London Regional Flood Risk Appraisal

October 2009

Contents **Page**

List of Diagrams

Executive Summary

The flooding in parts of England in 2007 gave a renewed focus to flood risk management. The Mayor is aware that flood risk is a major issue for London and that if the rainfall seen elsewhere in England in 2007 had fallen on London, it would have triggered a major civil emergency. The likelihood of flood is increasing with climate change. The potential consequences of flooding are also increasing as London's population continues to grow. This RFRA, combined with the policies in the draft replacement London Plan and a range of actions being undertaken by various organisations, aims to ensure that overall flood risk (probability x consequences) does not increase and that by addressing existing problems, overall risk is reduced.

Managing flood risk in London cuts across the responsibilities of many organisations. Whilst the Environment Agency has the lead responsibility, it is clear that co-ordinated actions/policies and collaborative working are required to manage and minimise the risks. This RFRA contains 19 recommendations, involving or lead by a range of organisations. Progress against the recommendations will be monitored annually in the London Plan Annual Monitoring Report.

Chapter 1 - Introduction

Regional Flood Risk Appraisal (RFRA)

1. Flood risk is a major issue for London. Diagram 1 illustrates that 15% of Greater London has some extent of known tidal and/or fluvial flood risk. The issue of flood risk has become increasingly recognised over recent years with much publicised floods during the 1990s and early part of the 21st century. This has followed a long period when major floods did not affect London and when, consequently, flooding had not received a high profile in matters relating to land use planning. Previous notable floods occurred in 1947 and 1953, each of which resulted in responses to increase flood protection through capital projects. The publication of PPG25 in 2001 marked a step change in the approach to flood risk management in the planning system.

2. In December 2006 PPS25 (Planning Policy Statement 25 Development and Flood Risk) was published. It continues to raise the profile of flood risk management amongst land use and planning considerations. One of the key elements it introduces is the requirement for Regional Planning bodies to produce a RFRA to accompany Regional Spatial Strategies. This fits in to a hierarchy of Flood Risk Appraisal:

Hierarchy of Flood Risk Appraisal

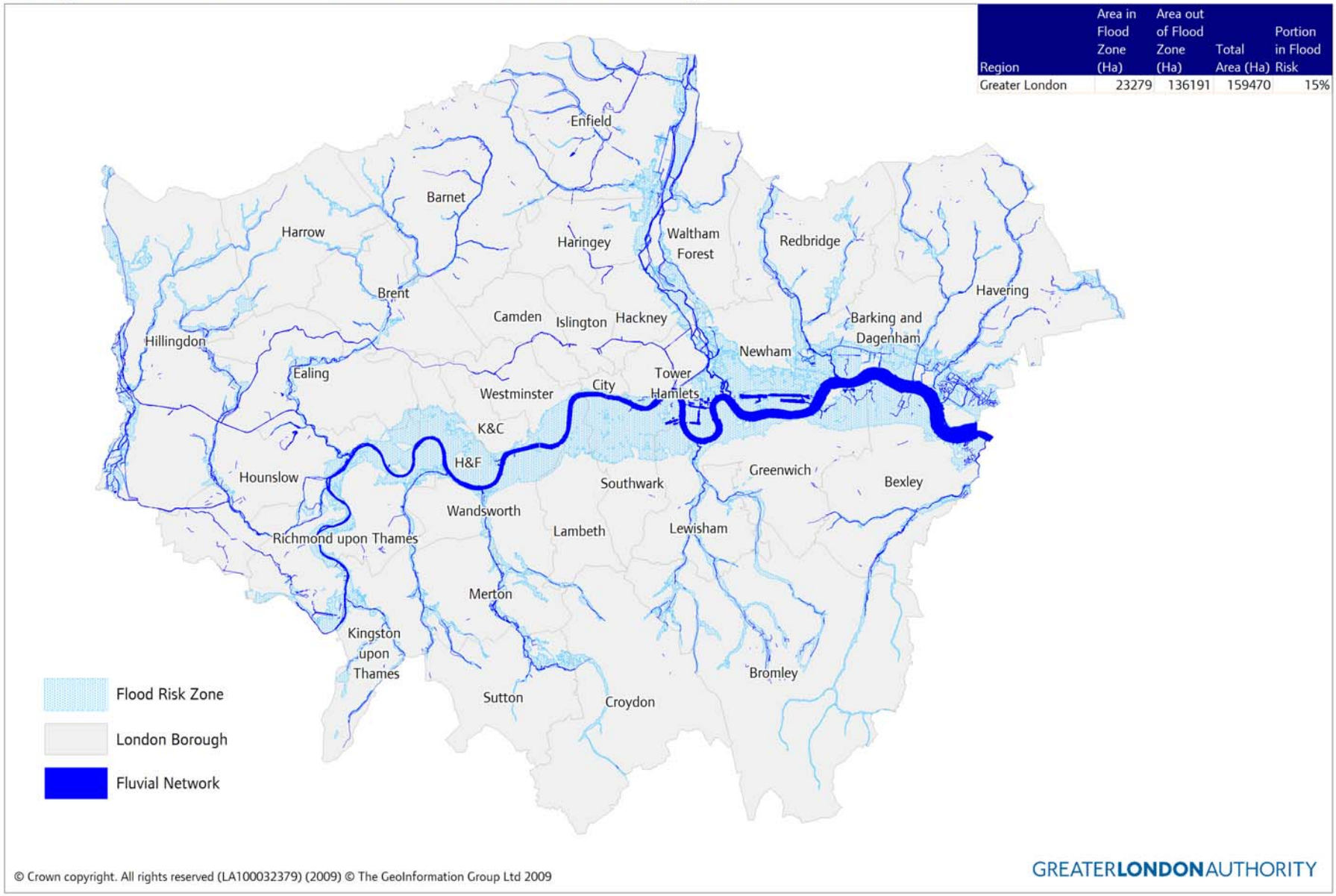
Flood Risk Management Tool	Applicable to	Prepared by
Regional Flood Risk Appraisal	Regional Spatial Strategy	Regional Planning Body
Strategic Flood Risk Assessment	Local Development Document or Area Action Plans	Local Planning Authority
Flood Risk Assessment	Specific sites	Developer/land owner

3. According to PPS25 a RFRA should include a broad consideration of flood risk, informed by appropriate operating authorities. This RFRA has been undertaken with the assistance of the Environment Agency. In 2008 Government published a Practice Guide to PPS25 http://www.communities.gov.uk/publications/planningandbuilding/pps25practiceguide . This is useful in highlighting how best to implement PPS25.

4. This RFRA deliberately crosses the boundary between land use planning and emergency planning, as suggested in the PPS25 Practice Guide. This has been done as the Mayor recognises that there is not always close liaison between the two disciplines and it will be important to stimulate greater links between them. The London Resilience Team has recently published its draft London Strategic Flood Plan (LSFP). This seeks to co-ordinate emergency services and emergency planners across London in the event of a major flood. This is the first time it has been updated since the opening of the Thames Barrier. It will be important to foster links between the RFRA and the LSFP.

5. The Environment Agency is the national lead on flood risk management and has produced or is producing further research which has been an important input to this Appraisal.

Diagram 1 Flood Zones and London Boroughs



Progress since Draft RFRA

6. In June 2007 the Mayor issued a draft RFRA for consultation. Since then a number of key events have taken place. The floods of summer 2007 and the subsequent Pitt Review are key but there are also some proposed changes to PPS25 that Government is currently consulting on and continued progress by Environment Agency on Catchment Flood Risk Management Plans and TE2100.

Consultation

7. The following organisations responded to the Consultation:

Environment Agency
London Borough Barking & Dagenham
London Borough Greenwich
London Borough Haringey
London Borough Richmond Upon Thames
London Development Agency
London Fire and Emergency Planning Authority
London Fire Brigade
Thames Water
Transport for London

8. The consultation was just prior to a series of major floods across England, particularly affecting Gloucestershire, Humberside and parts of Yorkshire. London suffered relatively minor flooding, however, the flooding acted as a wake up call for both London and the country as a whole. There can be no doubt that if the extremely high volumes of rainfall that affected some parts of the country had fallen across London, there would have been huge disruption, damage and danger to life that would have taken months, possibly years to have recovered from.

