the study area that have been reported to the Environment Agency. Further details are presented in Table 3-3 below.

3.5.12 It should be noted that there has not been a statutory obligation to record incidences of groundwater flooding in the past. It is therefore likely that this list of groundwater flooding incidents is not exhaustive.

Table 3-3 Available Groundwater Flooding Records

Bedrock Geological Unit*	Overlying Superficial Deposits*	Location	NGR	Incident N°**	Reported Incident	Year
London Clay Formation	Taplow Gravel Formation	Richmond	513594 169622	1	Flooded Cellar	2003
	Taplow Gravel Formation	London	513021 170670	2	Landowner has been informed there is shallow groundwater under his property & that he is at risk of groundwater flooding.	2005
	Alluvium	Hampton Court	514600 169200	3	Flow from bank for 22/23yrs	2001
	Taplow Gravel Formation	Teddington	514768 171311	4	Basement flooding	2003
	Taplow Gravel Formation	Teddington	514900 171300	5	Rising WL under home	2000
	Kempton Park Gravel Formation	Teddington	516480 170470	6	Water in air raid shelter in garden	2001



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Legend

- Richmond Borough Council
- Groundwater Flood Incident (EA Records)

Increased Potential for Elevated Groundwater in

- Permeable Superficial Deposits
- Consolidated Aquifers

Notes

1.The increased Potential for Elevated Groundwater map shows those areas within the London Boroughs where there is an increased potential for groundwater to rise sufficiently to interact with the ground surface or be within 2m of the groundsurface. Such groundwater rise could lead to the following:

-Flooding of basements of buildings below ground level;
-Flooding of buried services or other assets below ground level;
-Inundation of farmland, roads, commercial, residental and amenity areas;
-Flooding of ground floors of buildings above ground level; and Overflowing of sewers and drains

2.Incident records shown are generally unconfirmed and may include issues such as water main bursts or non-groundwater related problems.
3.Areas not shown to have increased potential for elevated groundwater should be considered to have a low potential for elevated groundwater - Lack of information does not imply 'no potential' of elevated groundwater in that area.
4.Includes groundwater flood mapping provided by JBA consulting, Copyright. Jeremy Benn Associates Limited 2008-2011, partially derived from data supplied by the Environment Agency.

London Borough Richmond

LONDON BOROUGH OF RICHMOND UPON THAMES

Surface Water Management Plan

Scale at A3	Date	Drawn by	Approved by
1:50,000	22/03/2011	C.Woolhouse	S.Cox

Increased Potential For Elevated Groundwater

Consultants

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SW1P 1PL

Drain London Programme Board Members

Environment Agency
Thames Water
LONDON COUNCILS
GREATER LONDON AUTHORITY

FIGURE 3.5.1

Filepath: D:\34786 Drain London_Tier 2_Group 8\700 Technical\711 GIS\01 Layout\Richmond\Increased Potential for Elevated GW.mxd

Bedrock Geological Unit*	Overlying Superficial Deposits*	Location	NGR	Incident N°**	Reported Incident	Year
	Kempton Park Gravel Formation	-	516519 170452	7	GW Flooding enquiry	2007
	Kempton Park Gravel Formation	Kingston-on-Thames	517200 169800	8	Water in Cellar	2001
	Kempton Park Gravel Formation	Hampton Wick	517200 169700	9	Water in cellar	2001
	Kempton Park Gravel Formation	Hampton Wick	517300 169700	10	Wet Basement	2000
	Edge of Alluvium	Twickenham	516000 172200	11	Boggy Garden	2000
	Edge of Langley Silt Formation	Richmond	517749 173031	12	Waterlogged patch of ground.	2004
	Edge of Langley Silt Formation	Twickenham	517200 174100	13	Installed sump and pump	2000
	Kempton Park Gravel Formation	-	518485 175405	14	Recent flooding through ground floor	2007
	Kempton Park Gravel Formation	Kew	519062 176193	15	Occasional water seepage in basement	2007
	Edge of Taplow Gravel Fn and Head	East Sheen SW14	520100 175000	16	Standing water in garden	2000
	Head	SW14	520200 175300	17	Waterlogged Garden	2000
	Head	SW14	520286 175147	18	Flooded basement	2003
	Taplow Gravel Formation	Richmond	520411 174638	19	Flooded Cellar	2010
	Kempton Park Gravel Formation	SW14	521178 175888	20	Buying property -info on flooding	2001
	Alluvium	-	521988 176110	21	Water in cellar after heavy rain	2008
	Taplow Gravel Formation	TW2	514212 174535	22	Water under floorboards	2003

Note: * Geology of incident based on plotted location (Figures 1, 2 and 3) and Environment Agency record
** Incident reference number as shown on Figures 1, 2 and 3.
Fn = Formation

3.5.13 Table 3-3 shows many of the reported incidents occurred during late 2000 / early 2001. This was a particularly wet period that resulted in both surface and groundwater flooding incidents in a number of locations across the country.

3.5.14 All of the flood incidents are located where permeable superficial deposits overlie the London Clay Formation aquiclude. A perched groundwater table is expected to exist within these superficial deposits and so it is likely the flood incidents are true groundwater flooding incidents.

POTENTIAL FOR ELEVATED GROUNDWATER DATA SETS

3.5.15 The areas in the Borough where there is an increased potential for groundwater levels to rise to within 2 m of the ground surface during periods of higher than average recharge are shown in Figure 3.5.1. These are separated into permeable superficial deposits and bedrock (consolidated) aquifers. The data set was produced for the whole of the Drain London project area, derived from four individual data sources:

- British Geological Survey (BGS). Groundwater Flood Susceptibility maps;

- Environment Agency (EA). Thames Estuary, 2100 groundwater hazard maps;
- DEFRA. Groundwater emergence maps; and
- JBA. Groundwater flood maps.

3.5.16 However, only the BGS groundwater flooding susceptibility and EA Thames Estuary data sets are relevant to the London Borough of Richmond upon Thames area.

3.5.17 Figure 3.5.1 shows that areas in the London Borough of Richmond upon Thames where there is an increased potential for elevated groundwater are associated with permeable superficial deposits; **North Twickenham, North Richmond and West Teddington have been defined as having the most potential for elevated groundwater levels.**

3.5.18 In general, the areas identified by the data set as having an increased potential for elevated groundwater are sensible and show a good correlation with recorded groundwater flood incidents. However, there are a number of discrepancies; incidents 1 to 5, 19 and 20 are located outside of the areas with increased potential for elevated groundwater. It is possible that the BGS data set may need to be refined at these locations.

SUMMARY OF POTENTIAL FOR ELEVATED GROUNDWATER

3.5.19 Due to the significant thickness of underlying London Clay Formation in the London Borough of Richmond upon Thames, the susceptibility from groundwater flooding from rising groundwater levels in the Chalk and 'Basal Sands' is considered to be negligible. Therefore, the key groundwater flooding mechanisms are associated with permeable superficial deposits.

Claygate Member in the Richmond Park Area

3.5.20 The Claygate Member and overlying Black Park Gravel Member are thought to be water bearing. There are no groundwater level data to confirm the depth to water and therefore site investigation will be important for any proposed development sites, particularly those considering basements / underground structures such as soakaways.

Locations where the London Clay Formation is overlain by superficial deposits

3.5.21 Figure 3.5.1 indicates that the superficial deposits (primarily River Terrace Deposits) in the Borough are water bearing and have an increased potential for elevated groundwater. Whilst no groundwater level data are available for the superficial deposits, where groundwater tables exist they are expected to be close to or at ground level, and may fluctuate with river stage. Therefore basements and cellars may be at risk from groundwater flooding and use of structures such as sheet piling may exacerbate the problem if they intercept the water table. It should be noted that only part of the superficial deposit outcrop is defined as having an increased potential for elevated groundwater. This is probably due to variations in the thickness and elevation of the deposits.

Locations where London Clay Formation outcrops at surface in the Richmond and Richmond Park area

3.5.22 The London Clay Formation is an aquiclude and does not permit groundwater flow. Therefore in areas where there are no overlying superficial deposits and the London Clay Formation is of an appreciable thickness, the potential for elevated groundwater levels is considered to be negligible. However, where the London Clay Formation has been removed and replaced with more permeable artificial ground, there may be increased potential of

elevated groundwater as groundwater becomes trapped in these deposits.

3.5.23 Finally, it is possible that groundwater springs could emerge from permeable superficial deposits and flow over the London Clay Formation, resulting in groundwater flooding. It is recommended that rolling ball analysis is undertaken as part of a more detailed assessment.

FUTURE SUSCEPTIBILITY

3.5.24 Susceptibility to groundwater flooding in the London Borough of Richmond upon Thames area may change as a result of climate change, or changes to flood management. One of the climate change predictions includes an increase of high rainfall events. This could lead to further groundwater flooding in the London Borough of Richmond upon Thames area due to increased perched groundwater levels and associated spring flows. It is also noted that a shift in drainage policy, with increased infiltration SUDS, may also lead to increased incidents of groundwater flooding.

3.5.25 Finally, the areas with increased potential for elevated groundwater may also change owing to future trends in river stage and changes to / increased flood defences. The Thames Estuary 2100 project is considering a number of options to manage the anticipated future increase in tidal and fluvial flood risk along the River Thames Estuary. The impact of these options should be considered further as part of a more detailed assessment.

3.5.26 A groundwater assessment for the London Borough of Richmond upon Thames is included in Appendix C2.

3.6 SEWER FLOODING

FLOODING MECHANISM

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

1. The rainfall event exceeds the capacity of the sewer system / drainage system

3.6.2 Sewer systems are typically designed and constructed to accommodate rainfall events with a 3.3% AEP (1 in 30 year return period) or less. Therefore, rainfall events with a return period of frequency greater than 1 in 30 years would be expected to result in surcharging of some of the sewer system. Thames Water informed the London Borough of Richmond upon Thames Scrutiny Task Group (created to provide a report into the 2007 flood event) that the sewer system across the Borough is only designed to accommodate a 1 in 10 or 1 in 15 year storm event. While Thames Water is concerned about the frequency of extreme events, it is not economically viable to build sewers that could cope with every extreme.

2. The system becomes blocked by debris or sediment

3.6.3 Overtime there is potential that road gullies can become blocked from fallen leaves and build up of silt. Richmond Council as highway authority aim to clean every gully within a one year cycle and that known problem areas are cleaned more regularly. It is recognised that the target cleansing cycle exceeds the Code of Good Practice for Highway Maintenance. The council also operate an autumn leaf collection patrol to mitigate the risk.

3.6.4 During the 2007 Scrutiny report it was stated by the Council's Assistant Head of Streetscene that 'only 85-90% of gullies are actually cleaned within the target cycle' and he also expressed the desire to clean more regularly. The Council only has one gully-cleaning machine which is often forced to stop regular maintenance to attend blocked gullies reported

by residents. A new street cleansing contract has now been let and the service response improved with better management and targeting of resources. It has now been determined that a single gully cleansing machine is capable of delivering the service.

Figure 3-2 Surface water flooding at junction of Amyand Park Road and Strafford Road caused by leaves partially blocking a drain, 25th December 2007

Source Richmond upon Thames scrutiny report

3. The system surcharges due to high water levels in receiving watercourses.

3.6.5 Within the Borough there is potential for river outlets to become submerged at high tide. When this happens, water is unable to discharge into the river and flows back along the sewer. Once storage capacity within the sewer itself is exceeded, the water will overflow into streets and houses. 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 blocked by high water levels in receiving watercourses, surcharging may again occur but in this instance flooding may contain untreated sewage.

3.6.6 Within the pluvial modelling methodology, the sewer system has been assumed to have a capacity of 6.5mm/hour. This has been represented by removing 6.5mm/hour from the inflow hyetograph for urban areas, and, in accordance with the specification, no connectivity between the sewer system and the above ground surface has been modelled. More detailed analysis of the interactions through the use of a combined surface water and sewer model could be undertaken in the future if thought beneficial.

RESPONSIBLE ORGANISATIONS

3.6.7 The Highway Authority (London Borough of Richmond upon Thames and TfL in the case of red routes) are responsible for the effectual drainage of roads in so far as ensuring that drains, including kerbs, road gullies and the pipe network which connects to the trunk sewers are maintained.

3.6.8 Thames Water are responsible for surface water drainage from development via adopted sewers and are responsible for maintaining trunk sewers into which much of Richmond's highway drainage connects.

3.6.9 Riparian owners are responsible for private drainage networks and receiving watercourses where they are small open channels and culverted urban watercourses (where land on either

bank is not in Council ownership or where historical agreements have been made).

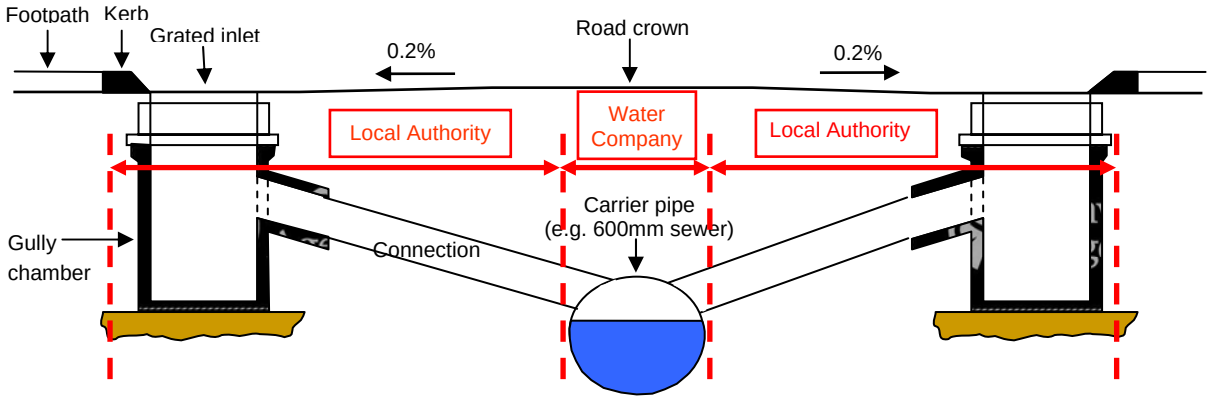

Figure 3-3 Surface Water Drainage Responsibility

3.6.10 In addition to the Thames Water network, there are also some sewers and drains which are in private ownership (often within industrial parks). Most of these private systems connect to the Thames Water public sewerage system for treatment; however private owners can also connect foul water to septic tanks and storm water to soakaways.

3.6.11 The majority of sewers across the Borough are 'combined' sewers which take both foul water (discharge from any sanitary fixture or appliance) and storm water (rainfall runoff). There are some separate sewers i.e. providing two piped networks, one containing rainfall runoff discharging to local watercourses and one carrying purely foul water to be sent for treatment. There are three sewerage treatment works serving the Borough:

- West of the River Thames is treated at Mogden Sewage Treatment Works
- Water from north Richmond and Kew is passes through the Kew pumping station for treatment at Mogden; and,
- Sewage from South Richmond and Ham is processed at Hogsmill treatment works.

THAMES WATER DATASETS

3.6.12 Thames Water have provided their DG5 database which details the total number of sewer flood incidents that have affected properties both externally and internally over the last 10 years. The DG5 dataset is provided on a five-digit postcode area, which makes it difficult to determine more precisely where sewer flooding problems may have occurred. In addition, Thames Water focus their efforts on removing properties from the DG5 register, and therefore this dataset may no longer accurately represent those properties which are currently at risk.

3.6.13 Thames Water has also provided details of their utility infrastructure including sewers, pumping stations and outfalls. This information has been overlaid onto critical drainage areas to inform on potential mitigation options for each location. Thames Water is keen to work with Councils in order to mitigate flood risk issues. Where required in order to further inform detailed design of mitigation options, Thames Water have agreed to make network models available. Figure D-4 (Appendix D) shows the Thames Water sewer network.

Figure D4 – Thames Water Sewer Network
Figure D5 – Historic Sewer Flooding Incidents

HISTORIC SEWER FLOODING RECORDS

3.6.14 A review of Figure D-5 (Appendix D) shows that there are records of sewer flooding in the majority of the Borough. The sewer flooding records highlight the following areas as being at a higher risk of sewer flooding *(numbers in brackets indicate number of records of sewer flooding incidents):*

- Barnes (east) SW151 (51-100 records of sewer flooding)
- Barnes (west) SW13 9 (21-50 records of sewer flooding)
- South Twickenham TW121 (21-50 records of sewer flooding)
- Whitton TW32 (21-50 records of flooding)

3.7 OTHER INFLUENCES

MAIN RIVERS

3.7.1 The Environment Agency has responsibility over flooding from designated Main Rivers which within the Borough include the Beverley Brook, River Crane and River Thames. The River Thames flows through the centre of the Borough extending from Hampton Court to Barnes. This watercourse poses both a tidal and fluvial flood risk to the Borough although the probability of fluvial flooding (alone) is higher than the tidal risk upstream of Teddington Weir as downstream of this point, the Borough is protected by a suite of Thames Tidal Defences.

3.7.2 The River Crane is located to the west of the River Thames entering the Borough from Hounslow and out falling to the River Thames to the north of St Margaret's. The watercourse flows within an urbanised corridor including culverted sections as well as open channel.

3.7.3 The Beverley Brook flows along the north eastern Borough boundary with Merton and Wandsworth again within a heavily urbanised corridor out falling to the River Thames in Barnes. The risk of fluvial flooding from main rivers has been assessed as part of the London Borough of Richmond Strategic Flood Risk Assessment (June 2008) and are therefore, not re-visited as part of this surface water study.

3.7.4 The London Borough of Richmond upon Thames regularly meet with the Environment Agency to discuss flood risk including maintenance of main rivers and ordinary watercourses. Figure D3 in Appendix D shows the Main Rivers and Flood Zones covering the London Borough of Richmond upon Thames using the Environment Agency Flood Map.

Figure 3.4.1 – EA Main Rivers, Ordinary Watercourses Flood Zones & Fluvial Flood Incidents

3.8 CRITICAL DRAINAGE AREAS

3.8.1 As shown in Figure 1, seven CDAs have been identified within or crossing the administrative boundary of the London Borough of Richmond upon Thames. CDA_001 overlaps into Hounslow and while Richmond is considered to be the 'lead' authority in terms of managing flood risk within this CDA, Hounslow also have a role to play in addressing flood risk within this area.

3.8.2 The remainder of this section provides a description of each CDA including details of the flooding mechanisms and interaction between flooding locations within the CDA, the level of validation, any specific assumptions made, and the number and types of receptors identified to be at risk.

Property Counts

3.8.3 Pluvial modelling completed as part of Phase 2 of the Drain London Project affords an improved understanding of the level of flood risk facing the London Borough of Richmond upon Thames. In order to provide a quantitative indication of potential risks, a property count for all properties across the entire Borough for all return periods modelled as part of the Drain London project for the London Borough of Richmond upon Thames has been undertaken and is shown in Table 3-4. This has been undertaken using the Environment Agency's National Receptors Dataset (NRD) and follows the methodology defined in the Drain London Data and Modelling Framework.

Table 3-4 Drain London Tier 2 Pluvial Modelling Property Count for the modelled event (1% AEP) for the entire Borough.

Property Type	Sub Category*	No. of properties flooded > 0.03m**	No. of properties flooded >0.5m***
Infrastructure	Essential Infrastructure	31	0
	Highly Vulnerable	8	0
	More Vulnerable	91	1
	Other Infrastructure	61	0
Households	Deprived (All)	0	0
	Deprived (Basements)	0	0
	Non-Deprived (All)	26,475	44
	Non-Deprived (Basements)	2,019	7
Commercial / Industrial	Commercial/Industrial (All)	1,796	7
	Commercial/Industrial Basements	688	4
Other		50	0
	TOTAL	**31,219**	**63**

* A full description of the sub-categories is included in Table 3-5 at the end of this Chapter.
** Building thresholds have been represented in the modelling as 'stubs' raised 100mm above the average ground level within the building footprint. A depth of >0.03m will result in a water level 0.03m above the property threshold, which is therefore considered to flood.
*** Buildings where the average depth of flooding across the building footprint is greater than 0.5m.

3.8.4 To provide an indication of the spatial flood risk across the Borough, a property count has been undertaken for each of the CDAs in the London Borough of Richmond upon Thames for the 1% AEP event. These values are included in the following sections for each CDA and a full summary is included in Table 3-5 at the end of this Section.

3.8.5 It is important to note that the counts have been undertaken on a CDA basis, and therefore, for those cross boundary CDAs, not all flooded properties will lie within the London Borough of Richmond upon Thames administrative area.

Mapping

Figures 3.8.1 – 3.8.7 show the modelling results for each CDA; two maps for each CDA, (a) and (b) have been included which show the surface water depth and surface water flood hazard rating during the rainfall event with a 1% AEP (1 in 100 annual probability)**.**

GROUP 8 CDA_001 TWICKENHAM

3.8.6 This CDA is located in the north west of the Borough and includes the Twickenham Rugby Ground. Pluvial mapping has identified surface water flow paths (overland flow) from residential areas in the west leading to pooling in the vicinity of the Duke of Northumberland River and within the boundaries of the Royal Military School of Music. Ground levels within this CDA are relatively flat leading to a number of discreet areas of pooling to depths of less than 0.4m in the 1% AEP event.

3.8.7 Following the July 2007 flood event, a list of flood locations was compiled from reports from various sources including street scene inspectors, members of the public and Council volunteers. Whitton Road in the south east of the CDA was recorded as having suffered flooding although there are no details of the source, duration of flood, location or depth of water available.

3.8.8 The Duke of Northumberland River flows in open channel in a northerly direction through the centre of the CDA and a small tributary of the River Crane flows easterly through a number of culverted sections before outfalling to the River Crane at the Chertsey Road Bridge. Flood Zone 3 is confined to the river channels, however approximately one third of the CDA is located within Flood Zone 2 associated with the River Crane. This would indicate an elevated potential of surcharging of the drainage network when the Duke of Northumberland and River Crane are in flood. Mogden sewage treatment works is located directly to the north of the CDA and there is an electricity substation located within a LFRZ on Gladstone Avenue.

3.8.9 The CDA is located within an area identified to be at increased potential for elevated groundwater (iPEG) (Figure 3.5.1, Section 3.2); however, the EA do not have any records of groundwater flooding in this area. The north of the CDA is identified on the Thames Water DG5 register as having 11-20 sewer flooding records over the last 10 years.

Summary Table – CDA 001 Twickenham		
LLFA	London Borough of Richmond upon Thames	
Flood Risk Categorisation:	Surface water, sewer flooding, increased potential for groundwater flooding	
Property Count 1% AEP	• Approximately **1417 non deprived households** flooded to a **depth greater than 0.03m** • Approximately **8 non deprived households** with basements are identified to be at risk of flooding to a **depth greater than 0.03m** • There are no deprived households identified as being at risk within the CDA	No properties are identified as being at risk of flooding to a depth greater than 0.5m
Critical Infrastructure	Electricity substation within LFRZ and adjacent to Duke of Northumberland River at Gladstone Avenue. A316 Chertsey Road, TFL Red Route	
Validation	Flooding reported on Whitton Road following July 2007 flood event. This was documented in the Richmond Scrutiny Report following this flood event.	
Assumptions / Comments	The 1417 households reflects the wide scale shallow flooding experienced across the CDA.	
Figures	Figure 3.8.1a – Surface Water Depth (1% AEP) Figure 3.8.1b – Surface Water Flood Hazard (1% AEP)	

THIS DRAWING MAY BE USED ONLY FOR THE PURPOSE INTENDED

NORTH

Borough Administrative Boundary
Critical Drainage Area
Permanent Water Body
Main River
Ordinary Watercourse
Culverted Watercourse

Flood Depth

<0.1m
0.1m to 0.25m
0.25m to 0.5m
0.5m to 1.0m
1.0m to 1.5m
>1.5m

Notes

1. This map only shows the predicted likelihood of surface water flooding (this includes flooding from sewers, drains, small watercourses and ditches that occurs in heavy rainfall) for defined areas, and due to the coarse nature of the source data used, are not detailed enough to account for precise addresses.
2. Users of this map should refer to section 3.2 of the Surface Water Management Plan for a complete description of limitations and accuracy of the flood/hazard extents shown.
3. This map provides a strategic overview of surface water flood risk and may be subject to further analysis in the future.