9. The Government quickly announced a review of flood risk, this was the Pitt Review http://archive.cabinetoffice.gov.uk/pittreview/thepittreview.html . This examined all aspects of flood risk management from forecasting and warning, to flood event management and evacuation/rescue to recovery and rehabilitation.

10. The publication of this RFRA has been delayed to take account of the Pitt Review, whose final report was published in June 2008 and the Government's response to the report.

The London Plan

11. The London Plan was originally published in 2004. It was reviewed twice during 2004-8, resulting in the publication (Feb 2008) of the London Plan Consolidated with changes since 2004. The Draft RFRA informed the Feb 2008 London Plan. The Mayor has now published a draft replacement London Plan, October 2009 with the intention of publishing a Replacement London Plan in late 2011.

12. The findings of this RFRA have shaped the policies within the draft replacement London Plan and the policy references contained in this RFRA are taken from that document. Flood risk is recognised as an important consideration for all developments and in combination with PPS25, policy 5.12 sets out the strategic approach in London. Flood risk is also referred to in relation to several of the Opportunity Areas where there

is known to be a particular risk. Flood risk has been an important constraint in identifying capacity for housing in London through the Strategic Housing Land Availability Assessment (SHLAA). Sites with a known flood risk had their capacity reduced depending upon the severity of the risk and no sites within the functional flood plain (zone 3b) or greenfield zone 3a sites were identified as having housing capacity.

The Sequential Test

13. PPS25 contains a sequential test to ensure that development takes place in the areas available at lowest flood risk. London is a unique city in the UK. It is heavily built up with a tightly drawn administrative boundary. The Green Belt policy is now long standing and has been largely successful in its aims of preventing London from spreading, preventing the coalescence of peripheral settlements and protecting open countryside. This success is now reaping the additional benefit of promoting the re-use and regeneration of brownfield land which is widely seen as an important element in achieving sustainable development. In some places that were generally undeveloped in the middle of the 20th Century, the Green Belt extends into London, for example in the Lee Valley. Other significant open spaces are also protected by the land use planning system with various levels of policy; the highest of these, Metropolitan Open Land (MOL) provides a similar level of protection to Green Belt.

14. The delineation of the Green Belt and the other protected open spaces in London mean that the scope for new development on land other than brownfield redevelopment land is extremely limited. Over recent years, monitoring (London Plan Annual Monitoring Reports) has indicated that over 96% of new development has been on brownfield sites. The vast majority of future development in London is therefore expected to take place on brownfield land.

15. Many of London's remaining large brownfield areas are either substantially or partially within flood zones. Diagram 4 demonstrates that 42% of the area of Opportunity Areas and 24% of the area of Intensification Areas are within known flood zones. However alternative sites for large scale development within London do not exist without encroaching into Green Belt, MOL or other protected spaces.

16. The SHLAA exercise examined the potential housing capacity of over 10,000 sites within London. Flood zone 3b and greenfield zone 3a sites were excluded as a strategic approach to the sequential test. It is clear however, that in order to meet London's housing need, consideration will have to be given to brownfield zone 3a sites.

17. Therefore from a strategic perspective, the sequential test permits the consideration of these sites for development. It will still be necessary for boroughs and developers to apply the sequential test locally and consider flood risk assessments at a more detailed level when allocating uses or applying for planning permission. It will still remain important to place more vulnerable uses in areas with lower flood risk in order to meet the Sequential Test at a local level.

How to use the RFRA

18. The RFRA is a strategic overview of flood risk across London. It does not represent a detailed analysis of flood risk in relation to any particular areas or sites. It contains a series of recommendations which are either region wide, applicable to boroughs in undertaking their SFRAs or apply to utility/service providers. Progress against these recommendations will be reported annually in the London Plan Annual Monitoring Report, normally published in February.

19. The RFRA will remain a live document with regular updates to reflect the changing position in relation to both climate change and development pressure and policy responses. The first anticipated review will be in early 2012 to reflect the final replacement London Plan and in general reviews should be no less frequent than every 5 years.

20. The RFRA should be useful to spatial planners, developers, infrastructure and utility operators and emergency planners. It is a specific aim of this RFRA to bring spatial planners and emergency planners into closer communication.

Chapter 2 - Overview of Flood Risk

21. London is exposed to 5 different potential sources of flooding. These are analysed below, each has different spatial impacts on London and requires a different set of responses. Some responses relate to the land use planning system, whilst others relate to broader spatial matters or operational considerations for a range of organisations.

Each type of flooding is analysed by examining:

- Nature of the risk
- Development locations that may be affected
- Information available
- Broad flood risk management options
- The likely impact of climate change
- Strategic recommendations

22. Chapter 3 goes on to consider flood risk in relation to key locations and infrastructure in London. In this way the RFRA represents an examination of both the potential future flood risk issues and the existing flood risk issues that affect London. By doing this it can make recommendations that fulfil one of two functions. Firstly, how to ensure that future flood risk is minimised and any residual flood risks are managed appropriately. Secondly, to promote new development that will help to reduce and manage existing flood risks. This approach is in line with PPS25.

Tidal Flood Risk

Nature of Risk

23. The River Thames and the lower reaches of some of the tributary rivers are affected by the tide. The River Thames has a very large tidal range, in excess of 7 metres on spring tides. The tide's influence reaches to Teddington Lock on the Thames and up several tributaries, for example as far as Lea Bridge on the River Lee.

24. Without the current river walls many areas of London alongside the Thames and along the tidal stretches of the tributaries would be inundated twice a day through the normal tidal cycle. River walls have been steadily built up since Roman times to give increasing levels of flood protection and to enable urban development.

25. The particular threat that has remained is from tidal surges. These occur when a combination of high tide, easterly winds and a weather system depression over the North Sea can cause the tide levels to increase significantly above the normal tidal range. Previous incidents of this type of flood risk date back to 1236. More recently, in 1928, 14 people were drowned in Westminster; this was the last time that central London suffered tidal flooding. In 1953 London was largely spared the impacts of a devastating tidal flood that cost the lives of over 300 people in the East of England. If that flood had funnelled further up the Thames the results could have been even more disastrous.