London Borough of Richmond upon Thames

LONDON BOROUGH OF RICHMOND UPON THAMES

Surface Water Management Plan

Scale at A3	Date	Drawn by	Approved by
1:7,500	20/07/11	A.HARRIS	J.ROBINSON

Group8_001 (Twickenham)
Surface Water Depth (m)
1 in 100 Chance of rainfall event occuring in any given year (1% AEP)

Consultants
CAPITA SYMONDS Flood Risk Management
Scott Wilson
URS / Scott Wilson
6 - 8 Greencoat Place
London
SW1P 1PL

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FIGURE 3.8.1a

0 125 250m

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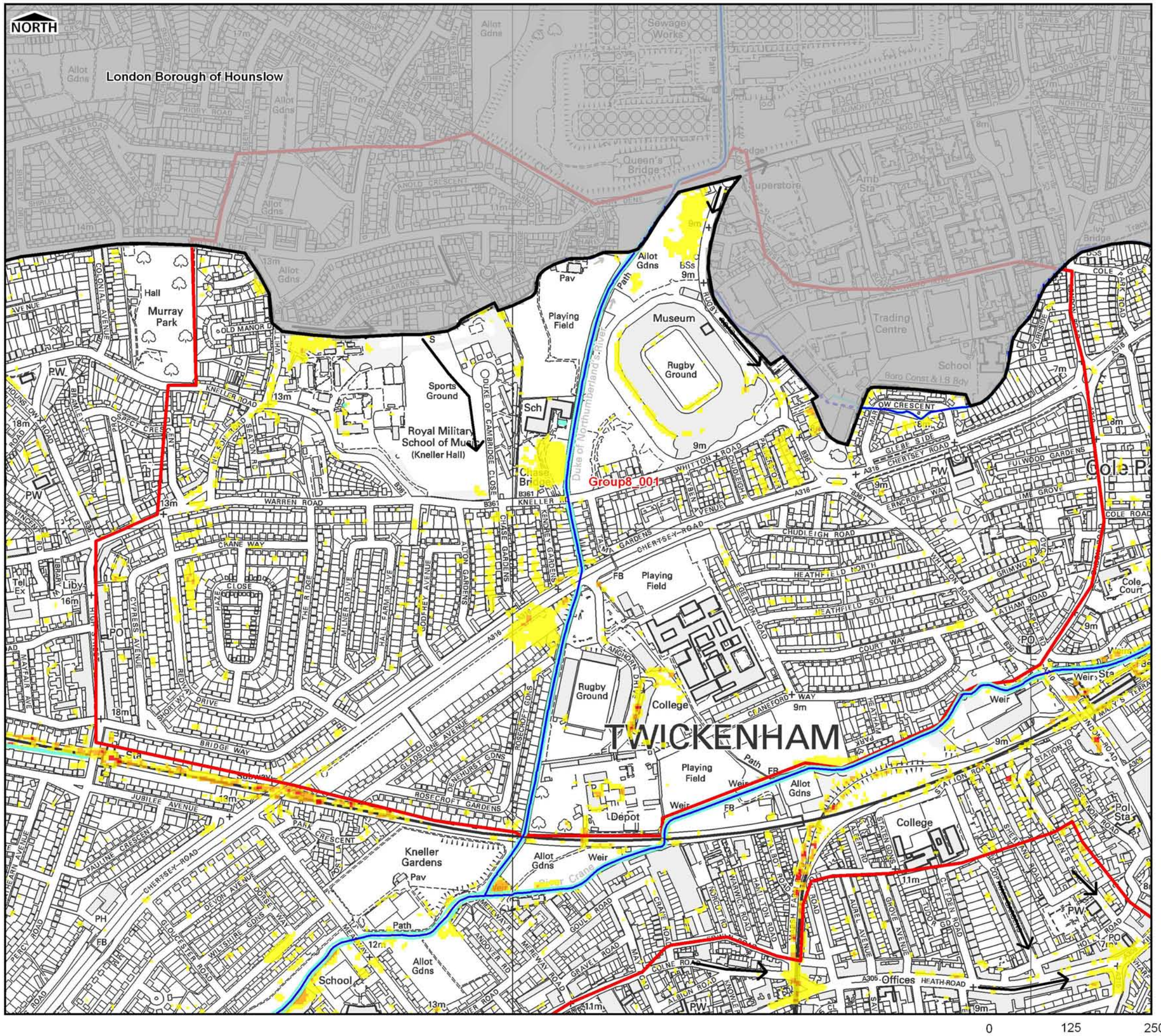

- Borough Administrative Boundary
- Critical Drainage Area
- Permanent Water Body
- Main River
- Ordinary Watercourse
- Culverted Watercourse

Flood Hazard

- <0.75 Caution (Very low hazard)
- 0.75 - 1.25 Moderate (Danger for some)
- 1.25 - 2.0 Significant (Danger for most)
- <2.0 Extreme (Danger for all)

→ Flow Direction Arrows

Notes

1. Flood Hazard has been defined based upon the joint EA and Defra R&D Technical Report FD2320 (January 2006).
2. Degree of flood hazard can be interpreted as follows:
- Caution: Flood zone with shallow flowing water or deep standing water
- Moderate: Flood zone with deep or fast flowing water. Dangerous for children, the elderly and the infirm
- Significant: Flood zone with deep fast flowing water. Dangerous for most people.
- Extreme: Flood zone with deep fast flowing water. Dangerous for all (including emergency services)
3. This map provides a strategic overview of surface water flood risk and may be subject to further analysis in the future.

London Borough of Richmond upon Thames

LONDON BOROUGH OF RICHMOND UPON THAMES

Surface Water Management Plan

Scale at A3	Date	Drawn by	Approved by
1:7,500	20/07/11	A.HARRIS	J.ROBINSON

Group8_001 (Twickenham)
Surface Water Flood Hazard Rating
1 in 100 Chance of rainfall event occuring in any given year (1% AEP)

Consultants
CAPITA SYMONDS Flood Risk Management
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London
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FIGURE 3.8.1b

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GROUP 8 CDA_002 ST MARGARETS

3.8.10 This CDA is located in the centre of the Borough within the natural floodplain of the River Thames. Pluvial modelling has identified a number of areas across the area where pooling of water to depths of less than 0.4m in the 1% AEP event may be experienced. This is to be expected as the generally level topography means that rainfall pools where it falls rather than quickly flowing away.

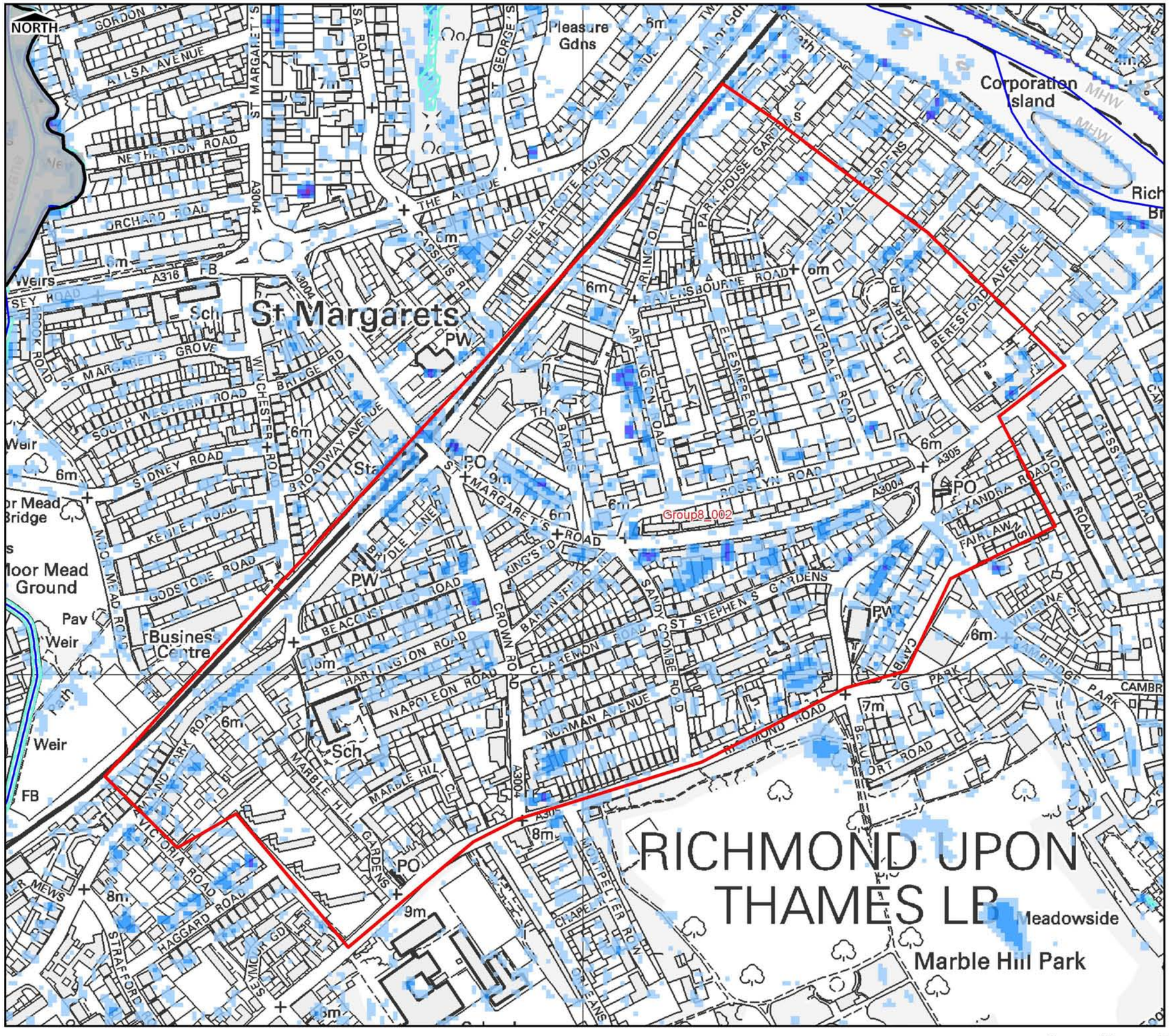
3.8.11 The Council have records of flooding at three locations within this CDA in July 2007, being Arlington Road, Beaconsfield Road and Amyand Road; records do not contain details of the type of flooding experienced, however, with reference to Figure 3-4 below, it is anticipated that flooding was caused through blockage, insufficient capacity or surcharging of the local surface water drainage infrastructure.

Figure 3-4 Flash Floods receding at Amyand Park Road, 14:45, 20th July 2007
Source Baylis Mews, extracted from the London Borough of Richmond 2007 Scrutiny Report

3.8.12 CDA_002 is located within an area identified to be at increased potential for elevated groundwater (iPEG) (Figure 3.5.1, Section 3.2) however, the EA have only provided one record of groundwater flooding within this area. The post code area TW1 2 covering St Margaret's has no recorded incidents of sewer flooding, however to the north and west, there are 1-5 sewer flood records on the Thames Water DG5 register.

Summary Table – CDA 002 St Margaret's		
LLFA	London Borough of Richmond upon Thames	
Flood Risk Categorisation:	Surface water, groundwater, sewer	
Property Count 1% AEP	• Approximately **927 non deprived households** flooded to a **depth greater than 0.03m** • Approximately **174 non deprived households** with basements are identified to be at risk of flooding to a **depth greater than 0.03m** There are no deprived households identified as being at risk within the CDA	No properties are identified as being at risk of flooding to a depth greater than 0.5m
Critical Infrastructure	No critical infrastructure identified.	
Validation	Records of flooding at Arlington Road, Beaconsfield Road and Amyand Park Road in July 2007. No details of these flood events available. One record of	

Summary Table – CDA 002 St Margaret's	
	groundwater flooding provided by the EA.
Assumptions / Comments	Flooding to a shallow depth is widespread across this CDA due to the flat topography
Figures	Figure 3.8.2a – Surface Water Depth (1% AEP) Figure 3.8.2b – Surface Water Flood Hazard (1% AEP)



THIS DRAWING MAY BE USED ONLY FOR THE PURPOSE INTENDED

- Borough Administrative Boundary
- Critical Drainage Area
- Permanent Water Body
- Main River
- Ordinary Watercourse
- Culverted Watercourse

Flood Depth

- <0.1m
- 0.1m to 0.25m
- 0.25m to 0.5m
- 0.5m to 1.0m
- 1.0m to 1.5m
- >1.5m

Notes

1. This map only shows the predicted likelihood of surface water flooding (this includes flooding from sewers, drains, small watercourses and ditches that occurs in heavy rainfall) for defined areas, and due to the coarse nature of the source data used, are not detailed enough to account for precise addresses.
2. Users of this map should refer to section 3.2 of the Surface Water Management Plan for a complete description of limitations and accuracy of the flood/hazard extents shown.
3. This map provides a strategic overview of surface water flood risk and may be subject to further analysis in the future.

London Borough of Richmond upon Thames

LONDON BOROUGH OF RICHMOND UPON THAMES

Surface Water Management Plan

Scale at A3	Date	Drawn by	Approved by
1:4,500	20/07/11	A.HARRIS	J.ROBINSON

Group8_002 (St Margarets)
Surface Water Depth (m)
1 in 100 Chance of rainfall event occuring in any given year (1% AEP)

Consultants
CAPITA SYMONDS Flood Risk Management
Scott Wilson
URS / Scott Wilson
6 - 8 Greencoat Place
London
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FIGURE 3.8.2a

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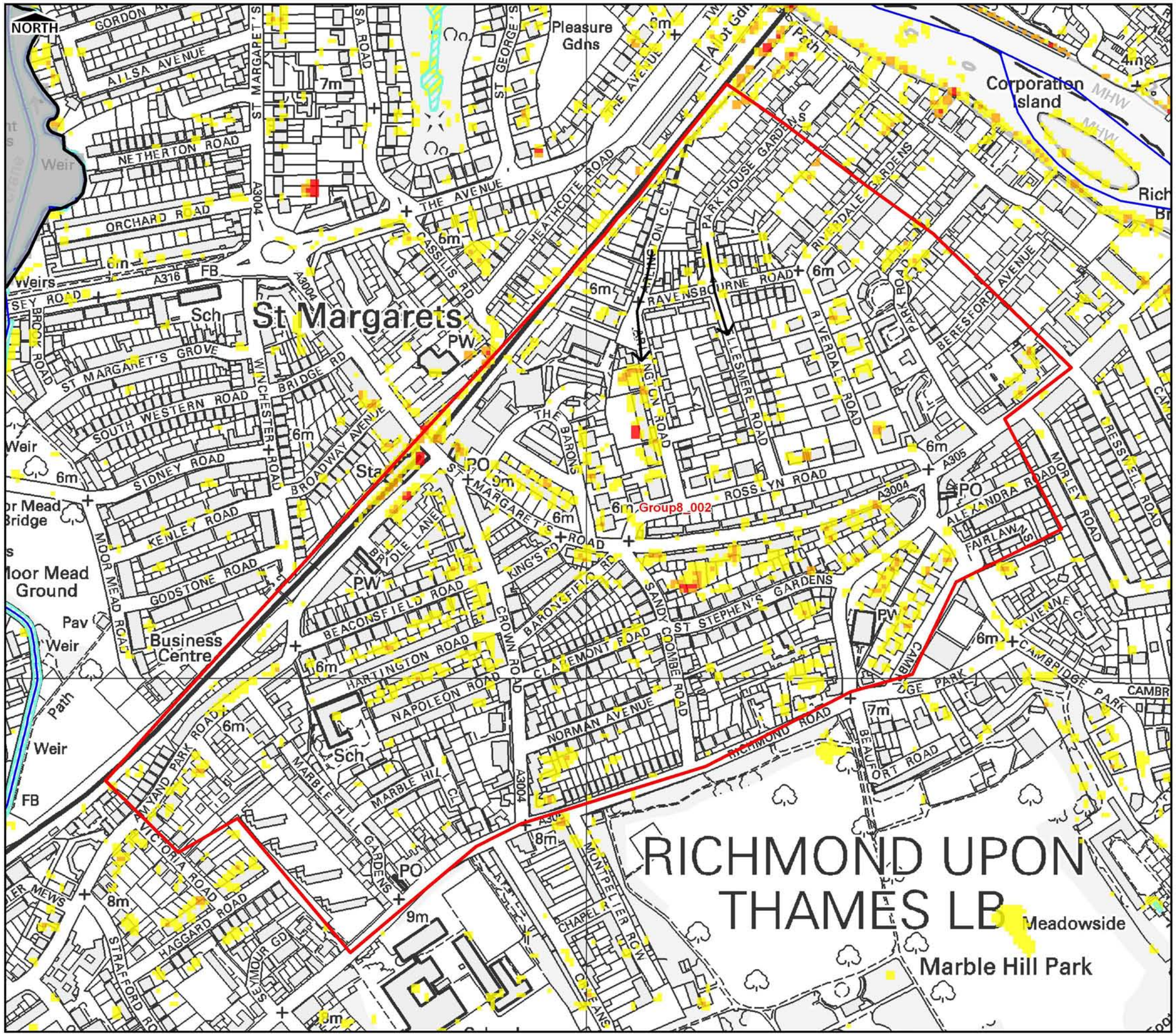

THIS DRAWING MAY BE USED ONLY FOR THE PURPOSE INTENDED

- Borough Administrative Boundary
- Critical Drainage Area
- Permanent Water Body
- Main River
- Ordinary Watercourse
- Culverted Watercourse

Flood Hazard

- <0.75 Caution (Very low hazard)
- 0.75 - 1.25 Moderate (Danger for some)
- 1.25 - 2.0 Significant (Danger for most)
- <2.0 Extreme (Danger for all)

→ Flow Direction Arrows

Notes

1. Flood Hazard has been defined based upon the joint EA and Defra R&D Technical Report FD2320 (January 2006).
2. Degree of flood hazard can be interpreted as follows:
- Caution: Flood zone with shallow flowing water or deep standing water
- Moderate: Flood zone with deep or fast flowing water. Dangerous for children, the elderly and the infirm
- Significant: Flood zone with deep fast flowing water. Dangerous for most people.
- Extreme: Flood zone with deep fast flowing water. Dangerous for all (including emergency services)
3. This map provides a strategic overview of surface water flood risk and may be subject to further analysis in the future.

London Borough of Richmond upon Thames

LONDON BOROUGH OF RICHMOND UPON THAMES

Surface Water Management Plan

Scale at A3	Date	Drawn by	Approved by
1:7,500	20/07/11	A.HARRIS	J.ROBINSON

Group8_002 (St Margarets)
Surface Water Flood Hazard Rating
1 in 100 Chance of rainfall event occuring in any given year (1% AEP)

Consultants
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SW1P 1PL

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FIGURE 3.8.2b

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GROUP 8 CDA_003 STRAWBERRY HILL

3.8.13 The Strawberry Hill CDA is located between Twickenham and Teddington in western Richmond upon Thames. Its catchment includes the large open areas of Fulwell Golf Course; the River Crane is located to the north and the River Thames to the east.

3.8.14 Pluvial modelling identifies two LFRZs within this CDA being at Heath Road and the junction of King Street and Heath Road. Surface water is flowing in an easterly direction towards the River Thames and pools at low points in the highway including the rail crossing at Heath Road (Figure 3-5 below). Flooding identified by pluvial modelling has been verified using Council records from July 2007, however, details of the flood source and exact location are not available. Further discussions with the Council have suggested that flooding at Heath Road rail crossing may occur as frequently as four times a year (in the last two years).

Figure 3-5 Heath Road, July 2007

© By Burnzy. Source Flickr accessed April 2011 www.flickr.com

3.8.15 Approximately one third of this CDA is identified as Flood Zone 2, being at residual risk of fluvial flooding should the River Thames flood defences fail. There is an elevated potential of surcharging of surface water sewers at this location due to the risk of tide locked drainage networks. The Council have records of flooding within this CDA due to the failure of a pumping station which is used to pump surface water from the Thames Water network into the River Thames.

3.8.16 The centre of this CDA in the vicinity of Strawberry Hill Golf Club is identified as being at increased potential for elevated groundwater (iPEG) (Figure 3.5.1, Section 3.2). The majority of the CDA is not identified by Thames Water DG5 records as having experienced flooding, however the east of the CDA (postcode area TW1 4) is located within an area with 1-5 sewer flooding records.

3.8.17 The first edition SWMP (JBA 2009) contained an inspection of flow paths and culvert capacity within the Fulwell and Strawberry Hill Golf Courses (images of local channels and culverts included in Figure 3-6 below). This modelling identified the railway line as a major flow path especially in the railway junction at Strawberry Hill golf course. The report concluded that there was a risk that if this flow path were to become blocked, surface water could accumulate within the Fulwell Golf Course and potentially flood Twickenham Bus Garage and adjacent industrial area.

3.8.18 Pluvial modelling completed as part of the Drain London study again shows the potential for the railway line to act as a flow path, however, the extent of flooding was not as great as the

Jacobs modelling due to variations between modelling techniques used.

Railway Line looking north from Stanley Road

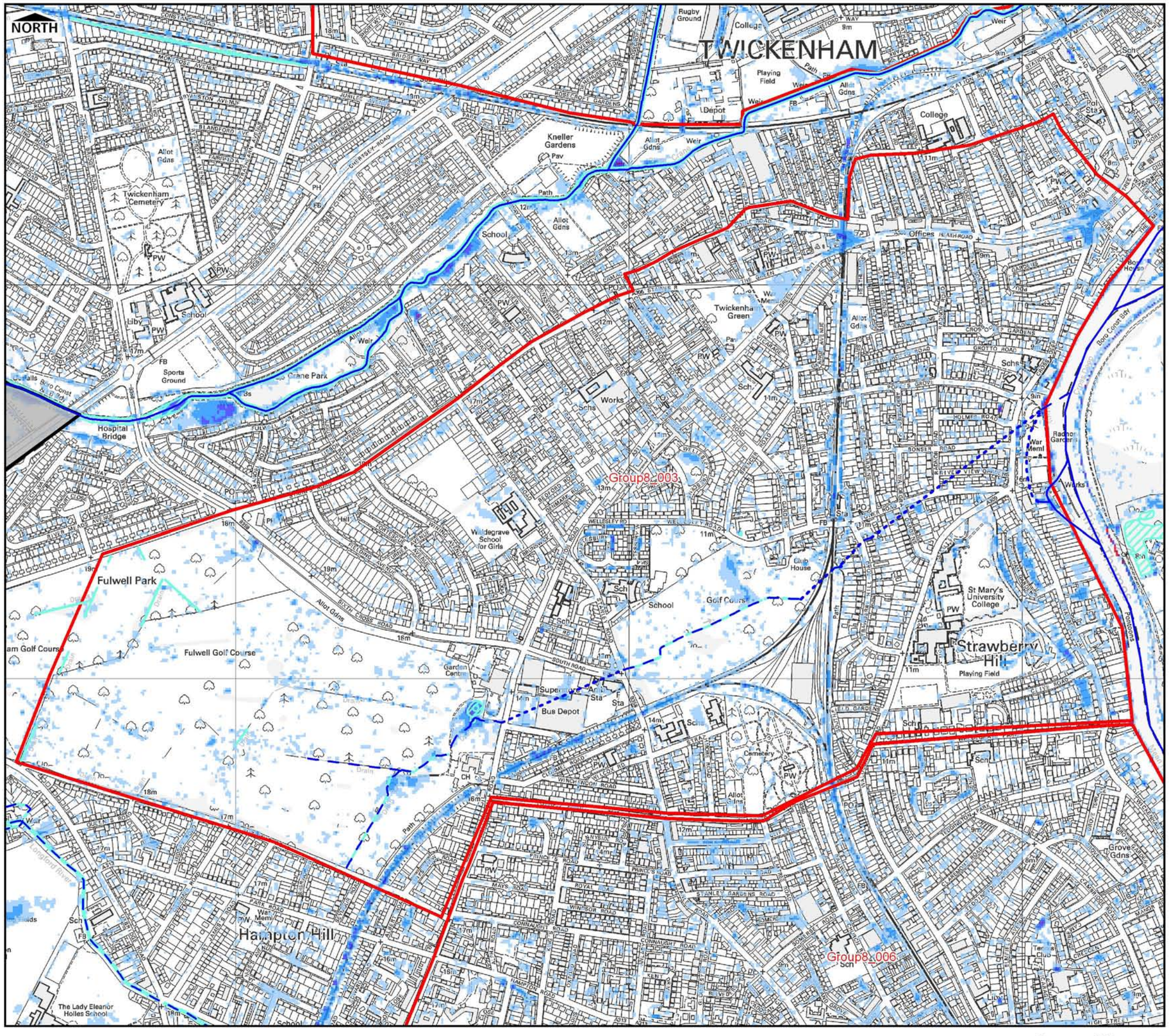
Open channel section in garden on Strawberry Hill Road

Pond in Fulwell Golf Course

Open channel in Fulwell Golf Course

Figure 3-6 Local Channels and Culverts within CDA_003 *(Source First Edition SWMP, Jacobs 2009)*

Summary Table – CDA 003 Strawberry Hill		
LLFA	London Borough of Richmond upon Thames	
Flood Risk Categorisation:	Surface Water, sewer flooding, while there is a risk of elevated groundwater, there are no records of groundwater flooding within the CDA	
Property Count 1% AEP	• Approximately **1967 non deprived households** predicted to flood to a **depth greater than 0.03m** • Approximately **56 non deprived households** with basements are predicted to be at risk of flooding to a **depth greater than 0.03m** There are no deprived households identified as being at risk within the CDA	1 Non deprived property is identified as being at risk of flooding to a depth greater than 0.5m 1 non deprived basement property is identified as being at risk of flooding to a depth greater than 0.5m.
Critical Infrastructure	Railway infrastructure (main line to London Waterloo), 1 fire station, 1 ambulance station	
Validation	Records of localised flooding at Heath Road. Council staff are aware of this issue which occurs regularly (every few years)	
Figures	Figure 3.8.3a – Surface Water Depth (1% AEP) Figure 3.8.3b – Surface Water Flood Hazard (1% AEP)	



THIS DRAWING MAY BE USED ONLY FOR THE PURPOSE INTENDED

- Borough Administrative Boundary
- Critical Drainage Area
- Permanent Water Body
- Main River
- Ordinary Watercourse
- Culverted Watercourse

Flood Depth

- <0.1m
- 0.1m to 0.25m
- 0.25m to 0.5m
- 0.5m to 1.0m
- 1.0m to 1.5m
- >1.5m

Notes

1. This map only shows the predicted likelihood of surface water flooding (this includes flooding from sewers, drains, small watercourses and ditches that occurs in heavy rainfall) for defined areas, and due to the coarse nature of the source data used, are not detailed enough to account for precise addresses.
2. Users of this map should refer to section 3.2 of the Surface Water Management Plan for a complete description of limitations and accuracy of the flood/hazard extents shown.
3. This map provides a strategic overview of surface water flood risk and may be subject to further analysis in the future.

London Borough of Richmond upon Thames

LONDON BOROUGH OF RICHMOND UPON THAMES

Surface Water Management Plan

Scale at A3	Date	Drawn by	Approved by
1:10,000	20/07/11	A.HARRIS	J.ROBINSON

Group8_003 (Strawberry Hill)
Surface Water Depth (m)
1 in 100 Chance of rainfall event occuring in any given year (1% AEP)

Consultants
CAPITA SYMONDS
Flood Risk Management
Scott Wilson
URS / Scott Wilson
6 - 8 Greencoat Place
London
SW1P 1PL

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FIGURE 3.8.3a

Filepath: N:\Current Projects\D134785 D134786 DRAIN LONDON Tier 2\02 Group 8 (D134786)\05 GIS

NORTH

TWICKENHAM

Group8_003

Group8_006

Fulwell Park

Fulwell Golf Course

Hampton Hill

Strawberry Hill

0 125 250m

- Borough Administrative Boundary
- Critical Drainage Area
- Permanent Water Body
- Main River
- Ordinary Watercourse
- Culverted Watercourse

Flood Hazard

- <0.75 Caution (Very low hazard)
- 0.75 - 1.25 Moderate (Danger for some)
- 1.25 - 2.0 Significant (Danger for most)
- <2.0 Extreme (Danger for all)

→ Flow Direction Arrows

Notes

1. Flood Hazard has been defined based upon the joint EA and Defra R&D Technical Report FD2320 (January 2006).
2. Degree of flood hazard can be interpreted as follows:
- Caution: Flood zone with shallow flowing water or deep standing water
- Moderate: Flood zone with deep or fast flowing water. Dangerous for children, the elderly and the infirm
- Significant: Flood zone with deep fast flowing water. Dangerous for most people.
- Extreme: Flood zone with deep fast flowing water. Dangerous for all (including emergency services)
3. This map provides a strategic overview of surface water flood risk and may be subject to further analysis in the future.

London Borough of Richmond upon Thames

LONDON BOROUGH OF RICHMOND UPON THAMES

Surface Water Management Plan

Scale at A3	Date	Drawn by	Approved by
1:10,000	20/07/11	A.HARRIS	J.ROBINSON

Group8_003 (Strawberry Hill)
Surface Water Flood Hazard Rating
1 in 100 Chance of rainfall event occuring in any given year (1% AEP)

Consultants
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URS / Scott Wilson
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London
SW1P 1PL

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FIGURE 3.8.3b

Filepath: N:\Current Projects\D134785 D134786 DRAIN LONDON Tier 2\02 Group 8 (D134786)\05 GIS

GROUP 8 CDA_004 RICHMOND AND MORTLAKE

3.8.19 The Richmond and Mortlake CDA is located to the north east of the Borough. Pluvial modelling has identified that within this CDA, overland flow from Richmond Park creates natural flow paths travelling in a northerly direction to pool behind the rail embankment which dissects the CDA in an east-west direction. The largest LFRZ is located at the Manor Road superstore which is enclosed between rail embankments. There is some steep topography in this CDA associated with Richmond Hill and there may be potential for basement flooding on roads including Church Road dependant on property threshold levels.

3.8.20 Pluvial modelling has identified the rail network as being at risk of surface water flooding, with the greatest depths identified at Richmond station and the rail crossing of Lower Mortlake Road. However, Network Rail does not have either location identified on their areas prone to flooding maps and it is assumed that they have no records of flooding at these locations. London underground does not have records of the District Line experiencing flooding within the Borough.

3.8.21 This CDA extends to the east into Mortlake. 25% of the CDA is located within Flood Zone 2 being at residual flood risk should the River Thames flood defences fail. Pluvial modelling results identify a LFRZ in a topographical low spot to the west of Mortlake Station. Local records have identified Mortlake, High Street and Worple Street, as experiencing flooding in July 2007 as well as the Upper Richmond Road. However, there are no further details available for the type or duration of flood event.

3.8.22 This CDA is identified as being at increased potential for elevated groundwater (iPEG) (Figure 3.5.1, Section 3.2) and the Environment Agency have provided four records of groundwater flooding, one to the north of Richmond Town Centre and three in East Sheen.

3.8.23 This CDA crosses four post code boundaries in which sewer flooding incidents have been recorded as follows:

Richmond Hill	TW106	1-5 incidents
Richmond Station	TW9 1	6-10 incidents
East Sheen	SW147	6-10 incidents
Mortlake	SW148	11-20 incidents

Summary Table – CDA 004 Richmond and Mortlake		
LLFA	London Borough of Richmond upon Thames	
Flood Risk Categorisation:	Surface Water, groundwater, sewer flooding	
Property Count 1% AEP	• Approximately **5566 non deprived households** predicted to flood to a **depth greater than 0.03m** • Approximately **664 non deprived households** with basements are predicted to be at risk of flooding to a **depth greater than 0.03m** There are no deprived households identified as being at risk within the CDA	• Approximately **34 Non deprived** property is identified as being at risk of flooding to a depth greater than 0.5m • Approximately **5 non deprived basement** properties are identified as being at risk of flooding to a depth greater than 0.5m.
Critical	Main line to London Waterloo railway infrastructure	

Infrastructure	London Underground District Line (above ground within this borough) 5 electricity substations 1 fire/ ambulance station A316 TFL Red Route Lower Mortlake Road A205 TFL Red Route Upper Richmond Road
Validation	Records of flooding at Worple Street and Richmond Road in July 2007 although there is little information available on these flood records
Assumptions / Comments	This is a large CDA, the higher property count reflects the larger CDA area
Figures	Figure 3.8.4a – Surface Water Depth (1% AEP) Figure 3.8.4b – Surface Water Flood Hazard (1% AEP)

NORTH

Group8_004

Group8_005

RICHMOND

North Sheen

Mortlake

East Sheen

Richmond Park
Deer Park

Golf Course

Petersham Common

East Sheen Common

The Bog

Teck Plantation

Two Storm Wood

Saw Pit Plantation

Sheen Cross Wood

Duke's Meadow

0 250 500m

- Borough Administrative Boundary
- Critical Drainage Area
- Permanent Water Body
- Main River
- Ordinary Watercourse
- Culverted Watercourse

Flood Depth

- <0.1m
- 0.1m to 0.25m
- 0.25m to 0.5m
- 0.5m to 1.0m
- 1.0m to 1.5m
- >1.5m

Notes

1. This map only shows the predicted likelihood of surface water flooding (this includes flooding from sewers, drains, small watercourses and ditches that occurs in heavy rainfall) for defined areas, and due to the coarse nature of the source data used, are not detailed enough to account for precise addresses.
2. Users of this map should refer to section 3.2 of the Surface Water Management Plan for a complete description of limitations and accuracy of the flood/hazard extents shown.
3. This map provides a strategic overview of surface water flood risk and may be subject to further analysis in the future.

London Borough of Richmond upon Thames

LONDON BOROUGH OF RICHMOND UPON THAMES

Surface Water Management Plan

Scale at A3	Date	Drawn by	Approved by
1:13,500	20/07/11	A.HARRIS	J.ROBINSON

Gp8_004 Richmond Town Centre & Mortlake
Surface Water Depth (m)
1 in 100 Chance of rainfall event occuring in any given year (1% AEP)

Consultants
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London
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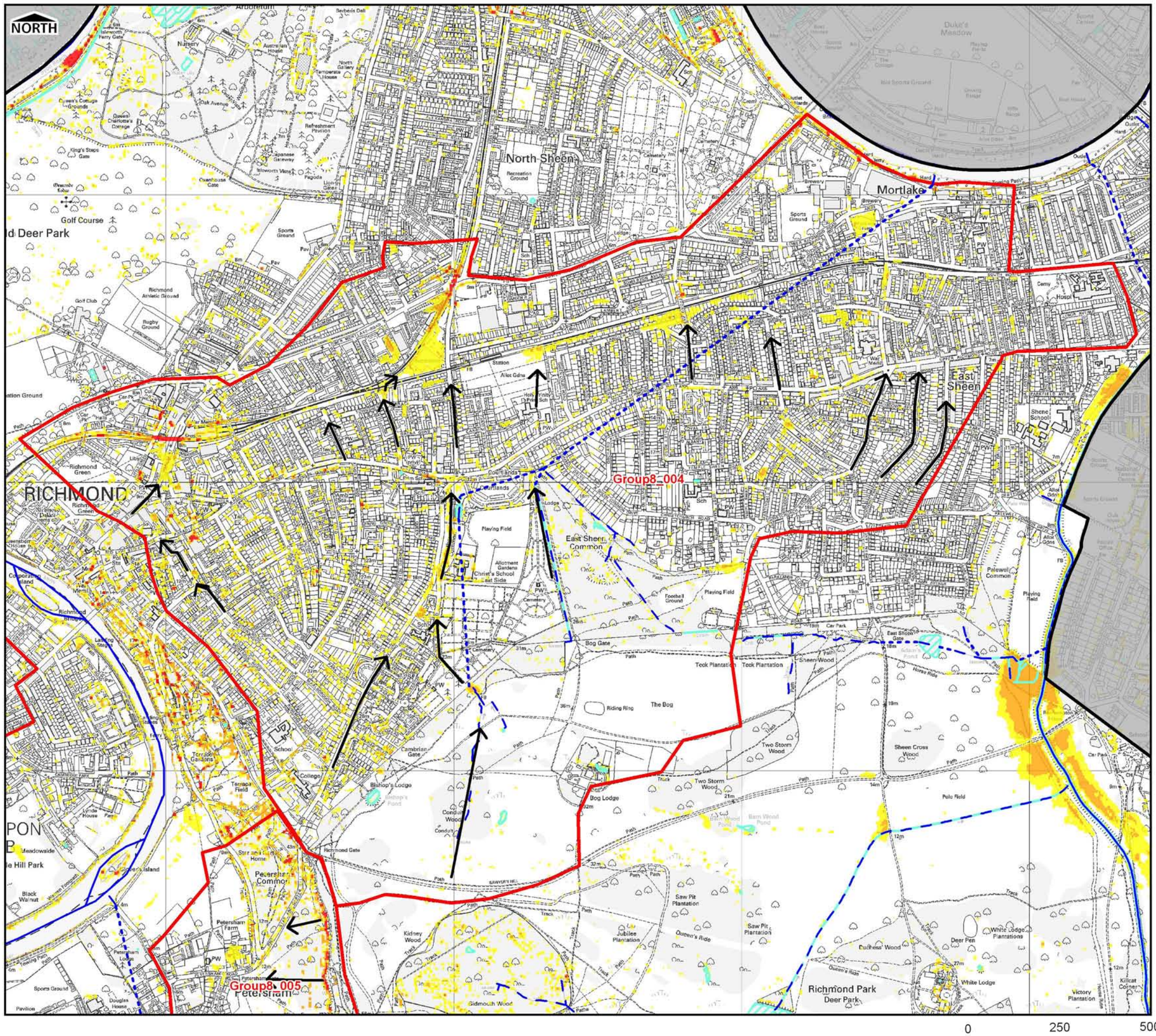
FIGURE 3.8.4a



Borough Administrative Boundary

Critical Drainage Area

Permanent Water Body

Main River

Ordinary Watercourse

Culverted Watercourse

Flood Hazard

- <0.75 Caution (Very low hazard)
- 0.75 - 1.25 Moderate (Danger for some)
- 1.25 - 2.0 Significant (Danger for most)
- <2.0 Extreme (Danger for all)

Flow Direction Arrows

Notes

1. Flood Hazard has been defined based upon the joint EA and Defra R&D Technical Report FD2320 (January 2006).
2. Degree of flood hazard can be interpreted as follows:
- Caution: Flood zone with shallow flowing water or deep standing water
- Moderate: Flood zone with deep or fast flowing water. Dangerous for children, the elderly and the infirm
- Significant: Flood zone with deep fast flowing water. Dangerous for most people.
- Extreme: Flood zone with deep fast flowing water. Dangerous for all (including emergency services)
3. This map provides a strategic overview of surface water flood risk and may be subject to further analysis in the future.

London Borough of Richmond upon Thames

LONDON BOROUGH OF RICHMOND UPON THAMES

Surface Water Management Plan

Scale at A3	Date	Drawn by	Approved by
1:13,500	20/07/11	A.HARRIS	J.ROBINSON

Gp8_004 Richmond Town Centre & Mortlake Surface Water Flood Hazard Rating 1 in 100 Chance of rainfall event occuring in any given year (1% AEP)

Consultants
CAPITA SYMONDS Flood Risk Management
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URS / Scott Wilson
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London
SW1P 1PL

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FIGURE 3.8.4b

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GROUP 8 CDA_005 PETERSHAM

3.8.24 The Council do not have any formal records of flooding in this location, however it is understood that local topography has led to flood incidents in the past in the Petersham Farm area. Pluvial modelling has identified that surface water from the common in the east flows onto the Petersham Road and where kerb heights allow; pools at the lowest point which is an area of residential property and associated car parking at Petersham Farm. There are some steep gradients in this CDA with an approximate fall of 15% from Petersham Common to Petersham Farm.

3.8.25 Petersham is not identified on the Thames Water DG5 register however, it is located within an area identified as having an increased potential for elevated groundwater. The Environment Agency does not have any records of groundwater flooding at this location.

Summary Table – CDA 005 Petersham		
LLFA	London Borough of Richmond upon Thames	
Flood Risk Categorisation:	Surface Water	
Property Count 1% AEP	• Approximately **55 non deprived households** predicted to flood to a **depth greater than 0.03m** • Approximately **1 non deprived households** with basements are predicted to be at risk of flooding to a **depth greater than 0.03m** There are no deprived households identified as being at risk within the CDA	No properties are identified as being at risk of flooding to a depth greater than 0.5m
Critical Infrastructure	None	
Validation	The Council are aware that there have been flooding issues within this CDA in the past although this area was not included on the July 2007 list of flooded property.	
Assumptions / Comments	Flooding within this CDA is relatively confined	
Figures	Figure 3.8.5a – Surface Water Depth (1% AEP) Figure 3.8.5b – Surface Water Flood Hazard (1% AEP)	

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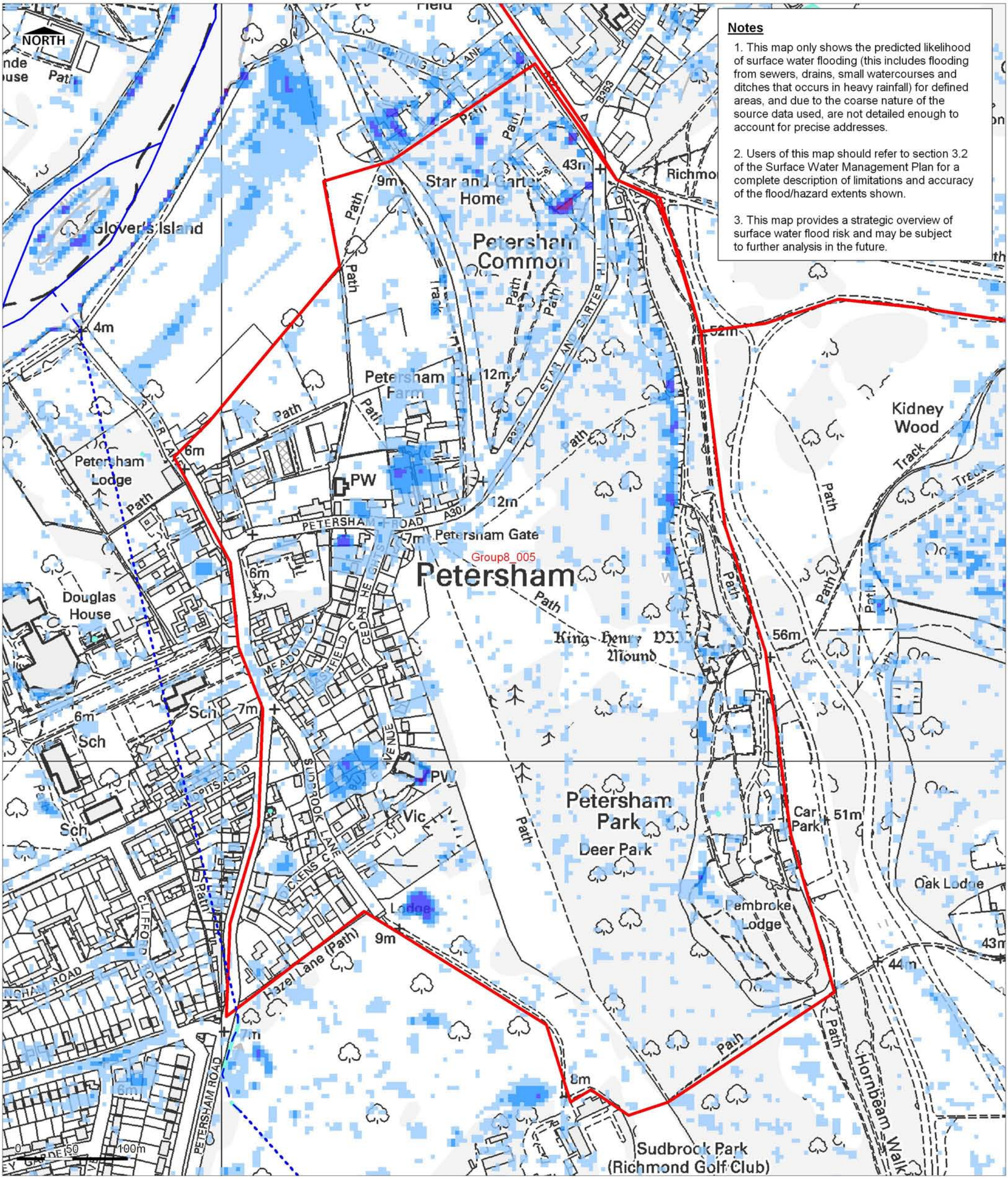

Notes

1. This map only shows the predicted likelihood of surface water flooding (this includes flooding from sewers, drains, small watercourses and ditches that occurs in heavy rainfall) for defined areas, and due to the coarse nature of the source data used, are not detailed enough to account for precise addresses.

2. Users of this map should refer to section 3.2 of the Surface Water Management Plan for a complete description of limitations and accuracy of the flood/hazard extents shown.

3. This map provides a strategic overview of surface water flood risk and may be subject to further analysis in the future.