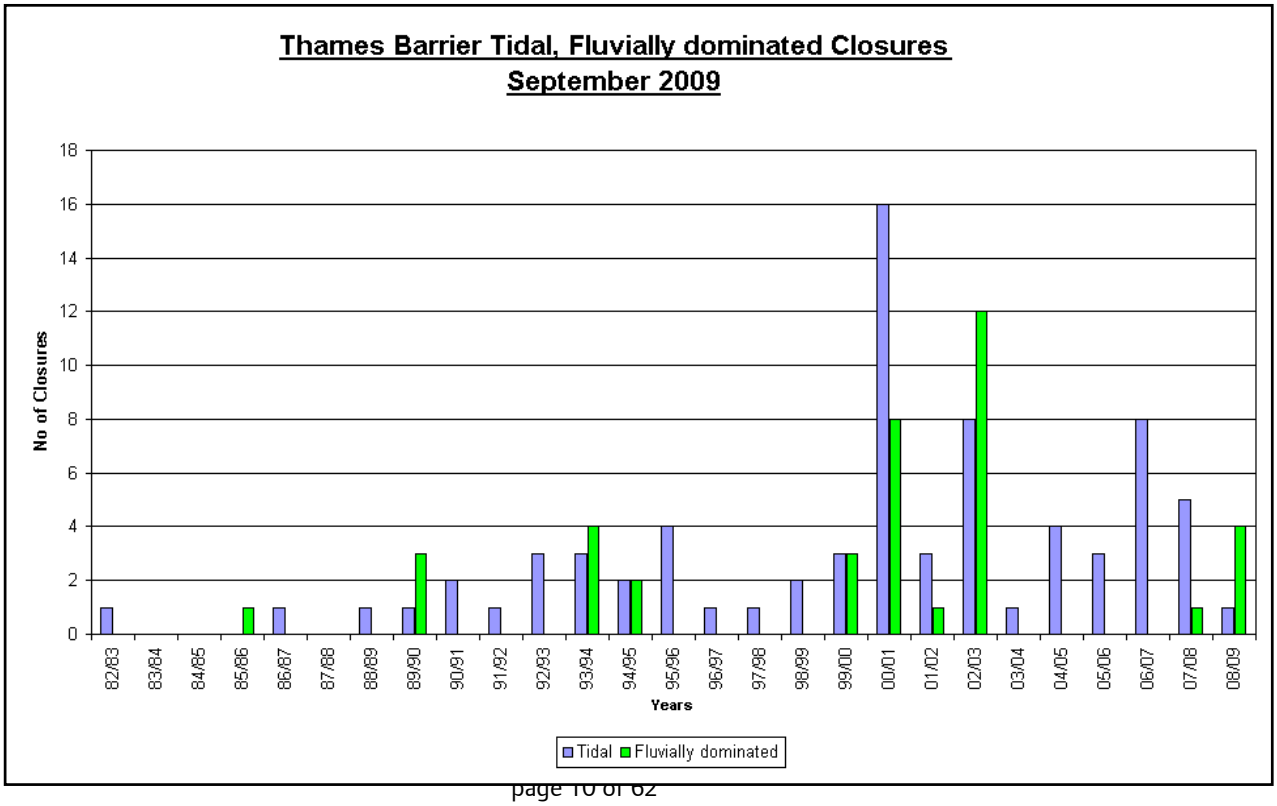
26. The area at risk of tidal flooding, including from storm surges approximates to the 5 metre contour line and is shown on Diagram 1. The area of London below the normal high tide range is approximately 6200ha and affects parts of 12 London boroughs. The area that could potentially be affected by a storm surge of the same magnitude as the 1953 flood covers 11 600ha and affects parts of 20 London boroughs.

27. As a result of the 1953 flood, a system of flood defences was constructed. The most iconic element of this is the Thames Barrier, which has been operational since 1982. There are also around 400 smaller barriers and movable flood gates downstream of the Thames Barrier and over 300km of river walls and embankments stretching into Essex and Kent that have been raised by 2 metres to give additional protection from storm surges. Upstream of the Thames Barrier river walls are still necessary to prevent the normal range of high tides from flooding parts of inner and central London. This system of tidal flood defences made allowance for sea level rise and London is therefore protected to a very high level. It is estimated that the level of protection will reduce down to standard of 1 in a 1000 year (0.1% chance per year) by 2030 and this will continue to decline if no further measures are taken.

28. Since its completion in 1982, the Thames Barrier has been closed 116 times (up to September 2009) to prevent flooding. Diagram 2 below indicates that the number of closures per year is fairly variable; however, there is a general increase in the number of closures. This ties in with climate change observations. Closure of the Thames Barrier also necessitates closure of other barriers and flood gates, prevents navigation and restricts the ability of other vessels to moor or unload cargoes downstream of the Barrier. The Environment Agency has indicated that closing the Thames Barrier more than 70 times in a year is not likely to be sustainable.

29. There are residual risks even given the high standard of flood risk management measures that are in place. These risks are two fold – either from an overtopping of the defences – ie a larger event than has been planned for or by a breach in the defences – ie a failure, either accidental or deliberate of the defences. The likelihood of such residual risks are very small however, the scale of consequences from rapid inundation and deep water in heavily urbanised areas mean that these residual risks must be considered.

Diagram 2 Thames Barrier Closures



Locations

30. The tidal flood risk area through London affects areas to the north and south of the Thames and up some of the tributary rivers. Given that much of the land alongside the Thames in central and inner London has been in active urban uses for centuries, it is not surprising that there is a lot of infrastructure already in place there although it is protected to a high standard by the combination of the river walls and the Thames Barrier.

31. In north east and south east London there are large areas of derelict or under used land forming the Thames Gateway. These areas have mostly been in industrial uses, many of which have now ceased or are declining. These areas make up some of the major opportunities for London to accommodate its own growth pressures. Being alongside the river it is to be expected that many of these areas will have an associated element of flood risk. Despite their derelict, underused or industrial nature these areas are also protected from flooding to a high standard.

Information available

32. The 1 in 1000 year tidal flood envelope is shown on diagram 1 and covers a wide area. It is closely related to the 5m land contour. This area is currently defended to a high standard by the combination of flood walls and embankments and the Thames Barrier and other movable gates and barriers.

33. The condition of flood defences is held on a database by the Environment Agency which carries out regular inspections to update the condition survey and take appropriate action either directly or through the structure owners to ensure that structures are in a sound condition. The vast majority of flood defences along the Tidal Thames are in a good structural condition.

34. The East London Strategic Flood Risk Assessment covers the Thames Gateway boroughs and is available from London Thames Gateway Partnership. It provides a good sub regional overview of flood risk including the impacts of a number of breach locations.

Flood Risk Management options

35. Flood defences for the Thames Estuary have been built up over hundreds of years and have tended to respond to flood events by successively raising the height of flood defences walls and embankments. The current defences were constructed through the 1970s and 1980s in response to the tidal surge of 1953 and include the Thames Barrier as the most iconic element of the defences. There are also many other flood gates and moveable structures that make up the defence system. This system of tidal flood defences was designed in the knowledge of sea level rise and it made allowances for this. Therefore protection to the 1 in 1000 year event is estimated to be given until 2030, after which the level of protection will decline below 1 in 1000 years unless other measures are taken.

36. The Environment Agency is undertaking the Thames Estuary 2100 (TE2100) project. This is the first time that planning for future flood risk management is taking place in anticipation of future flood risk rather than in response to a flood event. The consultation on TE2100 took place in April-June 2009. This RFRA takes account of the

policy initiatives in that draft. The final plan will be published in 2010 and this RFRA will be updated to incorporate any significant changes.

37. TE2100 indicates that the present system of flood risk management for tidal flooding can continue to provide an acceptable level of risk management up to 2030 without major alterations. Beyond 2030 more actions will be needed:

2010 – 2035:
- Work with Local Authorities and the construction industry to ensure that existing and new development is safe through spatial planning and local resilience measures
- Prepare joint riverside strategies establishing a shared vision for the riverside
- Continue to maintain, enhance, improve or replace existing flood management systems
- Work with Local Authorities and communities on the future use of the Thames Barrier in managing fluvial flooding in West London
- Continue flood forecasting and emergency planning activities
- Commence the creation of new inter-tidal habitat in the Lower estuary which is being lost as sea levels rise

2035 – 2070:
- Maintain, improve or replace the walls, embankments, barriers and gates along the Estuary.
- Work with Local Authorities and communities on enhancing and revitalising the Thames riverside
- Continue flood forecasting and emergency planning activities
- Continue replacing areas of inter-tidal habitats as sea-levels continue to rise
- Decide on and construct the option to manage increasing flood risk for the end of the Century and beyond

2070 – 2100:
- End of the century option operational (see 2035-2070).
- Further raising and adaptation of defences where required to keep new Barrier closures to within operational arrangements
- Continue programme of maintenance replacement and repair of upstream and downstream defences
- Continue flood forecasting and emergency planning activities

38. These actions will be easier, more affordable and more sustainably delivered if they are planned for from today. The Environment Agency has identified four broad areas (Reaches) of the Thames and have outlined the following general spatial options, it will be important for SFRAs and new developments to identify methods of implementing these options:

West London Reach (Teddington Lock to Hammersmith Bridge)
39. Enhanced channel capacity to cope with fluvial flood flows. Pursue options for small scale set back of development from river walls to enable river walls to be modified, raised and maintained in a sustainable, environmentally acceptable and cost effective way.

City Reach (Hammersmith Bridge to Thames Barrier)

40. Pursue options for small scale set back of development from river walls to enable river walls to be modified, raised and maintained in a more sustainable, environmentally acceptable and cost effective way.

Regeneration Reach (Thames Barrier to Tilbury Docks)
41. Pursue options for small scale set back of development from river walls to enable river walls to be modified, raised and maintained in a more sustainable, environmentally acceptable and cost effective way. In some cases there may be opportunities for larger scale set back as part of development in the Thames Gateway.

42. Large areas of currently undeveloped land such as Rainham/Wennington Marshes, Erith Marshes and Dartford/Crayford Marshes could be used as Strategic Flood Storage areas to use as emergency storm surge flood storage.

Lower Estuary Reach (Tilbury Docks to Southend)
43. This is outside London but options sited here could protect London. This area may provide environmental mitigation and compensation for impacts inside London.

Confluences
44. Particular care will be needed when examining the confluences of tributary rivers with the Tidal Thames given the interaction between the different systems. In particular there may be particularly severe effects when a high tide combines with peak fluvial flows. In general the flood defences have been built to a very high standard and therefore these area share high levels of flood risk protection.

45. The draft replacement London Plan promotes the set back of development as suggested for all three London Reaches (Policy 5.12). The open space areas are also protected by other mechanisms such as Green Belt Policy within Chapter 7.

The Likely Impact of Climate Change

46. Climate Change will have a major impact on the tidal flooding threat. The rising sea level will steadily reduce the level of protection that defences offer. The predictions for how quickly sea level will rise vary considerably depending on the assumptions used about emissions and climate modelling. The TE2100 project has considered a range of climate change derived sea level rises from 0.9m (Defra 2006 Climate Change Scenario) to 4m (High++ Level where all conceivable sea level rise contributions up to 2100 occur).

47. Up to 2030, i.e. to the end of the timeframe of the replacement London Plan, there are limited differences between predictions and existing flood risk management options can continue to provide appropriate risk management for tidal flooding. Beyond 2030 there is more variation in the projections. However it is clear that by starting to plan for these changes now, the ability to cope with more extreme situations will be improved. This is the aim of the London Plan policies.

Strategic Recommendations

Recommendation 1
All Thames-side planning authorities should consider in their SFRAs and put in place DPD policies to promote the setting back of development from the edge of the Thames

and tidal tributaries to enable sustainable and cost effective upgrade of river walls/embankments, in line with Policy 5.12, CFMPs and TE2100.

Recommendation 2
The London Boroughs of Richmond, Kingston, Hounslow and Wandsworth should put in place policies to avoid development that would prejudice the implementation of increased channel capacity between Teddington Lock and Hammersmith Bridge in line with TE2100 findings.

Recommendation 3
The London Boroughs of Havering and Bexley should put in place policies to prevent development that would prejudice the use of Rainham/Wennington Marshes, Erith Marshes and Dartford/Crayford Marshes for emergency flood storage in line with TE2100 findings. Although outside London, Thurrock and Dartford should also consider this aspect of flood risk management.

Recommendation 4
Boroughs at confluences of tributary rivers with the River Thames should pay particular attention to the interaction of fluvial and tidal flood risks. These are Havering, Barking & Dagenham, Newham, Tower Hamlets, Greenwich, Lewisham, Wandsworth, Hounslow, Richmond and Kingston.

Fluvial Flood Risk

Nature of Risk

48. London has many tributary rivers leading to the river Thames and the Thames itself is a fluvial river upstream of Teddington Lock. These are shown on Diagram 1. As with any river system there is a possibility that any of these rivers could flood. This could come from either particularly intense rainfall within the catchment or from a blockage or restriction to flow within the river channel.

49. The Environment Agency have produced Catchment Flood Management Plans (CFMP) for fluvial rivers in England and Wales. These CFMPs examine the characteristics of rivers, current and future flood risk and potential flood risk management measures and set out a long term view of flood risk (50-100 years). The CFMPs relevant to London are:

- Thames CFMP – July 2008
- North Kent Rivers CFMP – September 2008

50. As a predominantly urban area London's rivers are often heavily modified from their natural state. This means that rivers have been straightened, deepened, widened and constructed from materials such as concrete. These changes have often been made specifically to reduce the risk of flooding by either increasing the physical size of the river channel or increasing the rate at which it can convey water.

51. The urbanised river environment also contains many bridges, tunnels and culvert structures. These culverts are often underneath roads or railways but sometimes flow under substantial areas of land. These form potential flood risks as they can become blocked or restricted through litter or more likely larger debris such as shopping trolleys, mattresses or even vehicles. Culverts present a particular difficulty in that it is difficult and expensive to determine their condition and to carry out maintenance and repairs. It can also be difficult to ascertain ownership and maintenance responsibility for some culverts. It is also known that there are a significant number of illegal mis-connections of foul sewers to surface water culverts, these lead to ongoing pollution of rivers. In general opportunities to remove and open up culverts should be taken on environmental and aesthetic grounds as well as improving flood risk management. This is required in draft replacement London Plan policy 7.28.

52. In London the rate at which rainwater enters urban rivers is significantly higher than normally occurs naturally. This is because a larger proportion of London's surface is covered by hard impermeable surfaces which are positively drained via surface water sewers into local watercourses and then to larger tributaries. This also increases the absolute volume of rainwater that reaches rivers because there is less chance for water to soak into the ground, being taken up by vegetation or evaporate.

53. Such urban rivers respond very rapidly to rainfall and the opportunity for flood warnings to be issued is limited to as little as ½hr to 2 hrs in many cases. Some larger rivers such as the Lee or the fluvial Thames have much bigger upstream catchments so that flood flows can be detected several hours or even 1 or 2 days in advance, allowing for reasonable flood warnings to be issued.

Canals

54. London has many miles of canals. In general canals pose a low flood risk as they have limited surface water inputs. However the Grand Union Canal alongside the Colne

Valley and the River Lee Navigation are both intricately linked to large fluvial catchments and may convey flood waters from fluvial sources. A further consideration is that any canal which is on land higher than the surrounding land has the potential for a breach. Therefore consideration of flood risks from canals needs to be factored into SFRAs and FRAs.

Locations

55. Fluvial flooding affects parts of most London boroughs. As such it affects a number of Opportunity Areas, town centres and strategic infrastructure across the city. In general the scale is much smaller than tidal flooding. Fluvial flooding has been more frequent than tidal flooding meaning that many areas of floodplain have been left un-developed, often forming parks within the wider urban setting, the most prominent example being the Lee Valley Regional Park.

Information available

56. The flood risk zones are shown on Diagram 1. The Environment Agency also has modelled floodplains for some of the tributaries. Most tributaries have been modified to reduce the likelihood of flooding. In many cases these consist of raised river walls and widened channels. In the case of the River Lee an entire new flood relief channel was constructed along the east side of the Lee Valley in the 1970s. These channel modifications have generally resulted in a reduction of biodiversity value and amenity value and an increased maintenance requirement.

57. The Catchment Flood Management Plans classify flood plains into 6 broad types:

- Undeveloped natural flood plain
- Developed flood plain with no built defences
- Developed flood plain with built defences
- Developed flood plain with typically concrete river channels
- Major urban expansion in or close to flood plains
- Narrow flood plains and mixed use land

58. The CFMPs then identify five policy options to manage flood risk and the key messages that are relevant to each of these approaches.

59. These approaches are applied to policy units (sub-regional areas) that have been identified by geography, floodplain characteristics and land use types. More detailed actions for each policy unit, reflecting the relevant approach, have been identified to manage flood risk, today and in the future. These actions can be split into two types: those that help to reduce the likelihood of flooding occurring and those addressing the consequences if a flood does happen.