THIS DRAWING MAY BE USED ONLY FOR THE PURPOSE INTENDED

Legend

- Borough Administrative Boundary
- Critical Drainage Area
- Permanent Water Bodies
- Main River
- Ordinary Watercourse
- Culverted Watercourse

Flood Depth

- <0.1m
- 0.1m to 0.25m
- 0.25m to 0.5m
- 0.5m to 1.0m
- 1.0m to 1.5m
- >1.5m

London Borough of Richmond upon Thames

LONDON BOROUGH OF RICHMOND UPON THAMES

Surface Water Management Plan

Group8_005 (Petersham)
Surface Water Depth (m)
1 in 100 Chance of rainfall event occuring in any given year (1% AEP)

Consultants
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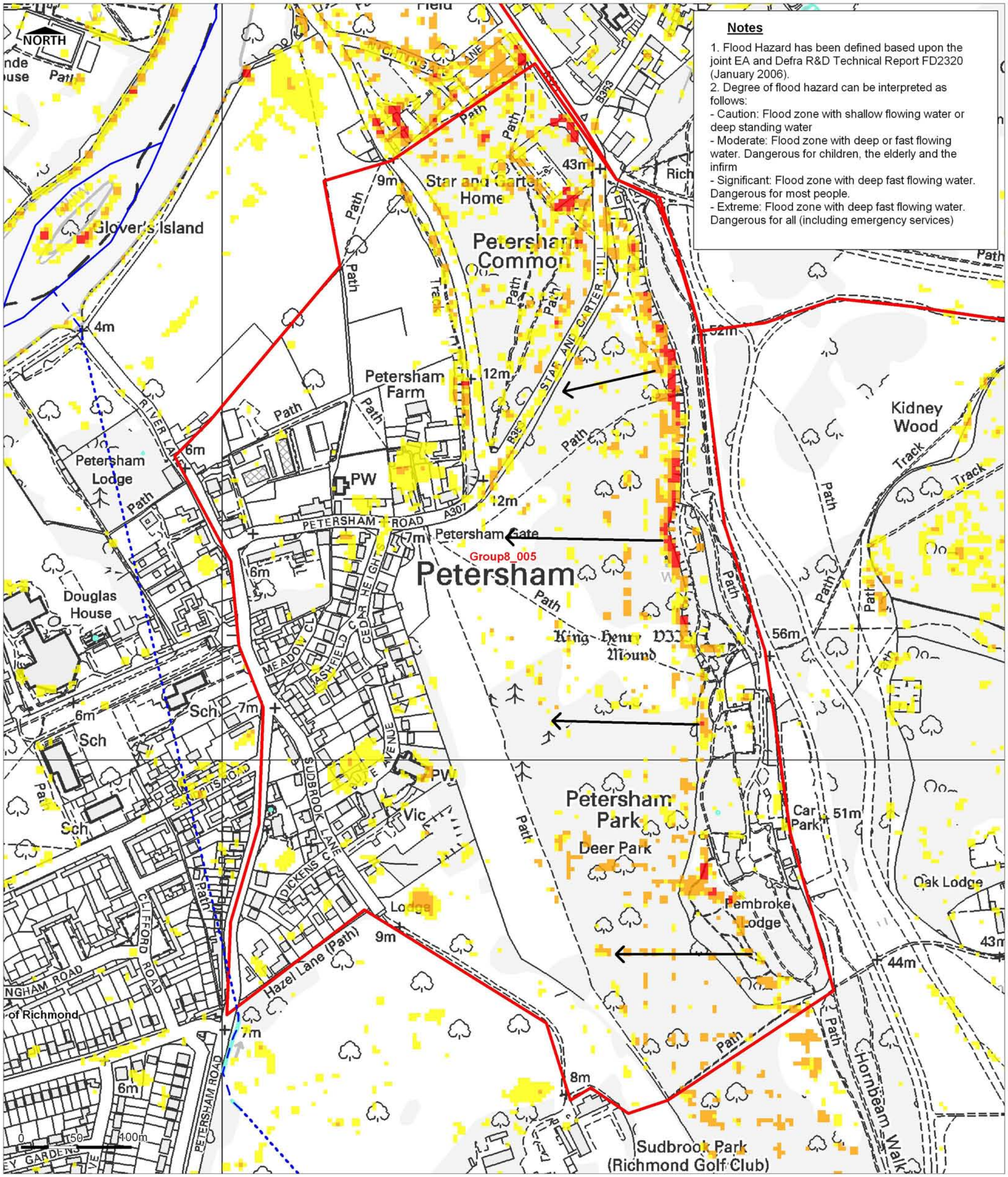
Scale at A3	Date	Drawn by	Approved by
1:4,500	20/07/11	A.HARRIS	J.ROBINSON

FIGURE 3.8.5a

Filepath: N:\Current Projects\D134785 D134786 DRAIN LONDON Tier 2\02 Group 8 (D134786)\05 GIS



THIS DRAWING MAY BE USED ONLY FOR THE PURPOSE INTENDED

Legend

- Borough Administrative Boundary
- Critical Drainage Area
- Permanent Water Bodies
- Main River
- Ordinary Watercourse
- Culverted Watercourse
- Flow Direction Arrows

Flood Hazard

- <0.75 Caution (Very low hazard)
- 0.75 - 1.25 Moderate (Danger for some)
- 1.25 - 2.0 Significant (Danger for most)
- <2.0 Extreme (Danger for all)

London Borough of Richmond upon Thames

LONDON BOROUGH OF RICHMOND UPON THAMES

Surface Water Management Plan

Scale at A3	Date	Drawn by	Approved by
1:4,500	20/07/11	A.HARRIS	J.ROBINSON

Group8_005 (Petersham)
Surface Water Flood Hazard Rating
1 in 100 Chance of rainfall event occuring in any given year (1% AEP)

Consultants
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FIGURE 3.8.5b

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GROUP 8 CDA _006 TEDDINGTON

3.8.26 Teddington is located in the west of the Borough, to the south of Twickenham and Strawberry Vale. The north east of the CDA is largely residential while the south west contains a large area of parkland (Bushy Park). The eastern extent of the CDA bounds the River Thames and is located partially within Flood Zone 2 and 3. In July 2007 the Council collected records of flooding at ten different locations within Teddington, some reported to contain raw sewage which would suggest surcharging of the local Thames Water network. The centre of Teddington (TW118) is recorded to have 6-10 instances of sewer flooding according to Thames Water records.

3.8.27 Pluvial modelling shows surface water from the northwest and Bushy Park pooling at topographical low spots on Broad Street and High Street. Anecdotal records from 2007 suggest that there was approximately a 300mm depth of water, sufficient to flood a number of shops. Where property was not flooded directly, wash from vehicles caused indirect flooding. Flood water took approximately an hour to drain away (from local residents comments).

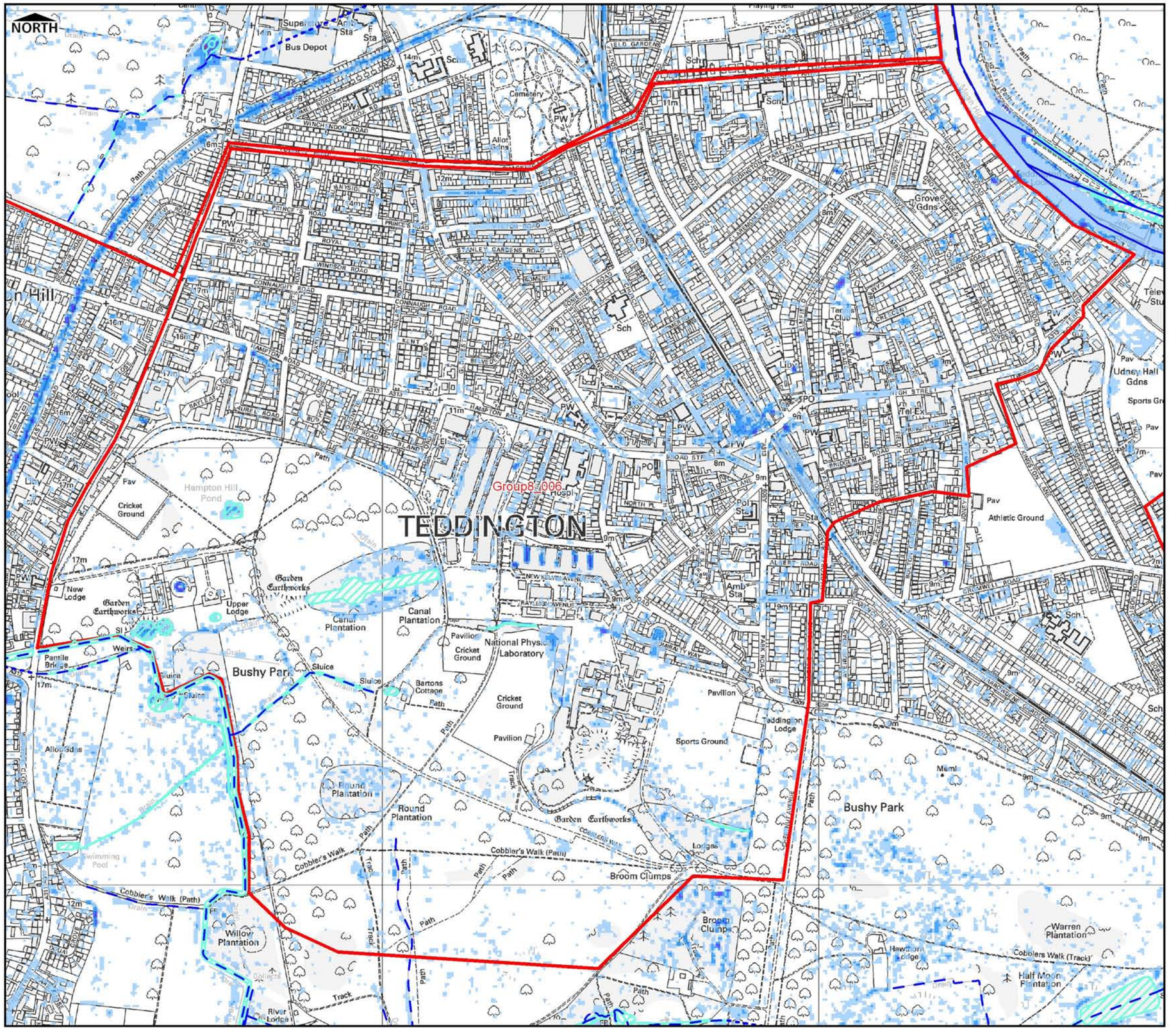
3.8.28 Reference to Figure 3.5.1 (Section 3.2) shows that Teddington is located in an area which has an increased potential for groundwater flooding (iPEG); however, the Environment Agency do not have any records of groundwater flooding within this CDA.

Figure 3-7 High Street, Teddington in July 2007

© by Waldopepper, via Flickr under the creative commons licence www.flickr.com

Summary Table – CDA 006 Teddington		
LLFA	London Borough of Richmond upon Thames	
Flood Risk Categorisation:	Surface Water, sewer	
Property Count 1% AEP	• Approximately **2076 non deprived households** predicted to flood to a **depth greater than 0.03m** • Approximately **147 non deprived households** with basements are predicted to be at risk of flooding to a **depth greater than 0.03m** There are no deprived households identified as being at risk within the CDA	No properties are identified as being at risk of flooding to a depth greater than 0.5m

Summary Table – CDA 006 Teddington	
Critical Infrastructure	Three electricity substations although they are not shown to be at risk of flooding, Teddington Memorial Hospital is located on the High Street, Main line rail infrastructure to London Waterloo.
Validation	Lower Teddington Road, Broad Street, Kingston Road and Thameside Place have records of flooding in July 2007 however there are no further details available.
Assumptions / Comments	When comparing the percentage of the CDA which is urbanised and the total CDA area, it is estimated that this CDA has the greatest surface water flood risk within Richmond upon Thames
Figures	Figure 3.8.6a – Surface Water Depth (1% AEP) Figure 3.8.6b – Surface Water Flood Hazard (1% AEP)



THIS DRAWING MAY BE USED ONLY FOR THE PURPOSE INTENDED

- Borough Administrative Boundary
- Critical Drainage Area
- Permanent Water Body
- Main River
- Ordinary Watercourse
- Culverted Watercourse

Flood Depth

- <0.1m
- 0.1m to 0.25m
- 0.25m to 0.5m
- 0.5m to 1.0m
- 1.0m to 1.5m
- >1.5m

Notes

1. This map only shows the predicted likelihood of surface water flooding (this includes flooding from sewers, drains, small watercourses and ditches that occurs in heavy rainfall) for defined areas, and due to the coarse nature of the source data used, are not detailed enough to account for precise addresses.
2. Users of this map should refer to section 3.2 of the Surface Water Management Plan for a complete description of limitations and accuracy of the flood/hazard extents shown.
3. This map provides a strategic overview of surface water flood risk and may be subject to further analysis in the future.

London Borough of Richmond upon Thames

LONDON BOROUGH OF RICHMOND UPON THAMES

Surface Water Management Plan

Scale at A3	Date	Drawn by	Approved by
1:9,000	20/07/11	A.HARRIS	J.ROBINSON

Group8_006 (Teddington)
Surface Water Depth (m)
1 in 100 Chance of rainfall event occuring in any given year (1% AEP)

Consultants
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FIGURE 3.8.6a

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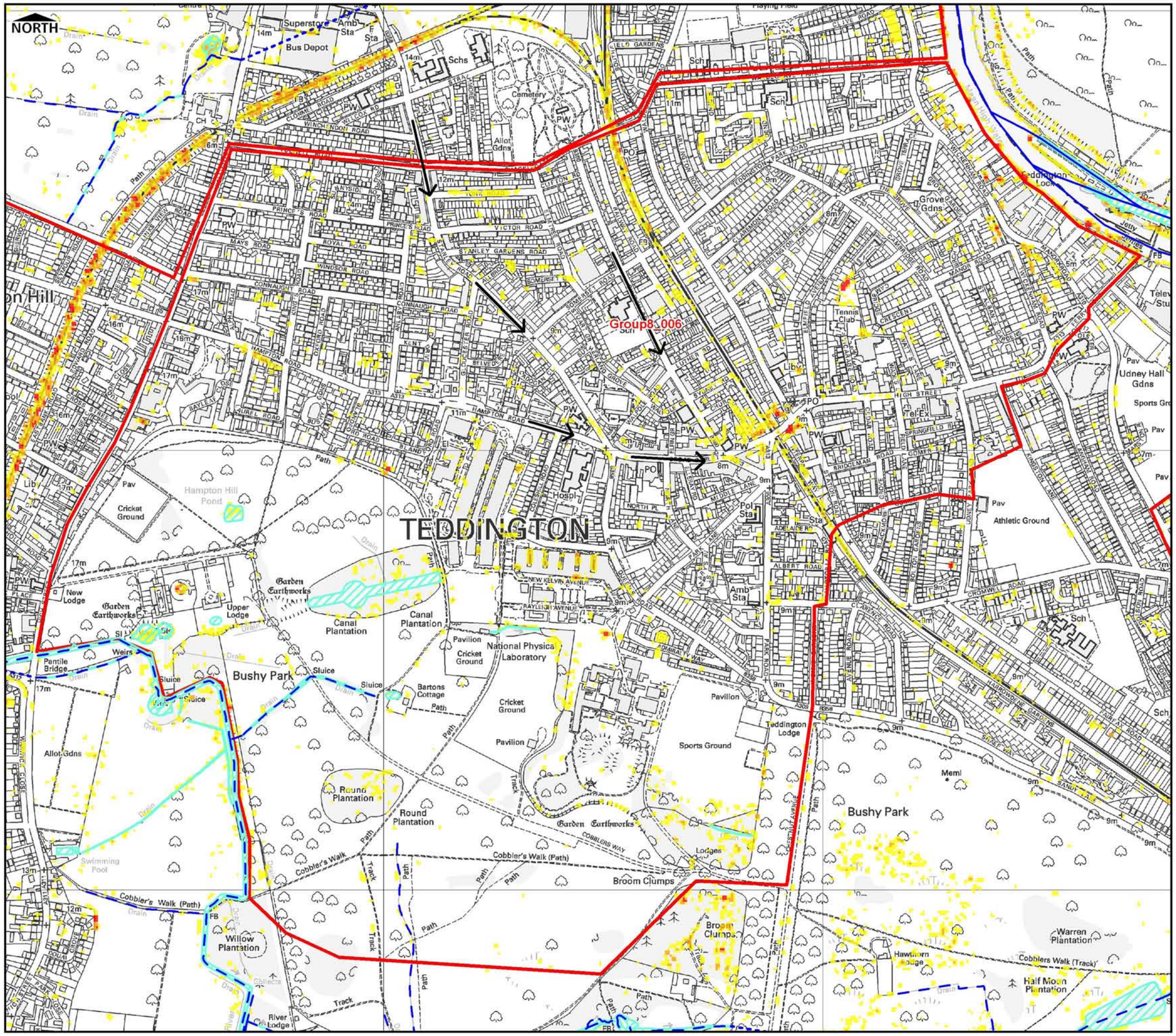

THIS DRAWING MAY BE USED ONLY FOR THE PURPOSE INTENDED

- Borough Administrative Boundary
- Critical Drainage Area
- Permanent Water Body
- Main River
- Ordinary Watercourse
- Culverted Watercourse

Flood Hazard

- <0.75 Caution (Very low hazard)
- 0.75 - 1.25 Moderate (Danger for some)
- 1.25 - 2.0 Significant (Danger for most)
- <2.0 Extreme (Danger for all)

→ Flow Direction Arrows

Notes

1. Flood Hazard has been defined based upon the joint EA and Defra R&D Technical Report FD2320 (January 2006).
2. Degree of flood hazard can be interpreted as follows:
- Caution: Flood zone with shallow flowing water or deep standing water
- Moderate: Flood zone with deep or fast flowing water. Dangerous for children, the elderly and the infirm
- Significant: Flood zone with deep fast flowing water. Dangerous for most people.
- Extreme: Flood zone with deep fast flowing water. Dangerous for all (including emergency services)
3. This map provides a strategic overview of surface water flood risk and may be subject to further analysis in the future.

London Borough of Richmond upon Thames

LONDON BOROUGH OF RICHMOND UPON THAMES

Surface Water Management Plan

Scale at A3	Date	Drawn by	Approved by
1:9,000	20/07/11	A.HARRIS	J.ROBINSON

Group8_006 (Teddington)
Surface Water Flood Hazard Rating
1 in 100 Chance of rainfall event occuring in any given year (1% AEP)

Consultants
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Scott Wilson
URS / Scott Wilson
6 - 8 Greencoat Place
London
SW1P 1PL

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FIGURE 3.8.6b

Filepath: N:\Current Projects\D134785 D134786 DRAIN LONDON Tier 2\02 Group 8 (D134786)\05 GIS

CDA_007 HAMPTON WICK

3.8.29 Hampton Wick is located in the south of the Borough on the west bank of the River Thames. Teddington is located to the north of this CDA and large areas of open land associated with Hampton Court are located to the south west. Gentle gradients associated with the River Thames floodplain are typical in this CDA and pluvial modelling has identified un-linked areas of pooling of water due to the lack of gravity fall. The Council has three records of flooding within this CDA being Kingston Road, Lower Teddington Road and Thameside Place, however there are no details available for the type of flooding experienced each time.

3.8.30 The CDA is not identified as being at increased risk of groundwater flooding (iPEG). However, the south of the CDA has 11-20 records of sewer flooding (DG5 register at KT1 4).

Summary Table – CDA 007 Hampton Wick		
LLFA	London Borough of Richmond upon Thames	
Flood Risk Categorisation:	Surface Water, sewer	
Property Count 1% AEP	• Approximately **9 non deprived households** predicted to flood to a **depth greater than 0.03m** • No non deprived households with basements are predicted to be at risk of flooding. • There are no deprived households identified as being at risk within the CDA	No properties are identified as being at risk of flooding to a depth greater than 0.5m
Critical Infrastructure	There is one substation within the CDA and one on the south western boundary. The London main line rail network to London Waterloo forms the southern CDA boundary.	
Validation	The Council has three records of flooding within this CDA in 2007 being Kingston Road, Lower Teddington Road and Thameside Place. Thames Water has 11-20 records of sewer flooding within the south of the CDA.	
Assumptions / Comments	Predicted flood risk in this CDA due to surface water sources is relatively small when compared to Teddington	
Figures	Figure 3.8.7a – Surface Water Depth (1% AEP) Figure 3.8.7b – Surface Water Flood Hazard (1% AEP)	

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Notes

1. This map only shows the predicted likelihood of surface water flooding (this includes flooding from sewers, drains, small watercourses and ditches that occurs in heavy rainfall) for defined areas, and due to the coarse nature of the source data used, are not detailed enough to account for precise addresses.

2. Users of this map should refer to section 3.2 of the Surface Water Management Plan for a complete description of limitations and accuracy of the flood/hazard extents shown.

3. This map provides a strategic overview of surface water flood risk and may be subject to further analysis in the future.

Legend

- Borough Administrative Boundary
- Critical Drainage Area
- Permanent Water Bodies
- Main River
- Ordinary Watercourse
- Culverted Watercourse

Flood Depth

- <0.1m
- 0.1m to 0.25m
- 0.25m to 0.5m
- 0.5m to 1.0m
- 1.0m to 1.5m
- >1.5m

London Borough of Richmond upon Thames

LONDON BOROUGH OF RICHMOND UPON THAMES

Surface Water Management Plan

Scale at A3	Date	Drawn by	Approved by
1:4,500	13/04/11	A.HARRIS	J.ROBINSON

Group8_007 (Hampton Wick)
Surface Water Depth (m)
1 in 100 Chance of rainfall event occuring in any given year (1% AEP)

Consultants
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Flood Risk Management
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6 - 8 Greencoat Place
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FIGURE 3.8.7a

Notes

1. Flood Hazard has been defined based upon the joint EA and Defra R&D Technical Report FD2320 (January 2006).
2. Degree of flood hazard can be interpreted as follows:
- Caution: Flood zone with shallow flowing water or deep standing water
- Moderate: Flood zone with deep or fast flowing water. Dangerous for children, the elderly and the infirm
- Significant: Flood zone with deep fast flowing water. Dangerous for most people.
- Extreme: Flood zone with deep fast flowing water. Dangerous for all (including emergency services)

Group8_007

Sluice

Mutton Pond

0 50 100m

THIS DRAWING MAY BE USED ONLY FOR THE PURPOSE INTENDED

Legend

- Borough Administrative Boundary
- Critical Drainage Area
- Permanent Water Bodies
- Main River
- Ordinary Watercourse
- Culverted Watercourse
- Flow Direction Arrows

Flood Hazard

- <0.75 Caution (Very low hazard)
- 0.75 - 1.25 Moderate (Danger for some)
- 1.25 - 2.0 Significant (Danger for most)
- <2.0 Extreme (Danger for all)

London Borough of Richmond upon Thames

LONDON BOROUGH OF RICHMOND UPON THAMES

Surface Water Management Plan

Scale at A3	Date	Drawn by	Approved by
1:4,500	20/07/11	A.HARRIS	J.ROBINSON

Group8_007 (Hampton Wick)
Surface Water Flood Hazard Rating
1 in 100 Chance of rainfall event occuring in any given year (1% AEP)

Consultants
CAPITA SYMONDS
Flood Risk Management
URS / Scott Wilson
6 - 8 Greencoat Place
London
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FIGURE 3.8.7b

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3.9 SUMMARY OF RISK

3.9.1 The following conclusions can be drawn from the Phase 2 assessment, which has involved pluvial modelling combined with site visits and review of historical flood records provided by the Council, Thames Water and the Environment Agency:

- Pluvial flooding is widely dispersed across the entire Borough;
- Flood depths in the 1% AEP are largely to depths of less than 0.5m, however the potential impacts are still large especially where vehicles' wash water floods property;
- Greater flood depths are experienced at topographical low points such as at railway embankment crossings;
- Seven (7) CDAs have been identified within the Borough where the potential for surface water flooding is estimated to be greatest;
- Teddington has the most comprehensive record of surface water flooding within the Borough;
- The London mainline Waterloo rail link and electricity substations have been identified within areas considered to be at greater flood risk;
- Generally the risk of groundwater flooding within the Borough is considered to be low. Areas of increased risk are typically located adjacent to watercourses or at locations where there is made ground.

RISK TO EXISTING PROPERTIES & INFRASTRUCTURE

3.9.2 As part of the Phase 2 assessment, a quantitative assessment of the number of properties at risk of flooding has been undertaken for each CDA. The rainfall event with a 1% AEP has been used to inform this assessment, as specified in the Drain London Data and Modelling Framework. A Full summary of the results of property counts are included in Table 3-5 at the end of this Section.

3.9.3 In order to provide a quantitative indication of potential risks, address point data (supplied by the Environment Agency) has been overlaid onto intermediate pluvial modelling depth results to establish the number of properties at risk within each specific area for any depth of water and specifically where affected by depths of greater than 0.5m.

3.9.4 Table 3-5 presents the approximate number of properties (including deprived households, commercial property and infrastructure) which may be affected in each of these areas during a 1% AEP rainfall event. It should be noted that this is a strategic study and these numbers are an estimation based on best available information at the time of this study..

3.9.5 These results show that within Richmond upon Thames:

- There are no households identified to be at risk which are also considered to be deprived.
- The CDA with the greatest number of houses predicted to be at risk of flooding to a depth greater than 0.5m in the 1% AEP is Richmond and Mortlake, however this is also the biggest CDA.

- Teddington has the greatest recorded flood history which is reflected by the number of properties estimated to be at risk in this location (2,076 properties).

3.9.6 In addition to property data, the location of infrastructure has been overlaid onto flood risk depth maps. This process has identified potential flood risk to the rail network at the A316 crossing at Lower Mortlake Road and at the topographical low point within Richmond railway station. In addition, highways (including Heath Road) may become blocked due to flooding at low points where rail crossings are provided. One electricity substation has been identified as being at potential risk of surface water flooding. This is located within CDA_001 Twickenham at Gladstone Avenue. The Borough should liaise with stakeholders including utility providers as having a small number of these installations affected by a storm may be manageable but the larger, cumulative effect could be more devastating. The Borough should liaise with stakeholders to ensure that these risks are mitigated wherever possible.

RISK TO FUTURE DEVELOPMENT (PROPERTIES AND INFRASTRUCTURE)

3.9.7 The Core Planning Strategy identifies that the Council will in accordance with the London Plan targets make provision for 270 housing units during the period 2007/2008 to 2016/17 and an indicative capacity range of between 150-330 units between 2017 and 2026/202. Richmond upon Thames is a Borough that is constrained by its already densely populated areas, large expanses of protected open space and the River Thames.