60. Three of the five policy options are used in London and they are specified below in relation to each of the catchments. SFRAs and FRAs should consider how to implement these policy approaches in local circumstances.

61. One of the main messages relevant to many of the London rivers is that redevelopment provides an opportunity to reduce flood risk. Draft replacement London Plan Policy 5.12 provides the scope to realise these opportunities.

London Catchments *(local authorities in italics are outside London but relevant to the management of the catchment)*
Each tributary river system in London has different attributes, these are described below:

River Lee - Boroughs affected: Barnet, Enfield, W Forest, Haringey, Hackney, Tower Hamlets, Newham
62. The River Lee catchment is a mixture of relatively small urban tributaries with very fast reaction times to flood and the main river Lee channel which has a large and substantially rural upstream catchment. The River Lee suffered extensive flooding in 1947 as a result of rapid snowmelt. In the 1970s the River Lee Flood Relief Channel was completed to reduce the risk of flooding through the Lee valley. It is known that the design specification for the River Lee Flood Channel was to accommodate a 1 in 70 year flood. This is below the level of protection that is now required for development under PPS25. Furthermore the level of protection is likely to have been reduced further by the extensive development in the Hertfordshire and west Essex upper catchment of the river Lee. It will therefore be important for the current level of flood protection through the Lee Valley to be re-assessed. This is particularly relevant given the extent of built development (including raised reservoirs) in the natural flood plain and the fact that there are considerable development proposals both within and outside London.

63. The Lee catchment also includes several tributaries which have experienced localised flooding, notably Salmons Brook, Ching Brook, Turkey Brook and Pymmes Brook. These are all highly urbanised catchments where flood risk needs to be addressed strategically.

64. The CFMP recommends an approach to take further action to reduce the risk of flooding (now and/or in the future) for the main River Lee river channels. For the tributaries to the Lee the CFMP recommends taking action to increase the frequency of flooding on open spaces to deliver benefits locally or elsewhere, which may constitute an overall flood risk reduction.

River Roding - Boroughs affected: Barking & Dagenham, Redbridge, Newham
65. The river here was extensively re-engineered during the 1980s and 1990s in conjunction with the construction of the North Circular Road and M11 and the introduction of a semi-tidal barrage in Barking. There has been localised flooding within London in recent years although most regular flooding occurs on agricultural land north of the London boundary. It would prove useful to examine the strategic flood risk along the length of the river Roding. The Environment Agency has prepared a River Roding Flood Risk Management Strategy.

66. For the London reaches of the River Roding, the CFMP recommends an approach to take further action to sustain current scale of flood risk into the future (responding to potential increases in flood risk from urban development, land use change, and climate change).

River Rom/Beam - Boroughs affected: Barking & Dagenham, Havering
67. There has been limited localised flooding in this catchment and the Beam wetlands serve as a strategic flood storage area. Development proposals will still need to consider their flood risk.

68. The CFMP recommends an approach to take further action to sustain current scale of flood risk into the future (responding to potential increases in flood risk from urban development, land use change, and climate change).

Ingrebourne - Boroughs affected: Havering, *Brentwood*
69. There has been some localised flooding to properties in Upminster and other flooding on open spaces through the river valley of this relatively natural tributary. There is also the tidal interaction where the southern part of the river becomes tide-locked at high tide.

70. The CFMP recommends an approach to take further action to sustain current scale of flood risk into the future (responding to potential increases in flood risk from urban development, land use change, and climate change).

Brent - Boroughs affected: Barnet, Brent, Harrow, Ealing, Hounslow
71. The River Brent and its various tributaries have suffered localised flooding, particularly in the upstream catchments of Harrow and Barnet. The Environment Agency has examined options to address this. These options should be examined and recommendations incorporated into SFRAs and LDD policies and form local policy objectives of reducing and storing surface water run-off. The Brent flows through extensive park areas offering opportunities for some flood risk management.

72. The CFMP recommends an approach to take further action to sustain current scale of flood risk into the future (responding to potential increases in flood risk from urban development, land use change, and climate change).

Crane - Boroughs affected: Harrow, Hillingdon, Ealing, Richmond, Hounslow
73. This river has historically suffered flooding problems in its lower reaches. The upper Reaches, known as the Yeading Brook, flow through considerable lengths of parks and open spaces giving some less sensitive areas for floodwater to be accommodated. Nevertheless a strategic examination of options for sustainable surface water management, bearing in mind climate change predictions, should be used to influence future development decisions and considerations of the management of the riverside open spaces.

74. The CFMP recommends an approach to take further action to sustain current scale of flood risk into the future (responding to potential increases in flood risk from urban development, land use change, and climate change).

River Colne and Pinn - Boroughs affected: Harrow, Hillingdon, *Spelthorne*
75. The Colne is a large tributary which in places forms London's western boundary. It has suffered extensive flooding in the past, although mostly of undeveloped land. Flood alleviation works have been undertaken. The River Pinn has had several recorded localised floods over recent years.

76. For the River Colne, the CFMP recommends an approach to take further action to sustain current scale of flood risk into the future (responding to potential increases in flood risk from urban development, land use change, and climate change) and for the Pinn it recommends taking action to increase the frequency of flooding on open spaces to deliver benefits locally or elsewhere, which may constitute an overall flood risk reduction.

Hogsmill Brook - Boroughs affected: Kingston, *Epsom & Ewell*
77. Some localised flooding has occurred on this river, notably through Kingston Town Centre. Most of the route of the river flows through open spaces and parts of the Green Belt.

78. The CFMP recommends taking action to increase the frequency of flooding on open spaces to deliver benefits locally or elsewhere, which may constitute an overall flood risk reduction.

Beverley Brook - Boroughs affected: Richmond, Wandsworth, Kingston, Merton.
79. Many parts of the floodplain remain as open space, notably through Richmond Park, although the Raynes Park area is identified as having an extensive floodplain. This coincides with the confluence of two tributaries and the river passing underneath several major road and railway structures.

80. The CFMP recommends an approach to take further action to sustain current scale of flood risk into the future (responding to potential increases in flood risk from urban development, land use change, and climate change).

Wandle - Boroughs affected: Wandsworth, Merton, Sutton, Croydon.
81. The downstream area of this river catchment runs through a heavily built up area with flood plain covering significant areas of already developed land. Some upstream areas south of Mitcham are more open with the possibility of enabling some upstream catchment storage.

82. The CFMP recommends an approach to take further action to sustain current scale of flood risk into the future (responding to potential increases in flood risk from urban development, land use change, and climate change).

Ravensbourne - Boroughs affected: Lewisham, Bromley, Greenwich
83. This is a relatively large river with several tributaries. In the downstream reaches the river is tightly confined by urban development although in the more southerly upstream reaches the river and its tributaries often flow through open spaces. The river has benefited from river restoration projects in recent years which have also improved flood risk management.

84. The CFMP recommends an approach to take further action to sustain current scale of flood risk into the future (responding to potential increases in flood risk from urban development, land use change, and climate change).

River Cray/Darent - Boroughs affected: Bexley, Bromley, Greenwich, *Dartford*
85. The upstream reaches stretch out into the Green Belt. Through much of the middle reaches the river runs through a mix of built up areas and open space and in the lower reaches there are extensive areas of floodplain and the interaction with the tidal Thames presents a further flood risk although the Dartford and Crayford marshes provide large areas of flood storage.

86. These catchments are covered by the North Kent Rivers CFMP which recommends an approach to take further action to reduce the risk of flooding (now and/or in the future).

Marsh Dykes – boroughs affects Bexley, Greenwich.
87. There are a number of modified and natural rivers in the Thamesmeand/Belvedere area which are unusual in that they are below the height of Thames flood defences and rely on storage reservoirs and pumped discharges.

88. TE2100 recommends an approach to take further action to sustain current scale of flood risk into the future (responding to potential increases in flood risk from urban development, land use change, and climate change). Furthermore it recommends careful consideration of new development given the particular risks of this low lying area and the difficulties in managing surface water following heavy rainfall events.