3.9.8 New development will be concentrated on existing urban villages and includes opportunities to re-develop Twickenham including improvements to the River Crane Corridor. The SWMP study has identified that some potential development areas within Twickenham are located within areas shown to be at increased risk of surface water flooding. Given the number of additional residential dwellings proposed for these areas, it is important that the risk of surface water flooding is clearly understood and mitigation measures are incorporated into any site development plans.

3.10 COMMUNICATE RISK

PROFESSIONAL STAKEHOLDERS

3.10.1 There are various professional stakeholders which are in interested in increasing their knowledge of risks from surface water flooding. It is essential that the SWMP partnership actively engages with these groups, where appropriate, to share the findings of this report. This will ensure that emerging plans and policies are informed by the latest and improved understanding of surface water flood risk issues.

LOCAL RESILIENCE FORUMS

3.10.2 In line with the Defra SWMP Technical Guidance it is strongly recommended that the information provided in the SWMP is issued to the Local Resilience Forum. Surface water flood maps and knowledge of historic flood events should be used to update Incident Management Plans and Community Risk Registers for the area. In addition, maps showing the depth of pluvial flooding during a range of return period rainfall events can be used to inform operations undertaken by emergency response teams especially near public buildings and major routes through the Borough. This information can be used in parallel with

Extreme Rainfall Alert (ERA) service provided by the Flood Forecasting Centre[8].

COMMUNICATION AND ENGAGEMENT PLAN

3.10.3 It is recommended that a Communication and Engagement Plan should be produced for the London Borough of Richmond upon Thames to effectively communicate and raise awareness of surface water flood risk to different audiences using a clearly defined process for internal and external communication with stakeholders and the public.

3.10.4 The Plan should:

- Develop clear key messages from the SWMP (and PFRA) relating to local surface water flood risk and management,
- Create simplified maps and meaningful data for communications materials,
- Clearly define a structure for multi-agency partnership working (based on the partnership structure identified in Phase 1 of the SWMP) and formalise through a Memorandum of Understanding,
- Provide innovative and 'bigger picture' communications and engagement techniques (e.g. Mayoral letter to all CEOs)

[8] The Flood Forecasting Centre was set up in 2008 by the Met Office and the Environment Agency to provide services to emergency and professional partners.

Table 3-5 Phase 2 Summary of Risk

CDA ID	Scheme Location	Moderation		Infrastructure						Households								Commercial / Industrial				Totals	
		Primary	Secondary	Essential		Highly Vulnerable		More Vulnerable		Non-Deprived (All)		Non-Deprived (Basements)		Deprived (All)		Deprived (Basements)		All		Basements Only		All	>0.5m
				All	> 0.5m Deep	All	> 0.5m Deep	All	> 0.5m Deep	All	> 0.5m Deep	All	> 0.5m Deep	All	> 0.5m Deep	All	> 0.5m Deep	All	> 0.5m Deep	All	> 0.5m Deep		
Group8_001	Twickenham	None	None	1	0	0	0	3	0	1417	0	8	0	0	0	0	0	44	0	7	0	1480	0
Group8_002	St Margaret's	None	None	0	0	0	0	2	0	927	0	174	0	0	0	0	0	43	0	23	0	1169	0
Group8_003	Strawberry Hill	None	None	1	0	2	0	14	0	1967	1	56	1	0	0	0	0	141	0	31	0	2212	2
Group8_004	Richmond Centre & Mortlake	None	None	7	0	1	0	23	0	5566	34	664	5	0	0	0	0	575	6	239	4	7075	49
Group8_005	Petersham	-	-	0	0	0	0	0	0	55	0	1	0	0	0	0	0	4	0	1	0	61	0
Group8_006	Teddington	None	None	3	0	1	0	8	0	2076	0	147	0	0	0	0	0	258	0	124	0	2617	0
Group8_007	Hampton Wick	None	None	1	0	0	0	1	0	442	0	9	0	0	0	0	0	15	0	6	0	474	0

Notes

The Summary of Risk table is populated by calculating the total number of units from each sub-category that are affected by surface water flooding in the modelled scenario for the rainfall event with a 1% AEP. In accordance with the Drain London Data and Modelling Framework, the Environment Agency National Receptor Database (NRD) Version 1.0 has been used to identify receptors at risk of flooding within each CDA. The type of receptor has been identified based on definitions (MCM Codes) within Appendix 3.1 of the Multi-Coloured Manual[9] and divided into sub-categories consistent with those within Planning Policy Statement 25: Development and Flood Risk[10]. A summary is provided in the following tables:

Infrastructure Sub-Categories	
Category	**Description**
Essential Infrastructure	• Essential transport infrastructure which has to cross the area at risk • Mass evacuation routes • Tube stations and entrances • Essential utility infrastructure which has to be located in a flood risk area for operation reasons • Electricity generating power stations and grid and primary substations • Water treatment works
Highly Vulnerable	• Police stations, Ambulance stations, Fire stations, Command Centres and telecommunications installations • Emergency disposal points • Installations requiring hazardous substances consent
More Vulnerable	• Hospitals • Health Services • Education establishments, nurseries • Landfill, waste treatment and waste management facilities for hazardous waste • Sewage treatment works • Prisons

Household & Basement Sub-Categories	
Category	**Description**
Households	• All residential dwellings • Caravans, mobile homes and park homes intended for permanent residential use • Student halls of residence, residential care homes, children's homes, social services homes and hostels
Deprived Households	• Those households falling into the lowest 20% of ranks by the Office of National Statistics' Indices of Multiple Deprivation.
Non-Deprived Households	• Those households not falling into the lowest 20% of ranks by the Office of National Statistics' Indices of Multiple Deprivation
Basements	• All basement properties, dwellings and vulnerable below ground structures (where identified in existing dataset including those provided by Thames Water and the Environment Agency's National Receptor Database).

[9] Flood Hazard Research Centre, 2010, Multi-Coloured Manual – 2010

[10] DCLG (Revised 2010) Planning Policy Statement 25: Development & Flood Risk

4. Phase 3: Options

4.1 OBJECTIVES

4.1.1 The purpose of Phase 3 is to identify a range of structural and non-structural measures for alleviating flood risk and short listing options to eliminate those that are not feasible or cost beneficial. The remaining options are then developed and tested against their relative effectiveness, benefits and costs. The target level of flood protection has been set at 1.3% AEP (1 in 75 annual probability) to align solutions with the likely level of insurance cover available to the general public.

4.1.2 To maintain continuity within the report and to reflect the flooding mechanisms within the Borough the option identification has taken place on an area-by-area (site-by-site) basis following the process established in Phase 2. Therefore, the options assessment undertaken as part of the SWMP assesses and short-lists the measures for each CDA and identifies any non-standard measures available.

4.1.3 Phase 3 delivers a high level option assessment for each of the seven CDAs identified in Phase 2. No monetised damages have been calculated and flood mitigation costs have been determined using engineering judgement, but have not undergone detailed analysis. Costs should therefore be treated at an order of magnitude level of accuracy. The options assessment presented here follows that described in the Defra SWMP Guidance but is focussed on highlighting areas for further detailed analysis and immediate 'quick win' actions.

4.1.4 In addition, the SWMP options assessment has been used to populate Table 4-6 and Table 4-7 which provide information to take forward to the Drain London Prioritisation Matrix (Tier 3 of the Drain London Project). The London wide prioritisation matrix will contain details of preferred options from all 33 London Boroughs which the GLA will use to prioritise some central funding for further analysis of CDAs and installation of mitigation measures.

4.2 MEASURES

4.2.1 This stage aims to identify a number of measures that have the potential to alleviate surface water flooding in the London Borough of Richmond upon Thames. It has been informed by the knowledge gained as part of the Phase 1 and Phase 2 assessment. Where possible options will be identified that have multiple benefits, for example to alleviate flooding from more than one source, or provide environmental benefits such as water quality, biodiversity and amenity benefits. At this stage the option identification pays no attention to constraints such as funding or delivery mechanisms to enable a robust assessment.

IDENTIFY MEASURES

4.2.2 As detailed in the Defra SWMP Guidance, measures have been identified regardless of the potential mechanism or funding. A standard set of structural and non-structural measures have been specified by the Drain London Forum for consideration within each CDA (Table 4-1) and follow the source-pathway-receptor model illustrated in Figure 4-1 below.

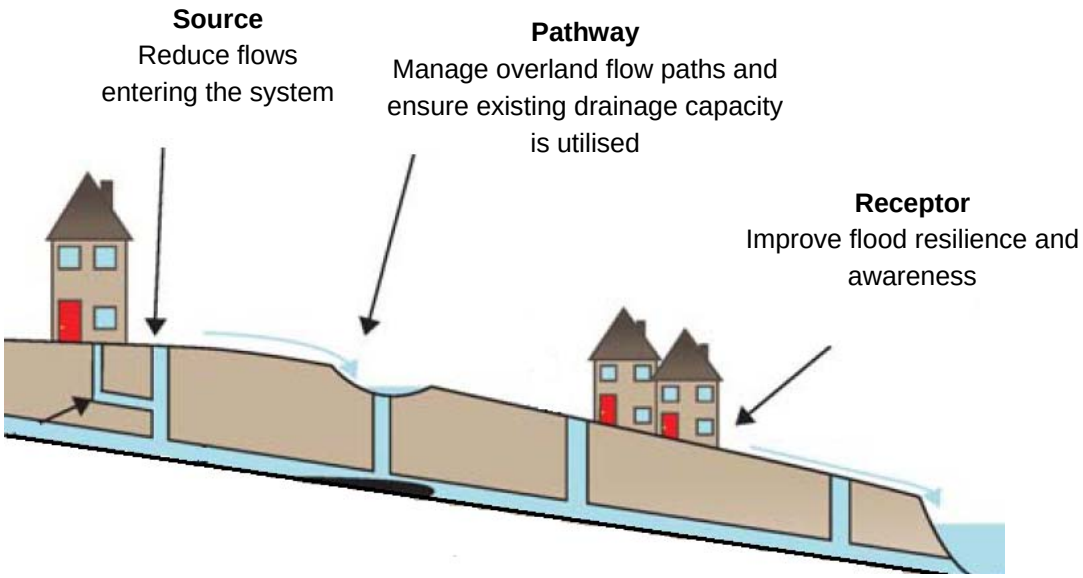


Figure 4-1 Source Pathway Receptor Model

4.2.3 Structural measures are considered to be those which require fixed or permanent assets to mitigate flood risks. Non-structural measures are those which are responses to urban flood risk that may not involve fixed or permanent facilities, and whose positive contribution to the reduction of flood risk is most likely through a process of influencing behaviour.

Table 4-1: Drain London Structural and Non-Structural Measures for Consideration

Source	Pathway	Receptor
Green roof	Increasing capacity in drainage systems	Improved weather warning
Soakaways	Separation of foul and surface water sewers	Planning policies to influence development
Swales	Improved maintenance regimes	Temporary or demountable flood defences
Permeable Paving	Managing overland flows	Social change, education and awareness
Rainwater Harvesting	Land management practices	Improved resilience and resistance measures

4.2.4 An opportunity assessment was undertaken for each CDA to evaluate where there were opportunities for the implementation of structural and non-structural measures identified by the Drain London Forum and through consultation with relevant stakeholders. The results from the Opportunity Assessment are summarised in Table 4-2 below and full details are included in Appendix E.

Table 4-2: Measures Opportunity Assessment

CDA ID	CDA Name	Source								Pathway							Receptor					
		Green Roof	Soakaways	Swales	Permeable Paving	Rainwater Harvesting	Detention Basins	Ponds and Wetlands	Other 'Source' Measures	Increasing Capacity in Drainage Systems	Separation of Foul and Surface Water Sewers	Managing Overland Flows (Online Storage)	Managing Overland Flows (Preferential Flow paths)	Land Management Practices	De-culverting Watercourse(s)	Other 'Pathway' Measures	Improved Weather Warning	Planning Policies to Influence Development	Temporary or Demountable Flood Defences	Social Change, Education and Awareness	Improved Resilience and Resistance Measures	Other 'Receptor' Measures
CDA_001	Twickenham	✓	✓	✓	✓	✓	✓	✗	N/A	✓	✗	✓	✓	✗	✗	N/A	✓	✓	✓	✓	✓	N/A
CDA_002	St Margaret's	✓	✓	✓	✓	✓	✓	✗	N/A	✓	✗	✓	✓	✗	✗	N/A	✓	✓	✓	✓	✓	N/A
CDA_003	Strawberry Hill	✓	✓	✓	✓	✓	✓	✓	N/A	✓	✗	✓	✓	✓	✗	N/A	✓	✓	✗	✓	✓	N/A
CDA_004	Richmond &	✓	✓	✓	✓	✓	✓	✓	N/A	✓	✓	✓	✓	✓	✗	N/A	✓	✓	✓	✓	✓	N/A
CDA_005	Petersham	✓	✓	✓	✓	✓	✓	✓	N/A	✓	✗	✓	✓	✓	✗	N/A	✓	✓	✓	✓	✓	N/A
CDA_006	Teddington	✓	✓	✓	✓	✓	✓	✓	N/A	✓	✗	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	N/A
CDA_007	Hampton Wick	✓	✓	✓	✓	✓	✓	✓	N/A	✓	✓	✓	✓	✗	✗	N/A	✓	✓	✗	✓	✓	N/A

Measures Opportunity Assessment Criteria	
✓	There may be opportunities for implementation of this mitigation measure within the CDA. Measure should be considered further in the Options Assessment on a site by site basis as limiting factors such as space and ground conditions may make them unviable.
✗	There are no foreseen opportunities for implementation of this measure within the CDA. The measure is not suitable or is required to address the surface water flood risk within the CDA.
N/A	Not applicable - to be used only where no other measures are identified.

Note: The above assessment is taken from Options Assessment spreadsheets complete for each CDA. A tick is used for both measures that have opportunity for implementation within the CDA and those where further investigation will be required. All measures identified with a ✓ will be taken forward for consideration within the next level of option assessment. Measures identified with a 'X' have no practical opportunity for implementation within the CDA and will not be assessed further as part of this SWMP.

Table 4-3 Identification of Potential Options

Description		Standard Measures Considered
Do Nothing	Make no intervention / maintenance	• None
Do Minimum	Continue existing maintenance regime	• None
Improved Maintenance	Improve existing maintenance regimes e.g. target improved maintenance to critical points in the system.	• Improved Maintenance Regimes
Planning Policy	Use forthcoming development control policies to direct development away from areas of surface water flood risk or implement flood risk reduction measures.	• Planning Policies to Influence Development
Source Control, Attenuation and SUDS	Source control methods aimed to reduce the rate and volume of surface water runoff through infiltration or storage, and therefore reduce the impact on receiving drainage systems.	• Green Roof • Soakaways • Swales • Permeable paving • Rainwater harvesting • Detention Basins • Ponds and Wetlands • Land Management Practices
Flood Storage / Permeability	Large-scale SUDS that have the potential to control the volume of surface water runoff entering the urban area, typically making use of large areas of green space. Upstream flood storage areas can reduce flows along major overland flow paths by attenuating excess water upstream.	• Detention Basins • Ponds and Wetlands • Managing Overland Flows (Online Storage) • Land Management Practices
Separate Surface Water and Foul Water Sewer Systems	Where the CDA is served by a combined drainage network separation of the surface water from the combined system should be considered.	• Separation of Foul and Surface Water Sewers
De-culvert / Increase Conveyance	De-culverting of watercourses and improving in-stream conveyance of water.	• Deculverting Watercourse(s)
Preferential / Designated Overland Flow Routes	Managing overland flow routes through the urban environment to improve conveyance and routing water to watercourses or storage locations.	• Managing Overland Flows (Preferential Flow paths) • Temporary or Demountable Flood Defences
Community Resilience	Improve community resilience and resistance of existing and new buildings to reduce damages from flooding, through, predominantly, non-structural measures.	• Improved Weather Warning • Temporary or Demountable Flood Defences • Social Change, Education and Awareness
Infrastructure Resilience	Improve resilience of critical infrastructure in the CDA that is likely to be impacted by surface water flooding e.g. electricity substations, pump houses.	• Improved Resilience and Resistance Measures
Other - Improvement to Drainage Infrastructure	Add storage to, or increase the capacity of, underground sewers and drains and improving the efficiency or number of road gullies.	• Increasing Capacity in Drainage Systems
Other or Combination of Above	Any alternative options that do not fit into above categories and any combination of the above options where it is considered that multiple options would be required to address the surface water flooding issues.	

IDENTIFY & SHORT LIST OPTIONS

4.2.5 Following the identification of measures that should be considered within the Borough, options have been identified and short listed for each CDA. As a detailed appraisal of cost and benefits of each of the measures is not deemed to be practical, a high-level scoring system for each of the options has been developed. The approach to short-listing the measures is based the guidance in FCRM[11] and Defra's SWMP technical guidance[12]. The scoring criteria are provided in Table 4-4.

Table 4-4: Options Assessment Short-Listing Criteria

Criteria	Description	Score
Technical	• Is it technically possible and buildable? • Will it be robust and reliable? • Would it require the development of a new technique for its implementation?	U: Unacceptable (measure eliminated from further consideration) -2: Severe negative outcome -1: Moderate negative outcome 0: Neutral +1: Moderate positive outcome +2: High positive outcome
Economic	• Will benefits exceed costs? • Is the measure within the available budget? • Estimate the whole life costs of the option including asset replacement, operation and maintenance. The scoring of this measure will depend on the budget available from the local authority although it should be remembered that alternative routes of funding could be available such as Thames Region Flood Defence Committee.	
Social	• Will the community benefit or suffer from implementation of the measure? • Does the option promote social cohesion or provide an improved access to recreation/open space? • Does the option result in opposition from local communities for example if an option involves the displacement of houses?	
Environmental	• Will the environment benefit or suffer from implementation of the measure? • Would the option provide a positive or negative effect on the environment for example, water quality and biodiversity?	
Objectives	• Will it help to achieve the objectives of the SWMP partnership? • Does the option meet the overall objective of alleviating flood risk?	

4.2.6 An options workshop was held on the 31st March 2011 at Richmond Council offices. This was attended by members of their planning team, street scene team, street care team, emergency planning team, highways team and the Environment Agency. The purpose of the meeting was to discuss and agree short-listed options identified for each CDA and to discuss works currently in progress.

4.2.7 The process aimed to ensure that inappropriate measures are eliminated early in the process to avoid investigation of options that are not acceptable to stakeholders. The agreed shortlisted options have been progressed to the Preferred Options stage where they will be further developed.

[11] Environment Agency (March 2010) *'Flood and Coastal Flood Risk Management Appraisal Guidance',* Environment Agency: Bristol.

[12] Defra (March 2010) *'Surface water management plan technical guidance',* Defra: London

4.3 PREFERRED OPTIONS

BOROUGH-WIDE PREFERRED OPTIONS

4.3.1 A number of Borough-wide options and policies have been identified that the Council and relevant stakeholders may consider adopting as part of their responsibility as LLFA for local flood risk management. These measures have been informed by the London Borough of Richmond Scrutiny Task Group Report following the 2007 flood event and are described further below.

1. Raising Community Awareness (Across the whole Borough)

4.3.2 A 'quick win' action that should be implemented in the short term is to increase awareness of flooding within communities at risk and across the Borough as a whole. This could be achieved through a number of measures including:

- Newsletters;
- Community Flood Plans
- Drop-in surgeries; and
- Promotion on Richmond Council's website (see Figure 4-2 below).

4.3.3 The aim of these actions is to raise awareness and improve understanding of the risks and consequences of surface water flooding amongst local communities and, through this, encourage residents to take up measures to combat flooding. Such measures may include installation of water butts to capture roof runoff and consideration of the extent and materials used when replacing permeable areas within hard standing areas within their property e.g. through the installation of driveways and patios.

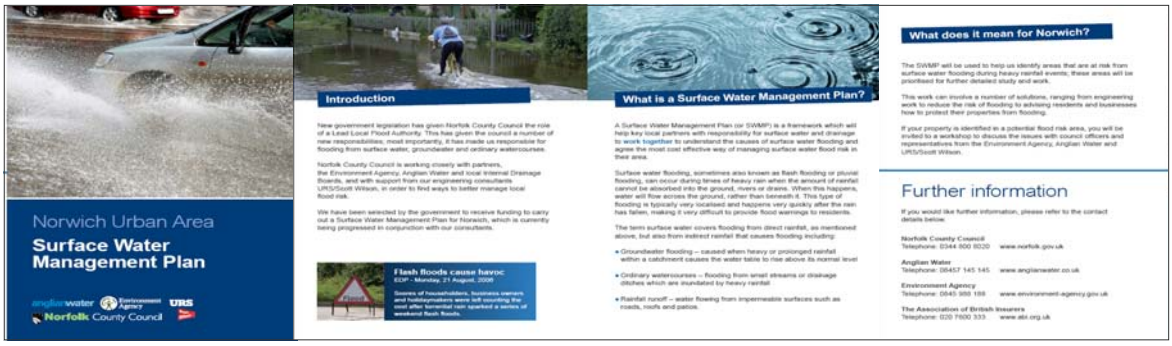


Figure 4-2 Example Newsletter (URS Scott Wilson, 2011)

4.3.4 Other more specific campaigns that could be taken forward are discussed below.

4.3.5 Thames Water and The Council could undertake a joint publicity and education campaign urging residents to report anyone disposing of inappropriate materials into the sewerage system. This could be combined with advice for traders on the responsible disposal of waste e.g. a fat collection service where the waste is turned into bio diesel. Perhaps such a scheme could be jointly taken forward across adjacent Boroughs to ensure demand.

4.3.6 Gully maintenance teams often raise issues with parked cars; the Council could raise awareness of the need for Gully cleaning.

4.3.7 The above awareness campaigns are summarised in the table below.

Option 1a:	Council and Thames Water jointly campaign to urge residents to report the disposal of inappropriate materials to the sewer network
Option1b:	Council and Thames Water jointly campaign for the recycling of fat to bio diesel. This should be investigated further at Flood Group Meetings.
Option 1c:	Council to raise awareness of gully clearing and parked vehicles.
Option 1d:	Council to undertake a publicity campaign promoting the use of permeable surfaces for paved front and back gardens (see planning and development section)

2. Ongoing Improvements to Maintenance of the Drainage Network

4.3.8 The management and maintenance of the urban drainage network in London Borough of Richmond upon Thames is the responsibility of a number of organisations:

- London Borough of Richmond upon Thames– highway drainage including gully pots
- Thames Water – main sewers, lateral sewers;
- Transport for London – highway drainage along red routes within the Borough (A316, A205);
- Environment Agency – culverts, raised defences, trash screens, Main River channels;
- Network Rail – railway drainage and culverts beneath raised rail embankments.

4.3.9 Effective cleansing of gully pots is fundamental to the drainage across the Borough (particularly important for more frequent lower magnitude events less than 3.3% AEP (<1:30 annual probability). The London Borough of Richmond upon Thames aims to clean every gully within a two-year cycle and sends out extra patrols in the autumn to bag up leaves (fallen leaves and build up of silt are the main causes of blockages in the highway drainage network). In addition, on highways located on steeper gradients surface water is noted to flow too quickly to enter the gully pots and drain away.

4.3.10 The sewer network in Richmond upon Thames is mostly Victorian and in places struggles to meet modern demands. Thames Water has a long term strategy for improvements on this system which within the London Borough of Richmond upon Thames include recent works to increase the capacity of Mogden sewage works.

4.3.11 In addition to long term strategies, Thames Water provides sewer cleaning to Trunk Sewers into which local surface water drainage connects. Following the 2007 Scrutiny Report it was recommended that Thames Water provided the Council with their sewer cleaning schedules, however this has not yet happened. The most significant cause of blockages in the Thames Water network is cooking fat and builder's washings (see Option 1a).

4.3.12 Options that could be considered by the London Borough of Richmond upon Thames and Thames Water with respect to highway drainage maintenance include:

Option 2a:	Thames Water provides the Borough with sewer cleaning schedules for Richmond upon Thames. Meeting this requirement should be facilitated through the Local Flood Group which Thames Water attends.
Option2b:	Thames Water to record date and location of inappropriate material being removed from the Thames Water network to help enforcement where necessary.
Option 2c:	The cleaning of gullies should be, where possible scheduled into the wider scheme to deep clean roads.
Option 2d:	If the Councils contractors are unable to clear a gully on two separate occasions, the request for that gully to be cleared was closed. This process has been updated so that the case should now only be closed when the gully is cleared. This process is still under review with the new contractor.
Option 2e:	Develop a GIS database of all Council-owned flood/drainage assets (in line with FWMA requirements).