Fluvial River Thames- boroughs affected: Kingston, Richmond, *Spelthorne*, *Elmbridge*
89. The fluvial reaches of the Thames are prone to large flood events from its extensive upstream catchment. There are no built flood defences and this stretch of the river is particularly noted for its historic and cultural value. Given the large upstream catchment close co-operation is needed with flood management further west. The Environment Agency is developing the Lower Thames Flood Risk Management Strategy.

90. The CFMP recommends an approach to take further action to reduce the risk of flooding (now and/or in the future).

Flood Risk Management options
91. Now that the CFMPs policy approaches have been determined, there needs to be continued work to ensure that these policy approaches are implemented. The actual detail of how these need to be implemented will require careful consideration of the local river and its flood plain characteristics. Draft replacement London Plan policy 5.12 sets out the strategic policy of managing flood risk through new development. In many cases setting development back from river edges will enable a range of flood risk management options to be used. This should enable the most sustainable, aesthetically pleasing and cost effective options to be selected.

92. Boroughs and individual developments will need to consider the sequential test and allocating more vulnerable land uses in areas of lowest risk.

93. Open spaces within development can be designed to accommodate flood waters. The Green Grid concept in East London is a good example. In some cases the flood risk is such that upstream flood storage may prove to be the most realistic option. Efforts to restore damaged river environments also present good opportunities to improve flood risk management. Such measures will need to be considered in conjunction with neighbouring local authorities and indeed regions.

94. Where a residual flood risk remains, flood risk assessments should consider what would happen to the development and its users/occupants if a flood were to occur and how the development would recover from the flooding.

95. Surface water should generally be managed at source. Large development locations offer particular opportunities to make significant changes to surface water management to become more sustainable.

The Likely Impact of Climate Change
96. Climate change predictions suggest that there will be an increased risk of flooding on tributary rivers due to more intense patterns of rainfall. Most predictions estimate

that peak flows will increase by 20% beyond 2050 with the possibility of up to 40% increases in peak flows.

97. This gives added emphasis to the need to consider the above range of flood risk management options and the Environment Agency's recommendations from the CFMPs. Furthermore methods of reducing surface water run off from urban development are important. This applies not only to development in or near to a floodplain or river but right across London. For those rivers whose headwaters originate beyond London, the GLA will be encouraging its strong stance on managing surface water to be taken up by the relevant planning authorities.

98. Where development proposals are on brownfield sites, there are real benefits to be gained by making a substantial reduction in the amount of surface water run-off generated through the redevelopment of the site. In cases where sites were used for predominantly industrial purposes the proportion of positively drained area is often close to 100% of the site. A residential development is likely to be in the range of 40-80% positively drained, leading to a reduction in surface water run-off. Adding in measures such as porous road and parking surfaces, green/brown roofs, storage ponds/tanks, swales, soakaways etc could reduce run-off to an estimated 20-50% of previous levels, and in some cases may be close to the natural (greenfield) run-off rate. This should be the aim of a sustainable approach to urban drainage.

Strategic Recommendations

Recommendation 5
Developments all across London should reduce surface water discharge in line with the Sustainable Drainage Hierarchy set out in Policy 5.13 of the draft replacement London Plan.

Recommendation 6
Regeneration and redevelopment of London's fluvial river corridors offer a crucial opportunity to reduce flood risk. SFRAs and policies should focus on making the most of this opportunity through appropriate location, layout and design of development as set out in PPS25 and the Thames CFMP. In particular opportunities should be sought to:

- Set back of development from the river edge to enable sustainable and cost effective flood risk management options
- Ensure that the buildings with residual flood risk are designed to be flood compatible or flood resilient
- Use open spaces within developments which have a residual flood risk to act as flood storage areas

Surface Water Flood Risk

Nature of Risk

99. The fluvial flood risk section dealt with the impact of surface water finding its way quickly into rivers. This section specifically examines the situation when rainfall is so intense it overloads the drainage network. This is a particular issue where development is dense or where there are large roof areas such as major rail stations. This type of flooding is hard to predict, occurs rapidly following intense rainfall and usually disperses fairly quickly, making reliable record keeping difficult. This lack of surface water flooding records has been found when compiling this RFRA and by the Drain London Scoping Report. The cases listed below represent little more than a snapshot of events that caught the media's attention.

100. Surface water flooding can be caused or exacerbated by blockages to the drainage network. New surface water drainage networks are normally designed to cope with storms of a 1 in 20 year intensity, however many existing systems may be constructed to different standards. It is to be expected that events above the design intensity will occur from time to time and will lead to surface water flooding. It is impractical and expensive to construct surface drainage networks that will cope with much higher storm return periods.

Locations

101. There are few records of surface water flooding events. Some incidences have been recorded at main line rail termini and some parts of the strategic road network, notably underpasses. The list below represents no more than a snapshot of recent known events as there is no comprehensive source of data relating to such flooding. Many areas with large roof areas, at low points in the drainage network or that have suffered blockages in the surface water system have experienced surface water flooding.

Opportunity Areas	Current surface water flood risk characteristics	Future surface water flood risk considerations
Waterloo	Press reports of flooding around the Mainline Waterloo Station	Development may be able to offer alternative surface water storage or disposal options
Kings Cross	Press reports of flooding around the Mainline King's Cross Station	Development may be able to offer alternative surface water storage or disposal options
Park Royal/ Willesden Junction	Press reports of flooding a A406 underpass	Development may be able to offer alternative surface water storage or disposal options

References

BBC News Pictures http://news.bbc.co.uk/1/hi/in_depth/photo_gallery/3536098.stm
News Story re: stations
http://news.bbc.co.uk/1/hi/england/2179611.stm
http://news.bbc.co.uk/1/hi/uk/1483228.stm
http://news.bbc.co.uk/1/hi/england/london/3665079.stm
http://www.thisislondon.co.uk/news/article-816629-details/Flood+misery+for+Londoners/article.do
http://www.thisislondon.co.uk/news/article-12406933-details/Mop+up+after+second+flood/article.do
http://www.thisislondon.co.uk/news/article-12344673-details/Driver+is+rescued+as+flood+sinks+stalled+car/article.do
http://www.thisislondon.co.uk/news/article-7826537-details/Month+of+rain+falls+in+just+two+days+/article.do
http://www.thisislondon.co.uk/news/article-1255120-details/Essex+hit+by+flash+floods/article.do
http://www.thisislondon.co.uk/news/article-430638-details/Travel+agony+after+London+%27monsoon%27/article.do

Information available

102. There are no comprehensive records of surface water flooding held for London. This is not thought to be unusual as other areas do not have such records either. This may be because the nature of surface water flooding is that it can occur very rapidly and in sporadic locations, and can dissipate quickly too. However the lack of any comprehensive records means that it is difficult to identify any areas that are particularly vulnerable to surface water flooding or any patterns to such flooding. Press reports and common sense suggest that areas with large roof expanses, such as large railways stations, industrial and warehouse buildings or low lying areas such as road underpasses will be particularly vulnerable. Key transport nodes are also likely to be the locations where most press attention is focused.

103. The Environment Agency is producing surface water flood risk maps which are based on topography rather than the drainage network. These maps will give a useful initial idea where surface waters may be expected to collect.

104. The Floods and Water Bill is expected to give the lead responsibility for managing surface water flood risk to local authorities.

Flood Risk Management options

105. The lack of recorded data limits a definitive assessment of options. For developments with large roof areas it would be prudent to design in surface water storage areas to cope with heavy localised storms; this could be done through maximising surface water storage and/or by building in oversized drainage pipework.

106. Green roofs and other surface water storage or infiltration may help to reduce the flood risk; these are actively encouraged in draft replacement London Plan policies 5.11 and 5.13. However, this form of flooding generally occurs following localised heavy rainfall and it is unlikely that such measures will have anything more than a marginal reduction in the flood risk.