3. Planning & Development Policies

4.3.13 As part of this Phase of work a single Policy Area has been defined across the Borough within which appropriate planning policies should be applied to manage flood risk. The reason for the inclusion of a policy area is to highlight the fact that even if a location does not fall within a CDA it does not mean that surface water discharge can be uncontrolled, merely that the need for considering direct options for the area are not so critical. The Richmond upon Thames Policy Area follows the Borough boundary and is illustrated below (Figure 4-3).

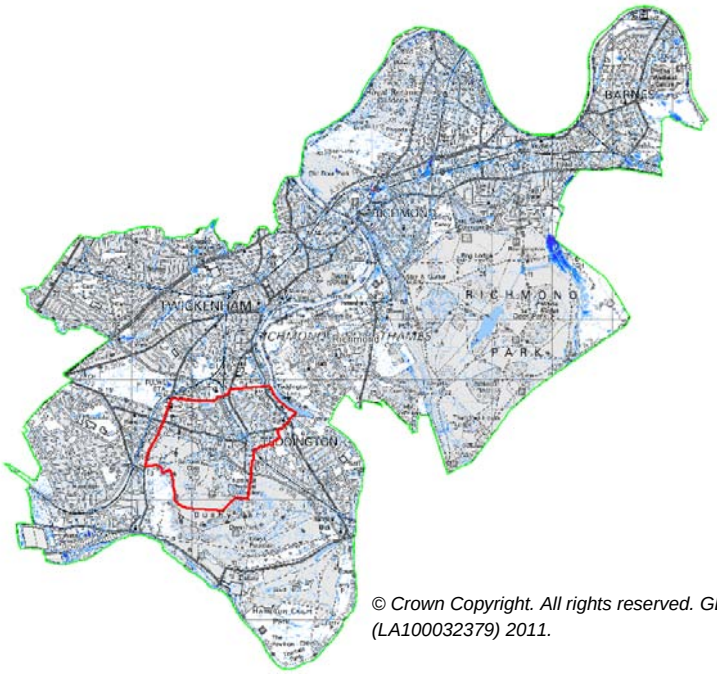


Figure 4-3 London Borough of Richmond upon Thames Policy Area

4.3.14 A summary of measures that can be applied throughout the Policy Area (Borough wide) are outlined below.

Paved Gardens

4.3.15 Impermeable paving in gardens can significantly increase surface water runoff entering the local drainage network. From the 1st October 2008 the permitted development rights that allow householders to pave their front garden with hard standing without planning permission was removed. Residents should be encouraged to design their gardens in a way that optimises drainage and reduces runoff. The Council should publicise this issue and refer to standard guidance on the surfacing of front gardens provided by the CLG and Environment Agency in September 2008[13].

Figure 4-4 Permeable front gardens allowing for parking

Source CLG/EA Guidance on the permeable surfacing of front gardens 2008 and Richmond Scrutiny Report 2008

[13] Department for Communities and Local Government, 2008, Guidance on the Permeable Surfacing of Front Gardens http://www.communities.gov.uk/documents/planningandbuilding/pdf/pavingfrontgardens.pdf

Council Owned Car Parks

4.3.16 Car parks across the Borough account for a large proportion of hard surfacing; which in turn contribute to surface water runoff and pressure on the local drainage network. The London Borough of Richmond upon Thames does not currently require the use of permeable surfaces when resurfacing old car parks or building new ones. It is vital that if the Council are promoting local residents to use sustainable drainage, they are seen to be leading the way.

Option 3a:	Council could encourage residents to ensure that paved areas in front gardens drain onto flower beds rather than running onto the highway.
Option3b:	The Council could aim to raise awareness of the options for installation and maintenance of permeable surfaces within property grounds.
Option 3c:	The Council could aim to provide an information portal that residents can consult for further information on permeable paving, including a list of 'approved suppliers' whom residents can contact to install permeable driveways etc.
Option 3d:	All new Council owned car parks and newly resurfaced car parks should be built with permeable surfaces to reduce runoff. They should be designed to incorporate surface water storage and should not be connected to the local drainage network wherever possible
Option 3e:	The Council should look into planning policy with regard to privately owned car park and potential for use of SUDS.

Sustainable Drainage Systems (SuDS)

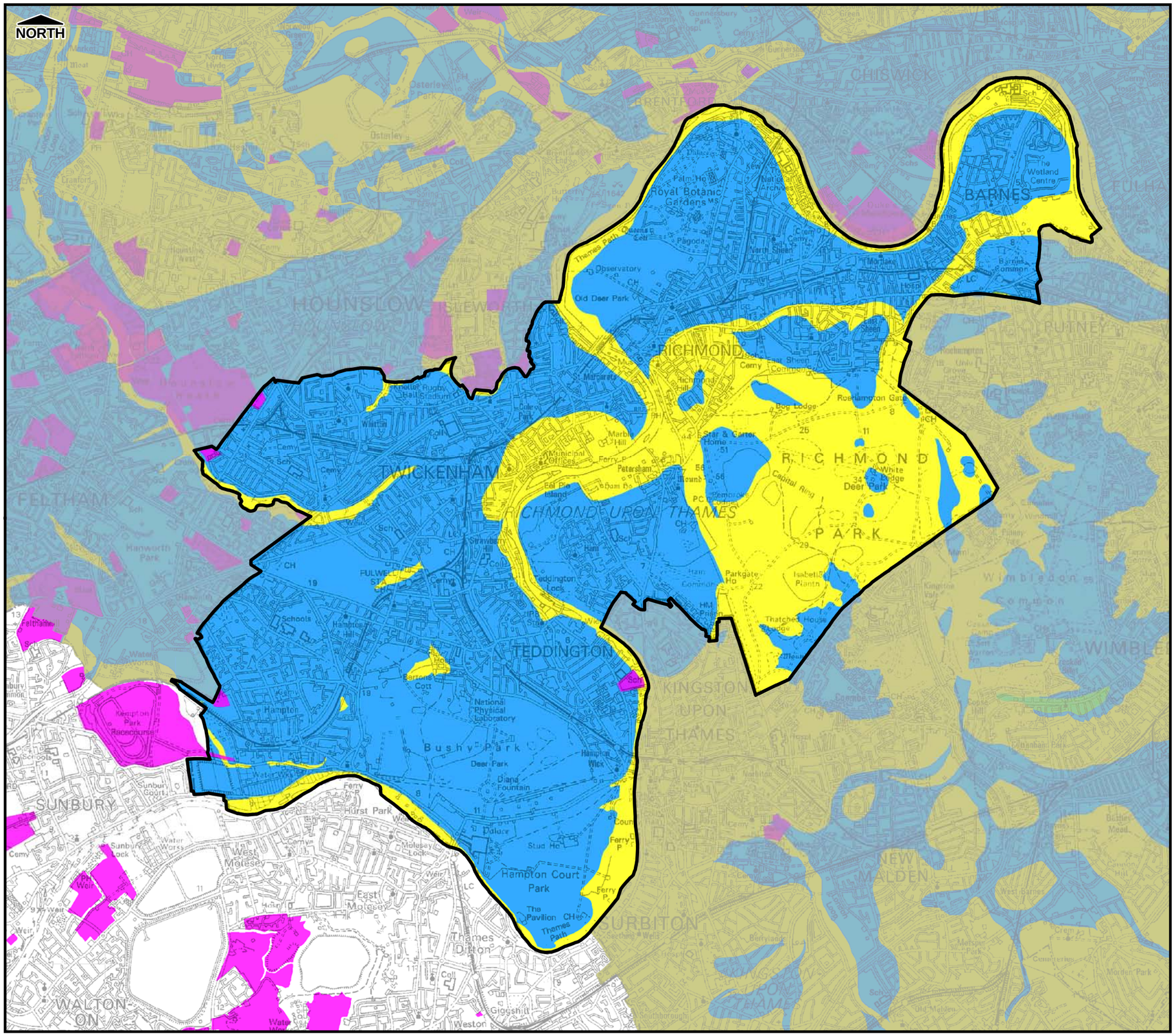
4.3.17 A number of policies have already been implemented within London Borough of Richmond upon Thames to ensure that new development incorporates Sustainable Drainage Systems (SuDS) wherever possible. It is recommended that these are reviewed and updated where necessary in the light of the Groundwater Assessment (Appendix C2) and the SuDS Suitability Map shown in Figure 4.3.1.

4.3.18 SuDS techniques can be used to reduce the rate and volume and improve the water quality of surface water discharges from sites to the receiving environment (i.e. natural watercourse or public sewer etc). Various SuDS techniques are available and operate on two main principles; attenuation and infiltration. All systems generally fall into one of these two categories, or a combination of the two.

Infiltration SuDS

4.3.19 This type of Sustainable Drainage System relies on discharges to ground, where ground conditions are suitable. Therefore, infiltration SuDS are reliant on the local ground conditions (i.e. permeability of soils and geology, the groundwater table depth and the importance of underlying aquifers as a potable resource) for their successful operation.

4.3.20 Development pressures and maximisation of the developable area may reduce the area available for infiltration systems. This can be overcome through the use of a combined approach with both attenuation and infiltration techniques e.g. attenuation storage may be provided in the sub-base of a permeable surface, within the chamber of a soakaway or as a



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Legend

- Richmond Borough Council

EA Groundwater Source Protection Zone

- Inner Zone
- Outer Zone
- Historic Landfill Site

Infiltration SUDS Suitability

- Infiltration SUDS potentially suitable
- Infiltration SUDS potentially unsuitable
- Infiltration SUDS Suitability Uncertain -Site investigation required

Notes

London Borough Richmond

LONDON BOROUGH OF RICHMOND UPON THAMES

Surface Water Management Plan

Scale at A3	Date	Drawn by	Approved by
1:50,000	22/03/2011	C.Woolhouse	S.Cox

Infiltration SUDS Suitability Map

Consultants

CAPITA SYMONDS Flood Risk Management

Scott Wilson

URS / Scott Wilson
6 - 8 Greencoat Place
London
SW1P 1PL

Drain London Programme Board Members

Environment Agency · Thames Water · LONDON COUNCILS · GREATERLONDONAUTHORITY

FIGURE 4.3.1

Filepath: D:\34786 Drain London_Tier 2_Group 8\700 Technical\711 GIS\01 Layout\Richmond\Infiltration SUDS Suitability Map.mxd

pond/water feature.

4.3.21 Permeable surfaces are designed to intercept rainfall and allow water to drain through to a sub-base. The use of a permeable sub-base can be used to temporarily store infiltrated run-off underneath the surface and allows the water to percolate into the underlying soils. Alternatively, stored water within the sub-base may be collected at a low point and discharged from the site at an agreed rate.

4.3.22 Permeable paving prevents runoff during low intensity rainfall, however, during intense rainfall events some runoff may occur from these surfaces.

4.3.23 Programmes should be implemented to ensure that permeable surfaces are kept well maintained to ensure the performance of these systems is not reduced. The use of grit and salt during winter months may adversely affect the drainage potential of certain permeable surfaces.

4.3.24 Types of permeable surfaces include:

- Grass/landscaped areas
- Gravel
- Solid Paving with Void Spaces
- Permeable Pavements

4.3.25 Where permeable surfaces are not a practical option more defined infiltration systems are available. In order to infiltrate the generated run-off to ground, a storage system is provided that allows the infiltration of the stored water into the surrounding ground through both the sides and base of the storage. These systems are constructed below ground and therefore may be advantageous with regards to the developable area of the site. Consideration needs to be given to construction methods, maintenance access and depth to the water table. The provision of large volumes of infiltration/sub-surface storage has potential cost implications. In addition, these systems should not be built within 5m of buildings, beneath roads or in soil that may dissolve or erode.

4.3.26 Various methods for providing infiltration below the ground include:

- Geocellular Systems
- Filter Drain
- Soakaway (Chamber)
- Soakaway (Trench)
- Soakaway (Granular Soakaway)

4.3.27 The infiltration SuDS suitability assessment shown on Figure 4 is based on minimum permeability data obtained from the BGS. There also exist maximum permeability data, however, only the minimum permeability is used, as this is understood to be more representative of the bulk permeability.

4.3.28 Three permeability zones have been identified:

- Infiltration SUDS potentially suitable: Minimum permeability is high or very high for bedrock (and superficial deposits if they exist).

- Infiltration SUDS potentially unsuitable: Minimum permeability is low or very low for bedrock (and superficial deposits if they exist).
- Infiltration SUDS suitability uncertain: Minimum permeability is low or very low for bedrock and high or very high for superficial deposits OR minimum permeability is low or very low for superficial deposits and high or very high for bedrock.

4.3.29 Figure 4.3.1 shows that across much of the Borough the use of infiltration measures are not suitable, for the remainder further site level investigations would be required.

4.3.30 It is noted that this is a high level assessment and only forms an approximate guide to infiltration SUDS suitability; a site specific investigation is required to confirm local conditions.

Attenuation SuDS

4.3.31 If ground conditions are not suitable for infiltration techniques then management of surface water runoff prior to discharge should be undertaken using attenuation techniques. This technique attenuates discharge from a site to reduce flood risk both within a site and to the surrounding area. It is important to assess the volume of water required to be stored prior to discharge to ensure adequate provision is made for storage. The amount of storage required should be calculated prior to detailed design of the development to ensure that surface water flooding issues are not created within the site.

4.3.32 The rate of discharge from the site should be agreed with the Local Planning Authority and the Environment Agency. If surface water cannot be discharged to a local watercourse then liaison with the Sewer Undertaker should be undertaken to agree rates of discharge and the adoption of the SuDS system (the Lead Local Flood Authority would normally adopt SuDS under the Flood and Water Management Act 2010). Large volumes of water may be required to be stored on site. Storage areas may be constructed above or below ground. Depending on the attenuation/storage systems implemented, appropriate maintenance procedures should be implemented to ensure continued performance of the system. On-site storage measures include basins, ponds, and other engineered forms consisting of underground storage.

4.3.33 Basins are areas that have been contoured (or alternatively embanked) to allow for the temporary storage of run-off from a developed site. Basins are designed to drain free of water and remain waterless in dry weather. These may form areas of public open space or recreational areas. Basins also provide areas for treatment of water by settlement of solids in ponded water and the absorption of pollutants by aquatic vegetation or other biological activity. The construction of basins uses relatively simple techniques. Local varieties of vegetation should be used wherever possible and should be fully established before the basins are used. Access to the basin should be provided so that inspection and maintenance is not restricted. This may include inspections, regular cutting of grass, annual clearance of aquatic vegetation and silt removal as required.

4.3.34 Ponds are designed to control discharge rates by storing the collected run-off and releasing it slowly once the risk of flooding has passed. Ponds can provide wildlife habitats, water features to enhance the urban landscape and, where water quality and flooding risks are acceptable, they can be used for recreation. It may be possible to integrate ponds and wetlands into public areas to create new community ponds. Ponds and wetlands trap silt that may need to be removed periodically. Ideally, the contaminants should be removed at source to prevent silt from reaching the pond or wetland in the first place. In situations where

this is not possible, consideration should be given to a small detention basin placed at the inlet to the pond in order to trap and subsequently remove the silt. Depending on the setting of a pond, health and safety issues may be important issues that need to be taken into consideration. The design of the pond can help to minimise any health and safety issues (i.e. shallower margins to the pond reduce the danger of falling in, fenced margins).

4.3.35 Various types of ponds are available for utilising as SuDS measures. These include:

- Balancing/Attenuating Ponds
- Flood Storage Reservoirs
- Lagoons
- Retention Ponds
- Wetlands

4.3.36 Site constraints and limitations such as developable area, economic viability and contamination may require engineered solutions to be implemented. These methods predominantly require the provision of storage beneath the ground surface, which may be advantageous with regards to the developable area of the site but should be used only if methods given in the previous section cannot be used. When implementing such approaches, consideration needs to be given to construction methods, maintenance access and to any development that takes place over the storage facility. The provision of large volumes of storage underground also has potential cost implications.

4.3.37 Methods for providing alternative attenuation include:

- Deep Shafts
- Geocellular Systems
- Oversized Pipes
- Rainwater Harvesting
- Storage Tanks
- Green Roofs

4.3.38 In some situations it may be preferable to combine infiltration and attenuation systems to maximise the management of surface water runoff, developable area and green open space.

Water conservation

4.3.39 Water conservation is a key option for reducing peak discharges and in turn downstream flood risk. This can be applied using a number of options including planning led encouragement of the use of rainfall in greywater systems and property level use of water butts. Both are described in more detail below.

Rainwater harvesting

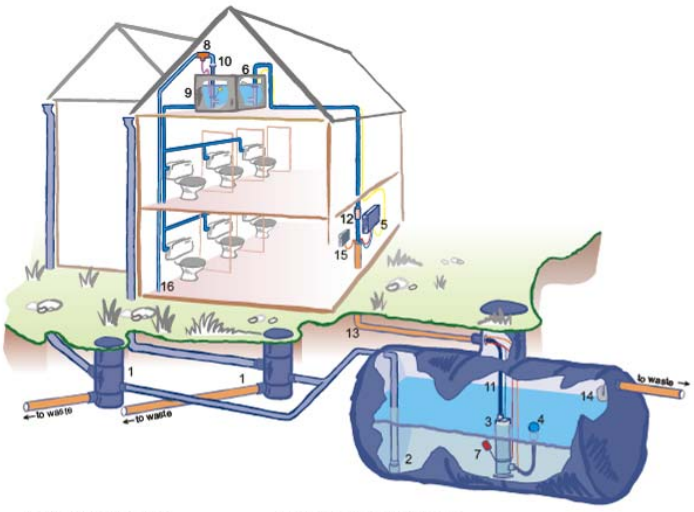
4.3.40 The potential for the use of rainwater harvesting should be jointly led by Thames Water and the Council. Promotion of the benefits of such schemes could be rolled out across multiple Boroughs to reduce costs. The principle of rainwater harvesting in both domestic and commercial property is the same. Rainwater from roof areas is passed through a filter and stored within large underground tanks. When water is required, it is delivered from the

storage tank to toilets, washing machines and garden taps for use. If the tank becomes low on stored water, demand is topped up from the mains supply. Any excess water can be discharged via an overflow to a soakaway or local drainage network.

4.3.41 Rainwater harvesting systems could be retrofitted to local schools within the Borough. A case study for Southampton University Student Services Building is described below, with an example layout of a system illustrated in Figure 4-5 below[14].

- Roof Area: 1000m^2
- Underground storage tank: 15,000 litres
- Building occupancy: 150 people
- Planned usage: 21 WCs and 3 urinals
- Expected annual rainwater collection: 410,000 litres
- Capital cost: £4325
- Expected pay back time 5.3 years (based on Southern Water 2006 tariff)

Option 3f:	The Council could consider providing an incentive scheme for the use of rainwater harvesting systems across the Borough. This may be linked to the Council's sustainability checklist.



1. Wisy WFF vortex Filter
2. Calmed inlet
3. Submersible pump
4. Floating suction filter
5. Control panel
6. Pumped demand float switch
7. Dry-run float switch
8. Solenoid valve
9. Mains demand float switch
10. Type AA air gap
11. Pressure hoses and cables
12. Non-return valve
13. 110mm pipe duct
14. Trapped overflow
15. Tank level gauge
16. Mains water supply

Figure 4-5 Example Rainwater Harvesting system in a commercial property

[14] Source: Rainwater Harvesting Systems UK

Water Butts

4.3.42 One of the preferred measures to reduce peak discharges and downstream flood risk, is the robust implementation of water butts on all new development within the Borough, and where higher surface water flooding risk has been identified, retrofitting these measures to existing properties. Given the constraints associated with the largely impermeable geology across the Borough, the wholesale implementation of water butts may significantly reduce peak discharges.

4.3.43 Water butts often have limited storage capacity as when a catchment is in flood, water butts are often full, however it is still considered that they have a role to play in the sustainable use of water. Overflow devices linked to soakaways or landscaped areas should be applied to ensure that there is always a volume of storage available.

4.3.44 Whether to construct formal spill pipes to soakaways, or to allow simple overspill to the adjacent ground are detailed decisions that will need to be based on a site-by-site basis. Such a decision will have only minor significance on the proposals with respect to the surface water drainage.

Rainwater Harvesting – Water Butts		
Description	**Benefits**	**Impacts**
Installation of water butts for all new development within Opportunity Areas	Ties in with SuDS hierarchy and reduces peak discharges to surface water	Positive impacts to sustainability and water re-use.
Retrofit water butts on all existing development (as shown on Figure 4-6)	Supplementary benefits beyond regeneration and redevelopment sites (volumetric reduction with opportunity for complimentary water quality improvements)	Currently no available incentives to encourage homeowners to install water butts.

Figure 4-6 Example of a 100L water butt retrofitted to existing development

Option 3g:	It is recommended that the Council promote the use of water butts across the Borough and provide information on costs, suppliers, installation and benefits. The Council may choose to make a bid to the Climate Change Fund to provide water butts and rainwater harvesting systems to residents at discounted rates.

Property Resilient Measures (Increasing Property or Gate Thresholds)

4.3.45 One method to reduce the risk of surface water flooding to properties is raising property or gate thresholds. Raising the threshold of entrances to property land, i.e. where there are currently gates adjacent to paved walls may offer flood resilience benefits, especially where the property contains a basement.

Figure 4-7 Raised Driveway, Croydon

Option 3h:	It is recommended that the Council aim to raise the awareness of the options for increasing property thresholds to protect against flooding.
Option 3i:	The Council could encourage residents to ensure that property thresholds are raised at least 100mm above surrounding ground levels, particularly in areas where roads / properties are known / identified to be susceptible to surface water flooding.

CDA LEVEL PREFERRED OPTIONS

4.3.46 Following the Options Workshop and consultation with relevant stakeholders, the preferred options (including combinations of measures) for each CDA have been identified and further assessed to:

- Estimate benefits; and
- Estimate approximate implementation costs.

4.3.47 For most CDAs, a range of options have been identified that could be further explored to alleviate flooding. These have been included within the Borough Action Plan as short, medium or long-term actions with an associated priority. However where there is a preferred capital scheme for a CDA, this has been identified and the estimated benefits and approximate costs have been assessed for inclusion in a London wide Prioritisation Matrix for consideration by the GLA. A summary of the preferred options is provided within Table 4-5 in Section 4.4 and further described in Sections 4.3.3 onwards.

Benefits

4.3.48 For the purpose of the Drain London Prioritisation Matrix, it is necessary to determine the benefits of each preferred option. The potential benefits of the scheme are measured using an estimated percentage of units removed from the predicted floodplain (eliminated) or where flood frequency is reduced (mitigated). This percentage has been determined by calculating the number of units within the LFRZ that the particular scheme has been designed to mitigate, as a percentage of the number of units within the CDA as a whole.

The input is restricted to multiples of five percent. It should be noted that the information within this table is purely for input into the Drain London Prioritisation Matrix and should be treated as such. Further modelling would be required to determine more accurately the potential benefits of each suggested scheme.

Costs

4.3.49 An estimated cost for the preferred flood mitigation option for each identified CDA has been calculated based on standard unit costs provided as part of Tier 1 of the Drain London Project to mitigate the 3.3% AEP (1 in 75 annual probability) event. No monetised damages have been calculated, and flood mitigation costs have been determined using engineering judgement, but have not undergone detailed analysis. The following standard assumptions have been applied, as determined in the Drain London Prioritisation Matrix Guidance:

- The costs are the capital costs for implementation of the scheme only.
- Costs do not include provisions for consultancy, design, supervision, planning process, permits, environmental assessment or optimum bias.
- No provision is made for weather (e.g. winter working).
- No provision is made for access constraints
- Where required, it will be stated if costs include approximate land acquisition components.
- No operational or maintenance costs are included.
- No provision is made for disposal of materials (e.g. for flood storage or soakaway clearance).