The Likely Impact of Climate Change

107. Current predictions anticipate that the intensity of storms is likely to increase. This will mean that both the likelihood of surface water flooding will increase and the consequences will increase as flood waters may be deeper given the higher volumes of rainwater. The application of the sustainable drainage hierarchy (Policy 5.13) should improve the ability of the urban area as a whole to cope with such storm events but individual locations will still be affected.

Drain London

108. Given the lack of information and need for co-ordinated action on surface water management, the Mayor has established an expert group to examine urban drainage issues in London in an integrated way. The initiative is called Drain London and involves the key agencies responsible for London's drainage. It has commissioned a scoping report which has confirmed that records of both surface water flood events and the drainage networks were patchy and un-coordinated. Government has recently announced it intention to award funding to Drain London to commission a surface water model and management plan for London, with more detailed analysis and proposals to manage surface water in high risk areas. Once the funding is confirmed, this work will be delivered in 2011. Future RFRAs and SRFAs will need to consider the outcomes of the Drain London research.

109. Integrated Urban Drainage pilots have been completed in the Brent and Hogsmill areas. In line with this RFRA and Drain London, these concluded that data and modelling were often poor and that institutional arrangements made co-ordination more difficult. Importantly, it was identified that problems with drainage were endemic to urban areas and that the key way of addressing these is through redevelopment. The Boroughs of Richmond and Kingston have now completed a Surface Water Management Plan.

Strategic Recommendations

Recommendation 7
Once funding is confirmed Drain London will investigate and plan for long term management of London's surface water infrastructure in order to reduce surface water flood risk.

Recommendation 8
Organisations responsible for development with large roof areas should investigate providing additional surface water run-off storage.

Foul Sewer Flood Risk

Nature of Risk
110. Foul sewer flooding occurs where sewers become blocked or overloaded and properties connected to the sewer system are located at a level below the hydraulic level of the sewage flow. These are often basement flats or premises in low lying areas. Sewer flooding is clearly particularly unpleasant and distressing as its contents are highly contaminated. At present Thames Water estimates that there are over 10,000 properties which are prone to sewer flooding (note this is a figure for all of Thames Water's operational area so includes properties outside London).

111. Thames Water is investing over £300million between 2005-2010 to combat sewer flooding at 10,000 properties. The aim is to virtually eradicate the problem in the foreseeable future.

112. There will also be some elements of a cross-over of issues from the Drain London project, particularly within the Combined Sewer areas of London.

113. In most of central and inner London the surface water and sewerage networks are combined in "Combined Sewers". During periods of heavy rain the combined sewage and rainwater is diverted to the River Thames via combined sewer overflows, to prevent significant flooding of homes, businesses, streets and gardens. The proposed Thames Tideway Tunnels are due for completion in 2020 and will intercept overflows at the river and transfer the flows for treatment at Beckton Sewage Treatment Works. This is a major civil engineering project with a projected cost of around £2bn. Draft replacement London Plan policy 5.14 sets out the strategic need for this project in order to prevent the discharge of millions of tonnes of untreated sewage and rainwater to the Thames.

Locations
114. The locations affected tend to be small discrete sub-catchments on the sewer network rather than any discernable patterns or particular locations.

Information available
115. Detailed records are held by Thames Water of locations where sewer flooding has been recorded either within a property or within the grounds of a property. The locations are generally very sporadic and not suited to mapping on a London-wide basis.

Flood Risk Management options
116. The nature of the problem dictates that the most effective solution is for Thames Water to carry out direct works to those parts of the sewer network linked to the affected property or group of properties. As can be seen from the figures above this is an expensive operation – averaging £32,000 per property for the programme between 2005-2010.

117. Future developments should be catered for by ensuring that the appropriate on and off site sewerage infrastructure is planned and delivered to fit in with proposed development. In line with draft replacement London Plan Policy 5.13 it is important to ensure that surface water is not discharged into the foul water system, thereby surcharging its capacity.

The Likely Impact of Climate Change
118. In theory climate change should not make a substantial difference to this problem. However, if surface water drains are wrongly connected to the foul system, then the expected increase in intensity of storm events would be likely to increase the likelihood of sewer flooding. Similarly, within the combined sewer area of London, increases in rainfall could trigger additional combined sewer discharges to the Thames. This problem should be largely overcome by 2020 through the completion of the Thames Tideway Tunnels. It will still be important to adhere to the London Plan Sustainable Drainage hierarchy (Draft replacement London Plan policy 5.13) in order to ensure the continued effectiveness of the sewer system and to prevent gradual increases in the number and scale of overflows to the new Thames Tideway Tunnel as climate change has more impact later in the century.

Strategic Recommendations

Recommendation 9
Thames Water to continue the programme of addressing foul sewer flooding.

Groundwater Flood Risk

Nature of Risk
119. Groundwater flows out of the ground at the point where the water table meets the surface; this acts as the source of many rivers and is also a valuable source of drinking water. Heavy rainfall can infiltrate the ground causing saturation; surplus water will then flow out to rivers or onto land potentially causing flooding. Groundwater tends to respond slowly to rainfall, so when groundwater flooding occurs it can persist for some time. The most well known such case in recent years was the flooding of Chichester in 1994. Within London there has only been recorded groundwater flooding within LB Enfield, although it may be possible for groundwater to cause elevated base flows into some of the rivers entering London as a result of increased groundwater flows from the surrounding hills of the Chilterns or the North Downs.

120. London has had an issue over the past 20 or so years with rising groundwater. This has occurred because the majority of London, including much of its underground

infrastructure such as tube lines and foundations for large buildings, was built at a time when the natural groundwater was suppressed due to large scale abstraction by manufacturing industry. With the steady reduction of industrial activity in London during the second half of the 20th century, groundwater levels began recovering to their natural levels thereby threatening to inundate the underground infrastructure or de-stabilize the ground surrounding the structures.

121. This problem has been addressed by the General Aquifer Research Development and Investigation Team (GARDIT). Through increased abstraction of the groundwater, notably by Thames Water, groundwater levels are now relatively stable and the Environment Agency is maintaining a regular monitoring regime.

Major Development Locations
122. There are no known locations where groundwater flooding has been a problem. The rising groundwater problem was mostly related to central and inner London, although this is now being managed.

Information available
123. The Environment Agency keeps detailed records of groundwater levels through comprehensive monitoring regime.

Flood Risk Management options
124. The continued abstraction of water by Thames Water is important to manage groundwater levels in the foreseeable future is expected to continue.

The Likely Impact of Climate Change
125. Increased groundwater levels are normally the result of prolonged rainfall with a degree of delay built in as water percolates through the ground. It is not yet clear whether the increased amount of winter rainfall will increase this risk or, as the total amount of rainfall is expected to remain relatively unchanged (just fall in more concentrated periods), the effect upon groundwater patterns and flows may remain stable. This needs to be kept under review.

Strategic Recommendations

Recommendation 10
That groundwater flood risk is kept under review.

Chapter 3– Spatial implications of flood risk

126. Chapter 1 dealt with the strategic overview of flood risk in London with particular reference to the draft replacement London Plan. Chapter 2 dealt with a more detailed analysis of the risk from the 5 types of flooding that could affect London. Chapter 3 now examines flood risk in relation to particular locations, boroughs and important infrastructure.

London Boroughs – Strategic Flood Risk Appraisals (SFRAs)

127. Most London boroughs have some extent of identified flood risk; see Diagram 1. For some this is limited to small areas along tributary streams, for others it includes large areas with potential for tidal flooding across a large proportion of the borough.

128. Most boroughs have now completed or nearly completed their SFRAs. These will need to be kept up to date and reviewed approximately every 3-5 years. Progress at August 2009 is given in the table below. In the case of the Thames, the East London boroughs have already co-operated in producing the East London SFRA; a similar approach to other parts of the Thames and the major tributaries such as the Rivers Lee and Colne may also prove beneficial and cost effective.