4.3.50 As a result, costs should be treated at an order of magnitude level of accuracy and have therefore been stated within the SWMP report as a series of cost bands.

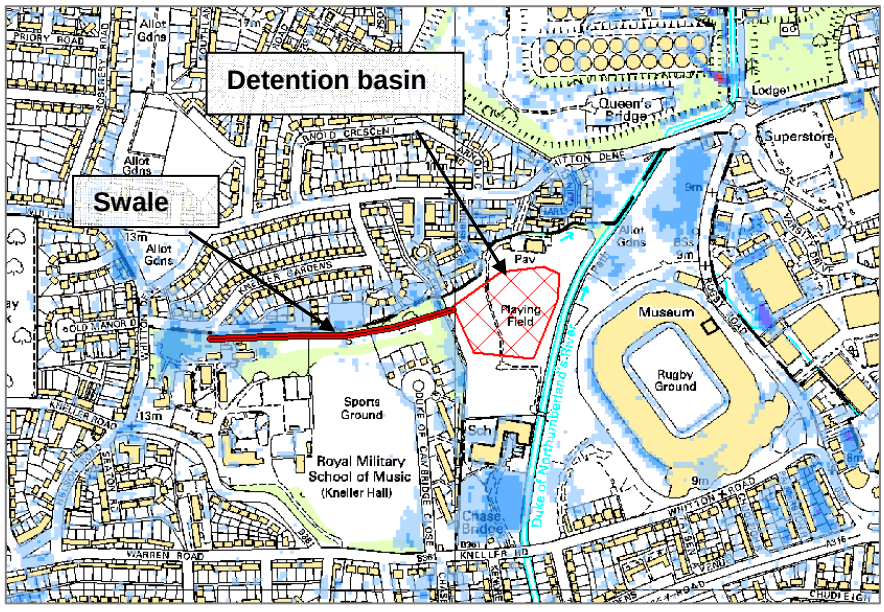
CDA_001 TWICKENHAM

The Twickenham CDA is an area of Richmond where there are a number of potential development sites incorporating land at Rugby Road. The opportunity to use planning policy to control surface water runoff from this site and others within the CDA should be thoroughly explored. Following consideration of individual options, it is considered that the most appropriate measure to be taken forward within this CDA is a combination of a swale and detention basin as described below. Funding of any measures within this CDA should be discussed with the London Borough of Hounslow which is located on the CDA boundary to the north

***Preferred option:* Source Control SUDS at Royal Military School of Music and adjacent playing fields (Figure 4-8)**

4.3.51 The option to create approximately 15,000m^3 storage contained within a **detention basin** on playing fields to the west of Duke of Northumberland River has been investigated. In addition, a **swale** approximately 380m long could be incorporated following the northern boundary of the Royal Military School of Music which would provide an additional 760m3 of storage[15]. Surface water drainage from the local network could be diverted to this swale and pond prior to discharge to the Duke of Northumberland River and would provide water quality improvements as well as flood storage and alleviate pressure on local piped networks.

Figure 4-8 Sketch to show possible location of swale and detention basin at Royal Military School of Music



4.3.52 The cost of such a scheme is estimated to be between £251k and £500k. The total volume of storage provided by this scheme is approximately 15,760m^3 and is only provides 10% mitigation on the existing situation when compared to the whole CDA. However, when comparing to the immediate vicinity of the proposed storage area, there are approximately 167 properties currently at risk that may have reduced flood risk should such a scheme be implemented. In order to confirm the potential improvement of a scheme at this location modelling would have to be re-run including the storage area which is currently beyond the

[15] Volume based on a 380m long swale that is 0.5m deep with a 1.5m bed, 2.5m wide banks at a 1 in 5 slope

scope of this SWMP. This modelling should include an assessment of the impact of fluvial flood risk at this location, as this potentially could limit storage provided in the detention basin during times of fluvial flood. High groundwater tables should also be investigated further as part of any future assessments at this location. All works should be taken forward in collaboration with the Environment Agency.

4.3.53 In addition to modelling requirements, land acquisition may be required. Further investigation is required to confirm the potential cost of this.

4.3.54 The combination of swale and detention basin has been taken forward to the Drain London prioritisation matrix.

4.3.55 Additional schemes for consideration within this CDA include:

Source control SUDS at Gladstone Avenue & electricity substation

4.3.56 In addition to the scheme outlined above, there is potential for a swale of up to 400m long to incorporated in open land at the rear of Gladstone Avenue. A swale of this length could provide up to 800m^3 storage[16] and while providing mitigation for up to 88 properties in the local area, it could also be designed to provide some protection to the electricity substation at this location. Further investigation should be undertaken into ground levels and base level of the substation in relation to flood risk. Site level defences such as creating a bund around the substation could be investigated. Assuming a 400m long swale, the cost of this scheme would be approximately £26k to £50k.

4.3.57 Protection of the substation at this location may be the responsibility of the asset owner/operator. Potential for funding a joint scheme should be investigated.

Improvement to drainage infrastructure Harlequin Close and Palmerton Road

4.3.58 These two locations are located in low points and drainage infrastructure is sized as 225mm. Thames Water should run a capacity check at this location and if there is capacity within the network, the council may choose to add additional gullies connecting to the network (estimated cost £215 per gully based on SPONS Price Book 2010). The 225mm carrier pipe connects to a large capacity local sewer so it is anticipated that there will be capacity in the network at this location. Addition of 10 gullies would cost <£25k.

On-going maintenance of drainage infrastructure – quick win

The CDA should be added to the priority list of gully maintenance to ensure that the existing system is working to its full capacity.

CDA_002 ST MARGARET'S

4.3.59 There is limited data available on past floods within this CDA, and pluvial modelling shows that while there are some areas of pooling in the 1% AEP flood event, these should not cause major disruption.

4.3.60 No capital schemes are suggested within this CDA to be taken forward to the Drain London prioritisation matrix, however, there are a number of smaller 'quick win' schemes which the Council should investigate further in parallel with Borough wide measures.

[16] Based on a swale that is 0.5m deep with a 1.5m bed, 2.5m wide banks at a 1 in 5 slope

Improvement to drainage infrastructure St Margaret's Road

Proposed schemes could include the increase in Thames Water sewer pipe diameter at St Margaret's Road from 225mm diameter. However, this is likely to be costly when compared to the risk; a quick GIS query indicates that there are approximately 60 properties at risk of flooding along St Margaret's Road to a depth greater than 0.03m during the 1% AEP flood event, however no properties at this location are estimated to be at risk of flooding to depths of 0.5m. In addition there are no records of flooding at this location. It is estimated that an increase in pipe diameter for 500m length in road to 1200mm diameter would cost between £101k and £250k.

Control of overland flow through creation of preferential flow paths

Pluvial modelling indicates that overland flow from local parkland (Marble Hill Park) and school playing fields may flow onto local highways increasing local flood risk in an extreme event. It is suggested that this risk be considered in the future when any landscaping is undertaken to ensure that flow paths are managed and where possible, surface water storage provided within green areas potentially through the use of swales.

Thames Water capacity check of local drainage infrastructure

It is advised that Thames Water complete a capacity check on the network within this CDA, if there is capacity within the system, a quick win could be to incorporate some new gullies at 'pinch points' within the network including Arlington Road and Beaconsfield Road where the council has flood records. This measure would cost <£25k however, the benefit would only be limited to properties in the local vicinity. Any works in CDA should be supported through liaison with local residents to gain further details of past flood events.

Thames Water should also ensure that outfalls to the River Thames are working as designed and should also provide details of their river outfall maintenance regime to the Borough. This could be provided through the South West London Flood Group.

On-going maintenance of drainage infrastructure

The CDA should be added to the priority list of gully maintenance to ensure that the existing system is working to its full capacity.

CDA_003 STRAWBERRY HILL

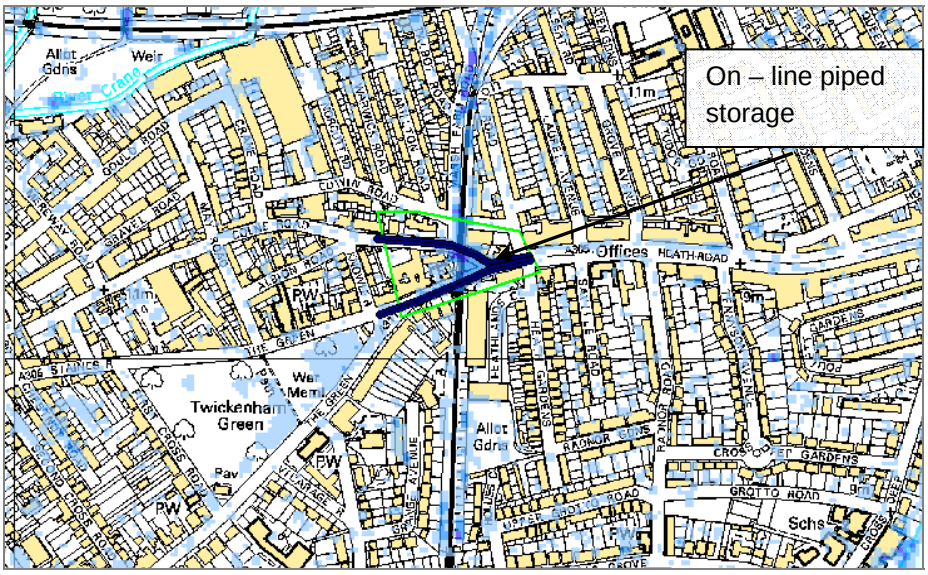
4.3.61 Surface water flood records highlight the crossing points of rail infrastructure as being the main risk within this CDA, however this disrupts traffic movement rather than flooding property.

Preferred option: ***Oversized pipe storage at Heath Road rail bridge (Figure 4-9)***

4.3.62 The preferred option for this CDA is to provide additional storage within pipes underneath the rail crossing as unfortunately local geology means that soakaways are not viable at this location.

4.3.63 The volume of water contained within the local vicinity in a 1% AEP flood event is estimated to be approximately 1800m^3. If a pipe 400m long was installed with a diameter of 1200mm, storage for approximately half of the potential flood water could be provided. It is estimated that including 8 new manholes the cost would be between £51k and £100k

Figure 4-9 Sketch to show possible location of pipe storage at Heath Road



4.3.64 This option has been included within Table 4-5 to be taken forward to the Prioritisation Matrix to inform Drain London Tier 3.

4.3.65 In addition to the capital scheme outlined above, it is suggested that some 'quick win' measures described below should be investigated further in parallel with Borough wide options described in Section 4.3.1.

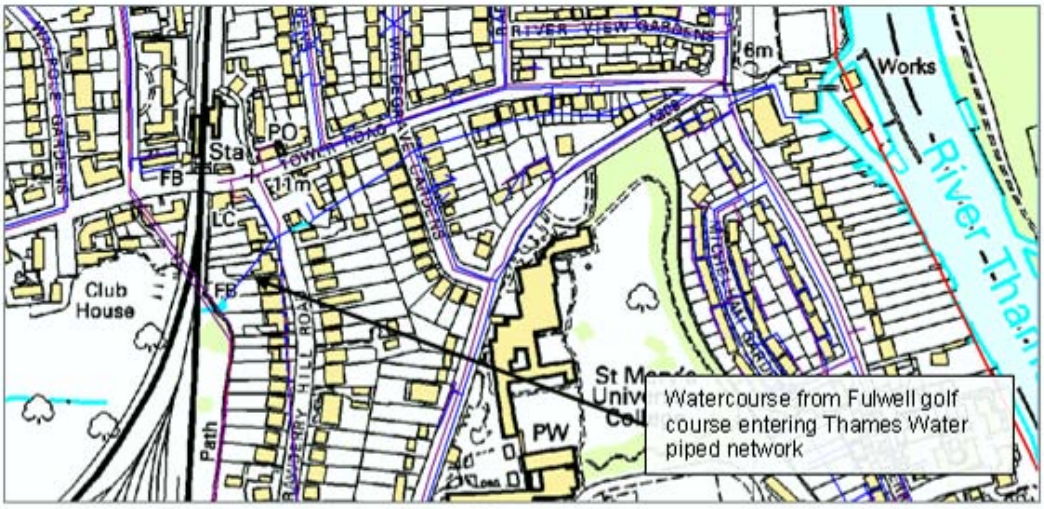
Thames Water capacity check of local drainage infrastructure

It is advised that Thames Water complete a capacity check at Heath Road/King Street and Heath Road rail crossing. Thames Water to establish if there is capacity within the network at this location and to identify any issues which may be leading to flooding at these locations. If there is sufficient capacity, the Council may choose to add more gullies to collect more runoff and discharge to the Thames Water sewer.

Condition survey of ordinary watercourse

A condition survey and ownership review of the watercourse extending from the Network Rail culvert at Fulwell Golf Course to the River Thames should be completed. Contact has been made with Thames Water as part of the SWMP as the watercourse is shown to enter a piped section which is shown on their network at this location (see Figure 4-9 below). If it is theirs' Thames Water need to confirm the maintenance regime and details should be added to the London Borough of Richmond upon Thames Drainage Asset Survey. Regular maintenance of all drainage assets including trash screens, River Thames outfalls and pumps should be completed within the CDA.

Figure 4-7 Thames Water Drainage Network identifying location of watercourse from Fulwell Golf Course to the River Thames



Incorporation of fringe drainage (swales) to control overland flow from Fulwell golf course to surrounding land

Ground levels on Sixth Cross Road and Hampton Road create flow paths for overland flow from Fulwell golf course onto the local highway. Liaison with the golf course should be initiated to discuss the control of overland flow from land management techniques and creation of preferential flow paths.

On-going maintenance of drainage infrastructure

The CDA should be added to the priority list of gully maintenance to ensure that the existing system is working to its full capacity.

CDA_004 RICHMOND TOWN CENTRE AND MORTLAKE

Preferred Option: *Flood Storage & Swale at Richmond Park/East Sheen Common*

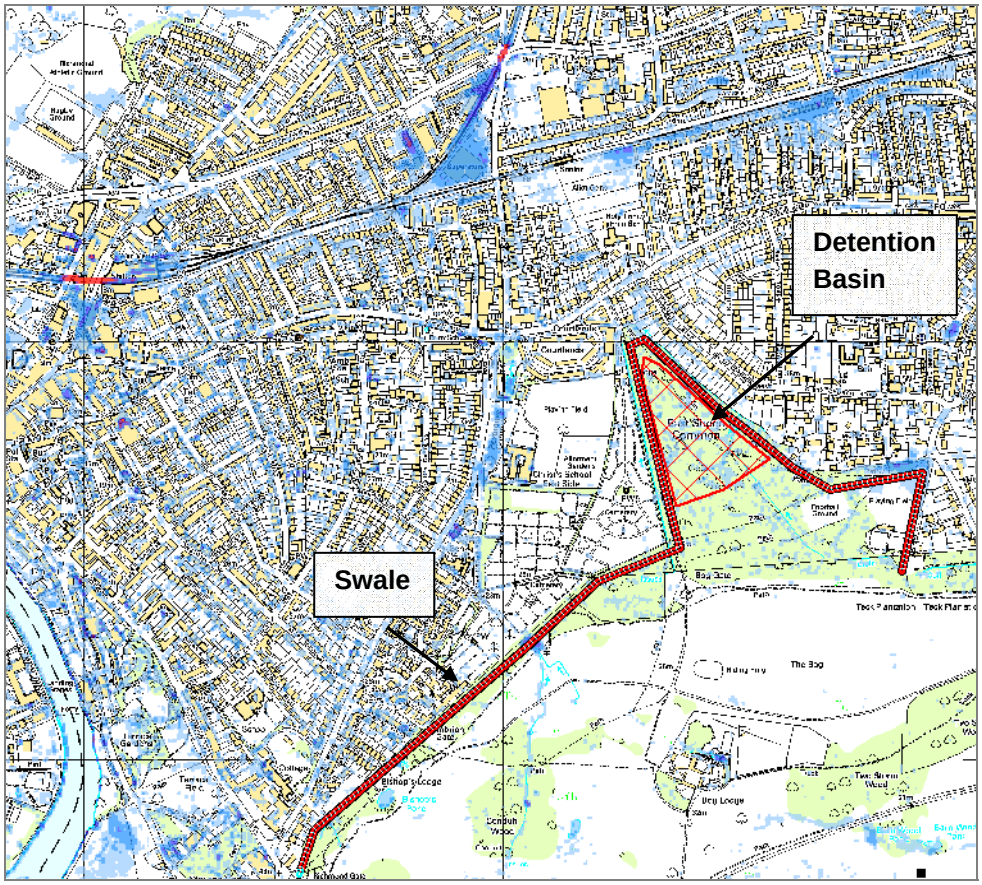
4.3.66 Following the options discussion regarding this CDA, it was decided that the risk of surface water flooding could be mitigated (in part) through the management of overland flows from Richmond Park. A detention basin has been sketched up with a storage volume of 50,000m^3, this has been supported by an adjoining swale running along the boundary of Richmond Park (see Figure 4-10 below). The cost of such a scheme is estimated to be >£1million (of which the swale is estimated to be £251k to £500k). This option has been taken forward to the Tier 3 prioritisation matrix.

4.3.67 In addition to the capital scheme described above, the following measures should be investigated further by the Borough:

Asset Survey of drainage channels at boundary of Richmond Park

An asset survey should be carried out to confirm the condition of drainage channels at the edge of Richmond Park. This survey should be used to confirm where the drainage channels connect to, what condition they are in and who is responsible for their maintenance. Details should be added to the Boroughs Asset Register.

Figure 4-8 Sketch to show possible location of a detention basin and swale at the boundary of Richmond Park



On-going maintenance of drainage infrastructure

There is a relatively steep gradient on some streets within this CDA (including Church Road) which may mean that water is not efficiently entering the local drainage network. Regular maintenance should help to alleviate this issue, it may be that some 'cut ins' could be provided where it is considered that gullies are not working to their full potential. These allow space for water to slow and drain naturally into the underlying drainage network.

Figure 4-9 Example of 'cut ins' used on The Gallop in the London Borough of Sutton

Retrofitting of SUDS schemes

This measure has been outlined within Section 4.3.1 Borough wide options. However, it is mentioned here again as the heavily urbanised nature of the north of this CDA leaves little potential for further storage. The council should look into providing standard advice

regarding retrofitting of industrial areas with water recycling technology and potentially permeable paving under car park areas. Both measures should be positively encouraged in all new development and within refurbishment of council owned buildings where possible (e.g. schools).

Thames Water capacity check of local drainage infrastructure

It is advised that Thames Water complete a capacity check at St Georges Road, in the vicinity of Tangier Road, Lower Mortlake Road at the superstore and in the vicinity of Richmond Town Centre rail station which are identified as being within LFRZ's associated with topographical lows. There is an increased risk of pooling of surface water which could create a flood risk to local property. Depending on the outcomes of the capacity check, the Borough may choose to improve the local drainage infrastructure through provision of additional gullies or improved flow path control which could be combined with speed control measures such as speed bumps.

On-going maintenance of drainage infrastructure – quick win

The CDA should be added to the priority list of gully maintenance to ensure that the existing system is working to its full capacity.

CDA_005 PETERSHAM

4.3.68 Due to the scale of flood risk within this CDA there are no capital schemes identified to be taken forward to the central Drain London prioritisation matrix for the purposes of Drain London Tier 3. Instead, it is suggested that the London Borough of Richmond upon Thames investigate the three potential solutions described below:

Source control SUDS at Petersham Park/Petersham Road

Richmond upon Thames Borough should further investigate the potential for implementing source control measures, potentially the inclusion of swales along the boundary of Petersham Park. This measure has been suggested within the Royal Borough of Kingston upon Thames CDA_008 and liaison with the Borough is suggested so that any lessons learnt can be applied to this CDA.

Alteration of local flow paths

Diversion of the natural flow path measures, raising of kerbs to prevent water flowing into property (Petersham Farm). This needs to be combined with addition of gullies to ensure that any flow that is diverted enters the drainage network rather than increasing flood risk to adjacent property.

Quick win - On-going maintenance of drainage infrastructure

The CDA should be added to the priority list of gully maintenance to ensure that the existing system is working to its full capacity.

Quick win – Property level flood protection.

The London Borough of Sutton has successfully implemented property level flood protection with funding from the Environment Agency and local residents. This option should be further investigated at this location.

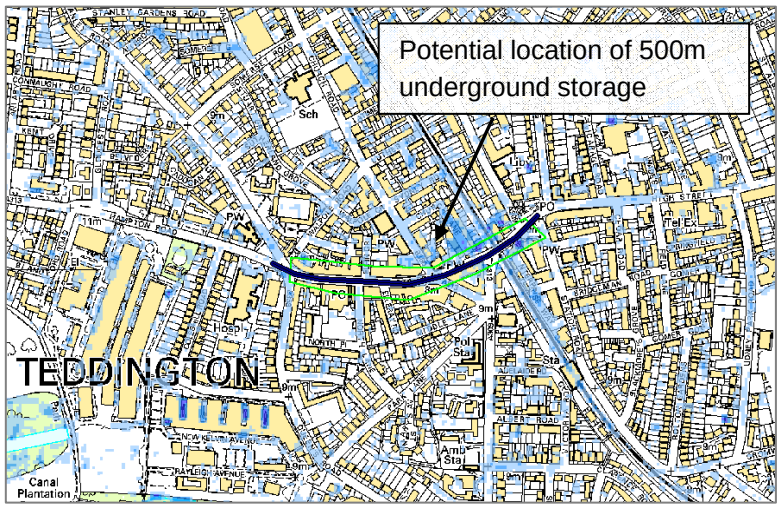
CDA_006 TEDDINGTON

4.3.69 This CDA has the worst flood history across the Borough and has some of the worst predicted future flooding. Options that should be applied within this CDA are a mix of measures to include both quick wins and capital schemes.

Preferred Option: *Flood Storage at Broad Street*

4.3.70 Following discussion at the options meeting, it was decided that it was imperative that a scheme was implemented at Broad Street Teddington. Due to the urbanised nature of the location and impermeable nature of the geology options available are limited and it is suggested that the council look to provide underground piped storage in collaboration with Thames Water. Initial calculations show pooling of approximately 1867m^3 water in the 1.3% AEP flood event. If a 1200mm diameter pipe (500m long) was provided at this location, 565m3 storage would be provided which will provide a 30% betterment on the existing situation. It is estimated that such a scheme will cost between £101k and £250k. Detailed modelling will be required in order to progress this scheme and any potential impact on the downstream catchment should be fully considered. Figure 4-10 is a sketch showing the possible location of an oversized pipe at Broad Street, Teddington.

Figure 4-10 Sketch to show possible location of an oversized pipe at Broad Street, Teddington



4.3.71 In addition to the capital scheme to be taken forward to the Drain London prioritisation matrix, the following options should be investigated further by the Borough:

Thames Water capacity check of local infrastructure

It is advised that Thames Water complete a capacity check within the Teddington CDA as there are reports of flood water containing foul water which suggests surcharging of the Thames Water network. The system appears to be separate which should be confirmed with Thames Water. Depending on the outcomes of the capacity check, the Borough may choose to improve the local drainage infrastructure through provision of additional gullies in the upstream catchment along Hampton Road to the west or improved flow path control which could be combined with speed control measures such as speed bumps.

Property Level flood protection schemes

This measure has been described at the Borough wide option level but it is particularly important that local residents and commercial property at Teddington are aware of potential surface water flood risks and how they can protect themselves through raising thresholds of property or re-designing shop frontages and doorways.

Source control SUDS Bushy Park

The council should liaise with local landowners to ensure that overland flow from parkland is not entering the local drainage network which is already under stress. Swales could be used to create preferential flow paths at the boundary of parkland.

Community Resilience

The Council should consider the feasibility of road closures during times of flood to prevent wash from vehicles entering property.

Quick win - On-going maintenance of drainage infrastructure

The CDA should be added to the priority list of gully maintenance to ensure that the existing system is working to its full capacity.

CDA_007 HAMPTON WICK

4.3.72 Pluvial modelling has identified relatively low level surface water flooding in this location with only 9 properties estimated to be at risk. However, Thames Water records indicate that there are 11-20 records of flooding on their DG5 register in the south of this CDA. No capital schemes are proposed for inclusion within the Drain London prioritisation matrix for Tier 3, however, it is suggested that the Borough use the links with Thames Water on the South West London Flood Group to discuss mitigation options of sewer flooding within this CDA. Potential options for mitigation which could be taken forward by the Council include:

Thames Water capacity check of local infrastructure

It is advised that Thames Water complete a capacity check within the Hampton Wick CDA as there are reports of flood water containing foul water which suggests surcharging of the Thames Water network. The system appears to be partly separate and partly combined, which needs to be confirmed by Thames Water. Depending on the outcomes of the capacity check and DG5 capital schemes, further liaison with Thames Water may be required to discuss mitigation measures.

On-going maintenance of drainage infrastructure

The CDA should be added to the priority list of gully maintenance to ensure that the existing system is working to its full capacity.

4.4 PREFERRED OPTIONS SUMMARY

4.4.1 A summary of mitigation options is presented in Table 4-5 below.

Table 4-5 Summary of Preferred options for Critical Drainage Areas

CDA_ID	CDA Name	Option Category	Option Description	Combination Scheme?	Costing & Storage Volumes										
					Measures	Unit Cost (£)	Unit Description	Unit	Length	Area	Depth	Volume	Number	Drain London Cost Band for Option	Drain London Cost Band for Combination Scheme
Group8_001	Twickenham	Source Control, Attenuation and SUDS	Detention basin on playing fields to the west of the Duke of Northumberland River	✓	Detention Basins	22	m3 of detention volume	m3	N/A	15000	N/A	15000	1	£251k - 500k	£251k - 500k
		Source Control, Attenuation and SUDS	Swale following the northern boundary of the Royal Military School of Music	✓	Swales	16	m2 of swale surface area	m2	380	2470	N/A	760	1	£26k - £50k	
		Source Control, Attenuation and SUDS	Swale on open land at Gladstone Avenue		Swales	16	m2 of swale surface area	m2	400	2600	N/A	800	1	£26k - £50k	-
		Other - Improvement to Drainage Infrastructure	Additional gullies on Harlequin Close and Palmerton Road		Increase the number or size of gullies to collect runoff and discharge to sewer	215	Per Gully	Per Gully	N/A	N/A	N/A	N/A	10	<£25k	-
Group8_002	St Margaret's	Other - Improvement to Drainage Infrastructure	St Margaret's Road, increase surface water pipe diameter from 225mm to 1200mm diameter.		Increasing Capacity in Drainage Systems	465	m of culvert (1200dia pipe)	m	500	N/A	N/A	2260	-	£101k - 250k	-
		Preferential / Designated Overland Flow Routes	Landscaping in the vicinity of Marble Hill Park to reduce surface water flowing onto the highway and surrounding properties.	✓	Managing Overland Flows (Preferential Flow paths)	–	N/A	N/A	N/A	N/A	N/A	N/A	N/A	-	Requires further assessment	£26k - £50k
		Other - Improvement to Drainage Infrastructure	Capacity check by Thames Water, depending on outcome, increase number of gullies on Arlington Road and Beaconsfield Road.	✓	Increase the number or size of gullies to collect runoff and discharge to sewer	215	Per Gully	Per Gully	N/A	N/A	N/A	N/A	10	<£25k	
		Improved Maintenance	The CDA should be added to the priority list of gully maintenance to ensure that the existing system is working to its full capacity (if not already on the list)	✓	Improved Maintenance Regimes		N/A	N/A	N/A	N/A	N/A	N/A	-	estimated to be limited cost (<£25k)	
Group8_003	Strawberry Hill	Other - Improvement to Drainage Infrastructure	Provide additional storage within pipes underneath rail crossing at Heath Road as soakaways are not viable at this location.	✓	Increasing Capacity in Drainage Systems	237.70	m of pipe*	m	400	1200mm diameter	N/A	N/A	-	£51k to £100k	£51k to £100k
		Other - Improvement to Drainage Infrastructure	Thames Water capacity check of pipe network at King Street/Heath Road. Depending on the results, add more gullies	✓	Increase the number or size of gullies to collect runoff and discharge to sewer	215	Per Gully	N/A	N/A	N/A	N/A	N/A	10	<£25k	
		De-culvert / Increase Conveyance	Condition survey of watercourse extending from the Network Rail culvert at Fulwell Golf Course to the River Thames.	✓	Other 'Pathway' Measures	N/A	N/A	N/A	N/A	N/A	N/A	N/A	-	Requires further assessment	Requires further assessment Requires further assessment
		Source Control, Attenuation and SUDS	Incorporate fringe drainage (swales) to control overland flow from Fulwell golf course to surrounding land.	✓	Increasing Capacity in Drainage Systems	N/A	N/A	N/A	N/A	N/A	N/A	N/A	-	Requires further assessment	
Group8_004	Richmond & Mortlake	Source Control, Attenuation and SUDS	Flood storage at Richmond Park/ East Sheen Common	✓	Detention Basins	22	m3 of detention volume	m3	N/A	N/A	N/A	50000	1	£1m - 10m	£1m - 10m
		Source Control, Attenuation and SUDS	Swale at the boundary of Richmond Park	✓	Swales	16	m2 of swale area	m2	2800	18200	N/A	5600	1	£251k - 500k	
		Other - Improvement to Drainage	Asset survey of condition of drainage channels at the edge of Richmond Park	✓	Other 'Pathway' Measures	N/A	N/A	N/A	N/A	N/A	N/A	N/A	-	Requires further assessment	

CDA_ID	CDA Name	Option Category	Option Description	Combination Scheme?	Costing & Storage Volumes										
					Measures	Unit Cost (£)	Unit Description	Unit	Length	Area	Depth	Volume	Number	Drain London Cost Band for Option	Drain London Cost Band for Combination Scheme
		Infrastructure													
		Planning Policy	Retrofitting SuDS schemes		Other 'Source' Measures	N/A	N/A	N/A	N/A	N/A	N/A	N/A	-	Requires further assessment	
Group 8_005	Petersham	Source Control, Attenuation and SUDS	Further investigate the potential for implementing source control measures, potentially including swales along the boundary of Petersham Park.	✓	Swales	16	m2 of swale area	m2	Requires further assessment	N/A	N/A	N/A	-	Requires further assessment	Requires further assessment
		Preferential / Designated Overland Flow Routes	Raising of kerbs and additional gullies to ensure that any overland flow is routed towards gullies and not into property.	✓	Managing Overland Flows (Preferential Flow paths)	215	Per Gully	Per Gully	N/A	N/A	N/A	N/A	10	<£25k	
Group8_006	Teddington	Other - Improvement to Drainage Infrastructure	Provision of underground pipe storage at Broad Street	✓	Managing Overland Flows (Online Storage)	237.70	m of pipe*	m	500	N/A	N/A	565	1	£101 to £250k	£101 to £250k
		Other - Improvement to Drainage Infrastructure	Thames Water capacity check of the pipe network at Broad Street. There are reports of foul water flooding which suggest under capacity of the combined system. Thames Water should also check the level and condition of any outfalls to the River Thames	✓	Other 'Pathway' Measures	N/A	N/A	N/A	N/A	N/A	N/A	N/A	-	Requires further assessment	
		Infrastructure Resilience	Property level protection at Broad Street. Building thresholds were above past flood levels, however water still entered property via wash from cars.		Temporary or Demountable Flood Defences	2000	Per property**	Per property	N/A	N/A	N/A	N/A	207 ***	£251k - 500k	-
		Community Resilience	Emergency planning - road closures to prevent wash from vehicles entering property		Social Change, Education and Awareness	N/A	N/A	N/A	N/A	N/A	N/A	N/A	-	Requires further assessment	-
		Source Control, Attenuation and SUDS	Control of overland flow from Bushy Park		Swales	N/A	m2 of swale area	N/A	N/A	N/A	N/A	N/A	-	Requires further assessment	-
Group8_007	Hampton Wick	Other - Improvement to Drainage Infrastructure	Liaise with Thames Water to discuss the potential for a capacity assessment followed by capital scheme to alleviate risk in areas served by a combined system.		Increasing Capacity in Drainage Systems	N/A	m of culvert	N/A	N/A	N/A	N/A	N/A	-		-

Note: This table has been produced to assist with the preliminary cost estimates as part of the SWMP for London Borough of Richmond upon Thames. All dimensions and costs are indicative and should only be used for preliminary estimates due to the generalised nature of the information used to compile it.

An estimated cost for the preferred flood mitigation option for each identified CDA has been calculated based on standard unit costs provided as part of Tier 1 of the Drain London Project to mitigate the 3.3% AEP (1 in 75 year event). No monetised damages have been calculated, and flood mitigation costs have been determined using engineering judgement, but have not undergone detailed analysis. The following standard assumptions have been applied, as determined in the Drain London Prioritisation Matrix Guidance:

- The costs are the capital costs for implementation of the scheme only.
- Costs do not include provisions for consultancy, design, supervision, planning process, permits, environmental assessment or optimum bias.
- No provision is made for weather (e.g. winter working).
- No provision is made for access constraints
- Where required, it will be stated if costs include approximate land acquisition components.
- No operational or maintenance costs are included.
- No provision is made for disposal of materials (e.g. for flood storage or soakaway clearance).

As a result, costs should be treated at an order of magnitude level of accuracy and have therefore been stated within this table and reporting text as a series of cost bands.

Swales are assumed to be 1.5m wide for the purposes of costing. The exact size of swales would need to be confirmed as part of site specific options assessments

* Unit cost (£237.70) based on 1200mm dia concrete pipes with rebated flexible joints to BS5911 Class L;excavation and supports, backfilling in trenches included. See SPONS 2007 p214

** £2k per property for property level protection is based on the London Borough of Sutton findings having installed a scheme of this type in 2010

*** referring to the total number of properties in the property count within this CDA 2076. 10% to be mitigated using property level defences

4.5 Recommendations for Next Steps and Quick Wins

4.5.1 Taking into account the nature of the surface water flooding in the London Borough of Richmond upon Thames, the options identified through the Phase 3 Options Assessment, and requirements under the FWMA and FRR2009, it is considered that the London Borough of Richmond upon Thames should prioritise the following actions in the short to medium-term:

- Identify and record surface water assets as part of the London Borough of Richmond upon Thames Asset Register, prioritising those areas that are known to regularly flood and are therefore likely to require maintenance or upgrading in the short-term;
- Develop a local strategy for flood risk management;
- Consider the provision of an 'Information Portal' via the London Borough of Richmond upon Thames website, for local flood risk information including links to the relevant Environment Agency web pages that provide advice on measures that can be taken by residents to mitigate surface water flooding to / around their property. This could be developed in conjunction with the South West London Flood Group and include:
    - A list of appropriate property-level flood risk resilience measures that could be installed in a property;
    - A link to websites / information sources providing further information such as the National Flood Forum 'blue pages';
    - An update on work being undertaken in the Borough by the Council and/or other Stakeholders to address surface water flood risk; and,
- Prepare a Communication Plan to effectively communicate and raise awareness of surface water flood risk to different audiences using a clearly defined process for internal and external communication with stakeholders and the public.
- Use the findings of the SWMP to review the priority areas that are currently targeted for gully cleansing and maintenance and amend if necessary.
- Collate and review information on Ordinary Watercourses in the Borough to gain an improved understanding of surface water flooding in the vicinity of these watercourses as well as ownership and maintenance responsibility for each watercourse.
- In conjunction with Thames Water, determine the capacity of the existing sewer network along Harlequin Close and Palmerton Road (CDA_001 Twickenham), Arlington Road and Beaconsfield Road (CDA_002 St Margaret's), Heath Road (CDA_003 Strawberry Hill) and St Georges Road (CDA_004 Richmond Centre). Options for increasing the surface water sewer capacity, or number of gullies connecting to the system at these locations should be investigated.
- Undertake a Drainage Capacity Study for the Teddington (Broad Street) CDA_006. The Study could consider the following:
    - Identifying and recording surface water assets, including type, location and condition, as required for preparation of the Asset Register;
    - Determine the condition and capacity of gullies and carrier pipes;
    - Determining the connections to Thames Water surface sewers and assets;
    - Undertaking CCTV surveys of those areas which experience regular surcharging and flooding;

- Clearing those gullies or pipes identified as blocked during investigations (as part of annual maintenance routine); and,
- Determining upgrade requirements and costs for the local drainage infrastructure and seek funding opportunities to implement these.

4.6 Option Prioritisation

4.6.1 The Prioritisation Matrix was developed out of the need for a robust, simple and transparent methodology to prioritise the allocation of funding for surface water management schemes across the 33 London Boroughs by the Drain London Programme Board. As such, the prioritisation should be understood in the high-level decision-making context it was designed for. It is not intended to constitute a detailed cost-benefit analysis of individual surface water flood alleviation schemes.

4.6.2 The information within Tables 4-5 (above) and Table 4-6 will be used by the Drain London Programme Board to populate the Drain London Prioritisation Matrix and identify capital schemes to be taken forward under the Tier 3 package of works.

Table 4-6 Phase 3 Summary of Preferred Options (*for input into Drain London Prioritisation Matrix only)*

CDA ID	Scheme Location	Scheme Category	Infrastructure						Households				Commercial / Industrial		Capital Cost Band
			Essential		Highly Vulnerable		More Vulnerable		Non-Deprived (All)		Deprived (All)		All		
			Eliminated (%)	Mitigated (%)	Eliminated (%)	Mitigated (%)	Eliminated (%)	Mitigated (%)	Eliminated (%)	Mitigated (%)	Eliminated (%)	Mitigated (%)	Eliminated (%)	Mitigated (%)	
CDA_001	Royal Military School of Music	Source Control SUDS	0	100	0	0	0	0	0	10	0	0	0	2	£251k-£500k
CDA_002	St Margaret's - No capital measures identified for inclusion within the Drain London Prioritisation Matrix. It is suggested that 'quick win' measures be applied.														
CDA_003*	Heath Road rail crossing	Flood storage	0	0	0	0	0	0	0	2	0	0	0	4	£51-£100k
CDA_004	Richmond Park	Source control SUDS	0	0	0	0	0	4	0	7	0	0	0	1	>£1m
CDA_005	Petersham - No capital measures identified for inclusion within the Drain London Prioritisation Matrix. It is suggested that 'quick win' measures be applied.														
CDA_006	Teddington	Flood storage	0	0	0	0	0	37	0	11	0	0	0	28	£101k-£250k.
CDA_007	Hampton Wick - No capital measures identified for inclusion within the Drain London Prioritisation Matrix. Further liaison with Thames water required														

Note: The Drain London Prioritisation Matrix requires an estimation of the percentage of total number of units that have the potential to benefit from the proposed scheme. This has been determined by calculating the number of units within the Local Flood Risk Zone that the scheme has been designed to mitigate, as a percentage of the number of units within the CDA as a whole. The input is restricted to multiples of five percent. It should be noted that the information within this table is purely for input into the Drain London Prioritisation Matrix and should be treated as such.

*CDA_003 Heath Road Rail Crossing shows 0% mitigation of infrastructure as there is no 'property point' within the technical query associated with the railway line therefore there is no measured improvement to flooding shown in Table 4-6. The prioritisation matrix allows a moderation column for strategically important infrastructure; this will be used to highlight the importance of the London to Woking rail link.

5. Phase 4: Implementation and Review

5.1 ACTION PLAN

5.1.1 The purpose of Phase 4 of the SWMP is to clearly identify actions and responsibilities for the ongoing management of surface water flood risk within the London Borough of Richmond upon Thames that have been identified throughout the work undertaken in Phases 1 to 3.

5.1.2 A draft Action Plan has been produced for the London Borough of Richmond upon Thames (see Appendix I). This includes capital and maintenance actions and programmes of work for each partner/stakeholder, including the proposed timing and manner of implementing the actions; a programme of further work or follow up actions; and, a list of other flood risk management measures being undertaken in the plan area to achieve objective in European legislation (such as Water Framework Directive or Habitats Directive).

5.1.3 The purpose of the Action Plan is to:

- Outline the actions required to implement the preferred options identified in Phase 3;
- Identify the partners or stakeholders responsible for implementing the action;
- Provide an indication of the priority of the actions and a timescale for delivery;
- Outline actions required to meet the requirements for London Borough of Richmond upon Thames as LLFA under the FWMA 2010.

5.1.4 Actions within the draft Action Plan have been categorised as summarised in Table 5-1.

Table 5-1 Types of Action within the draft Action Plan for LB Richmond upon Thames

Definition	Action Type Abbreviation	Description
Flood and Water Management Act / Flood Risk Regulations	FWMA / FRR2009	Duties and actions as required by the FRR2009 and FWMA - Refer to Appendix A of the LGG 'Preliminary Framework to assist the development of the Local Strategy for Flood Risk Management' (February 2011) for minimum requirements.
Policy Action	Policy	Spatial planning or development control actions.
Communication / Partnerships	C+M	Actions to communicate risk internally or externally to LLFA or create / improve flood risk related partnerships.
Financial / Resourcing	F+R	Actions to secure funding internally / externally to support works or additional resources to deliver actions.
Investigation / Feasibility / Design	I/F/D	Further investigation / feasibility study / Design of mitigation.
Flooding Mitigation Action	FMA	Maintenance or capital works undertaken to mitigate flood risk.

5.1.5 As identified in Table 5-1, a number of the key actions for London Borough of Richmond upon Thames relate to duties and responsibilities under the FWMA and the FRR2009 outlined in Section 1.7. It is likely that these actions may require consideration of internal Borough functions, roles of specific personnel, and adopting new systems of data collection and asset management.

5.1.6 Actions that will need to be delivered through policy include policies or strategies for influencing the use of rainwater harvesting techniques, managing driveway resurfacing and associated drainage, and the use of SuDS.

5.1.7 As our understanding about surface water flood risk improves and more information is made available, it becomes increasingly important to be able to communicate the risk effectively both within the London Borough of Richmond upon Thames and to other stakeholders and members of the public. To this end a number of actions relate to the future communication of flood risk and the London Borough of Richmond upon Thames have begun to consider the implementation of a Communication Plan to deliver this action.

5.1.8 Continuing to forge partnerships with neighbouring London Boroughs through the establishment of the South West London Flood Group will be essential to the continued management of surface water across this area in a joined-up manner. Collaboration with neighbouring London Boroughs is also likely to aid each local authority in meeting the requirements of the FRR2009 and taking on new roles and responsibilities under the FWMA.

5.1.9 As well as these Borough-wide actions, a number of actions have been identified for specific CDAs based upon the preferred options identified for each CDA. Within London Borough of Richmond upon Thames, these are predominantly either capital works in the form of SuDS and creation of flood storage areas, or further investigation through more detailed modelling and initial surveys, or where appropriate feasibility studies.

5.1.10 As part of the preparation of the Action Plan and SWMP, the requirement for a Strategic Environmental Assessment (SEA), an Appropriate Assessment (required by the Habitats Directive) or and Article 4.7 assessment (under the Water Framework Directive) was considered. A screening decision was made which suggested that the SWMP alone does not require any of the environmental assessments described above. However, it is possible that any actions which are taken forward will require such assessments and it is envisaged that the requirement for this will form part of the feasibility studies for individual schemes.

5.2 Ongoing Monitoring

5.2.1 The partnership arrangements established as part of the SWMP process should continue beyond the completion of the SWMP in order to discuss the implementation of the proposed actions, review opportunities for operational efficiency and to review any legislative changes.

5.2.2 The SWMP Action Plan should be reviewed and updated once every six years as a minimum, but there may be circumstances which might trigger a review and/or an update of the action plan in the interim, for example:

- Occurrence of a surface water flood event;
- Additional data or modelling becoming available, **which may alter the understanding of risk within the study area;**

- If the outcome of investment decisions by partners is different to the preferred option, which may require a revision to the action plan, and;
- Additional (**major**) development or other changes in the catchment which may affect the surface water flood risk.

6. References

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Forecast cost estimates do not include such costs associated with any negotiations, appeals or other non-technical actions associated with the agreement on measures to meet the requirements of the authorities, nor are potential business loss and interruption costs considered that may be incurred as part of any technical measures.

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Appendix A - Data Review

A review of the data provided as part of Drain London Tier 1 package of works and that used within this SWMP has been undertaken. An assessment of the quality of the data has been completed, using the criteria set out in the Defra SWMP Guidance, which is summarised in Table A-1.

Table A-1 Data Review Scoring System (from Table 3-1 in Defra SWMP Guidance 2010)

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

Colour Label used in Data Review Columns	
GY	No data (hidden column)
R	Not useful information
O	Potentially useful / needs further work
GN	Useful information

Appendix B - Asset Register Recommendation

A review of the data provided as part of Drain London Tier 1 package of works and that used within this SWMP has been undertaken and is provided electronically alongside this report.

Appendix C - Risk Assessment: Technical Details

Appendix C1 –Pluvial Modelling Methodology

Appendix C2 – Intermediate Assessment of Groundwater Flooding Susceptibility

Appendix D - Figures

Appendix E - Options Assessments

The Options Assessments for each CDA have been undertaken in Excel Worksheets. These are provided electronically as part of this report.

List of Excel Worksheets

RIC_GP8_001 Twickenham Options Assessment Table_01.xls
RIC_GP8_002 St Margaret's Options Assessment Table_01.xls
RIC_GP8_003 Strawberry Hill Options Assessment Table_01.xls
RIC_GP8_004 Richmond and Mortlake Options Assessment Table_01.xls
RIC_GP8_005 Petersham Options Assessment Table_01.xls
RIC_GP8_006 Teddington Options Assessment Table_01.xls
RIC_GP8_007 Hampton Wick Options Assessment Table_01.xls

Table E-1 Drain London Prioritisation Matrix Unit Costing Spreadsheet

Defra Classification	Measure	Cost Rate (£)	Unit	Notes / Source
Source	green roof;	£146	m2 of roof	GLA - Living Roofs and Walls - Technical Report: Supporting London Plan Policy (2008)
	soakaways;	£219	m3 of stored volume	CIRIA SUDS Manual (2007)
	swales;	£16	m2 of swale area	CIRIA SUDS Manual (2007)
	permeable paving;	£44	m2 of surface	CIRIA SUDS Manual (2007)
	rainwater harvesting;	£1,100	m3 of stored volume	Adapted from: http://www.rainwaterharvesting.co.uk/
	detention basins	£22	m3 of detention volume	CIRIA SUDS Manual (2007)
	ponds and wetlands.	£33	m3 of detention volume	CIRIA SUDS Manual (2007)
	Other 'Source' measures	N/A	N/A	Justification to be supplied by consultant
Pathway	increasing capacity in drainage systems;	Table 21	m of culvert	EA FRM Estimating Guide (2010) – Refer Appendix B
	separation of foul and surface water sewers;	£465	m2 of separation catchment area	Adapted from Thames Water Counters Creek Project (http://www.thameswater.co.uk/cps/rde/xchg/corp/hs.xsl/9344.htm)
	improved maintenance regimes;	N/A	N/A	Justification to be supplied by consultant
	managing overland flows	N/A	N/A	Justification to be supplied by consultant
	land management practices.	N/A	N/A	Justification to be supplied by consultant
	Other 'Pathway' measures	N/A	N/A	Justification to be supplied by consultant
Receptor	improved weather warning;	N/A	N/A	Justification to be supplied by consultant
	planning policies to influence development;	N/A	N/A	Justification to be supplied by consultant
	temporary or demountable flood defences;	£25,000	Per property protected	Adapted from: http://www.floodguarduk.co.uk/ AND http://www.ukfloodbarriers.com/
	social change, education and awareness	N/A	N/A	Justification to be supplied by consultant
	improved resilience and resistance measures	£22,000	Per property protected	Adapted from Defra "Flood resistance and resilience solutions: an R&D scoping study" (2007)
	Other 'Receptor' measures	N/A	N/A	Justification to be supplied by consultant

Appendix F - Peer Review

Appendix G - Spatial Planning Information Pack

Appendix H - Resilience Forum & Emergency Planner Information

Appendix I - Action Plan