129. It is important for SFRA to identify areas where there are particular flood risks. For example, some low lying areas of land will be susceptible to ponding of water, in other areas there may be particular risks of a breach of flood defences or rapid inundation of flood waters with high velocities. This type of analysis will assist in determining locations where development may have to be constrained or altered to avoid particularly high risks.

130. The first round of completed SFRAs provide an excellent baseline study of flood risk for each borough and have generated detailed descriptions of prevailing flood risk. When the SFRAs are updated, they should consider further;

- Where appropriate, taking forward key recommendations into flood risk management policies within the LDF.
- Using the characterisation of risk to identify areas where redevelopment could be an opportunity to reduce flood risk. Where is redevelopment likely and capable of contributing to a reduction in flood risk (reducing probability and/or consequence) - this could be achieved through relocating building and improving layout and design (e.g. designing in resistance), removing certain vulnerable land uses, providing flood compatible open spaces.

131. These issues may require design considerations at the masterplan or community scale and a SFRA could identify where this type of planning is required. Some SFRAs have started to present this analysis through identification of character areas, others have started to link spatial planning policy to enhancement of emergency planning capability.

Diagram 3 – SFRA progress at September 2009

Borough	Level 1 Progress	Level 2 Progress
Barking and Dagenham	Complete	Complete
Barnet	Complete	Ongoing for Colindale AAP
Bexley	Final draft level 1	Not started
Brent	Complete	Complete
Bromley	Complete	Completed
Camden	Complete	Ongoing
City of London	Complete	Ongoing
Croydon	Complete	Complete
Ealing	Complete	Unclear if needed
Enfield	Complete	Ongoing
Greenwich	First draft	Not started
Hackney	Complete	Being commissioned
Hammersmith & Fulham	Final draft	Not started
Haringey	Complete	Ongoing
Harrow	Complete	Ongoing
Havering	Complete	Complete
Hillingdon	Complete	Unclear if needed
Hounslow	Complete	Complete
Islington	Complete	Unclear if needed
Kensington and Chelsea	Ongoing	Not started
Kingston upon Thames	Complete	Complete
Lambeth	Complete	Complete
Lewisham	Complete	Not started
Merton	Complete	Ongoing
Newham	Ongoing	Ongoing
Redbridge	Complete	Complete
Richmond upon Thames	Complete	Not needed
Southwark	Complete	Complete
Sutton	Complete	Complete
Tower Hamlets	Complete	Complete
Waltham Forest	Complete	Ongoing
Wandsworth	Complete	Complete
Westminster	Ongoing	Ongoing

Major Development Locations

132. The London Plan contains two categories of major development location; Opportunity Areas and Intensification Areas. These are the places where large scale development is expected to take place over the next 20 or so years. Each of these will involve up to several thousand new dwellings and/or employment space for up to several thousand people and frequently a mix of many different land uses to promote sustainable development.

133. 31 of the 43 areas have some form of identified tidal or fluvial flood risk; these issues are highlighted in the table below. Surface water and sewer flooding are much more sporadic and can occur almost anywhere under certain conditions, therefore there are only limited references to these in the table.

134. The presence of an element of flood risk is something that, according to PPS25 needs to be understood, planned for and managed. Appropriate development can still come forward and indeed may actually result in a reduction of flood risk both on site and for surrounding areas.

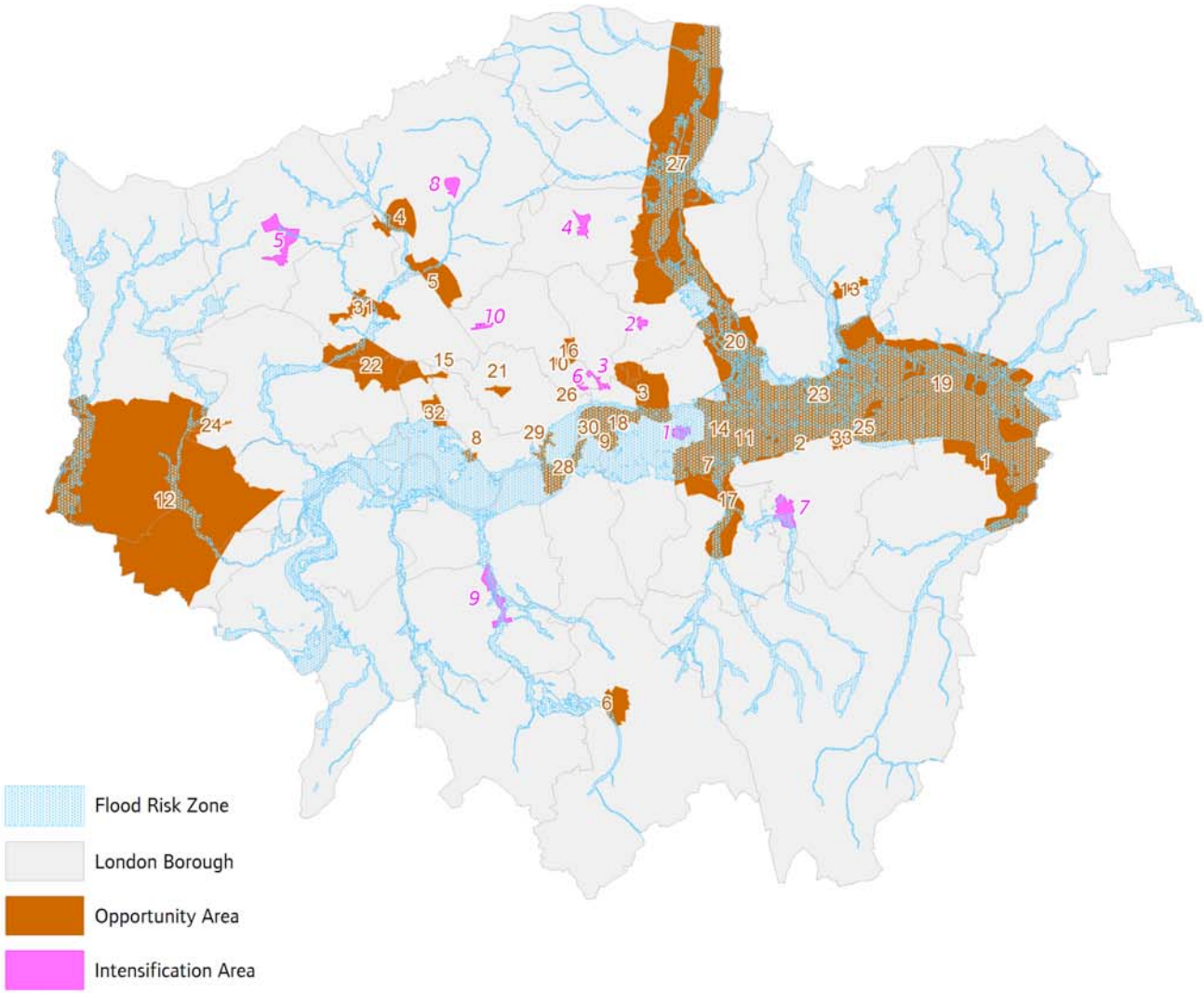
	Current flood risk characteristics	Future flood risk considerations
Opportunity Areas		
Bexley Riverside	Downstream of the Thames Barrier protected from storm surges by raised river walls. Contains several shipping-related industries requiring operational access to the river. Also contain parts of the Darent flood plain which is protected by tidal defences	Raising river walls and embankments beyond 2030 for normal tides and tidal surges. Open spaces to be retained for potential flood storage need to consider long term future of Darent Industrial Estate and use of Crayford Marshes for emergency tidal flooding
Charlton Riverside	Straddling the Thames Barrier, protected from storm surges by raised river walls but with land lying significantly below high tide levels.	Raising river walls and embankments beyond 2030 for normal tides and tidal surges. Open spaces to be retained for potential flood storage.
City Fringe	Intensively developed protected from daily flooding by river walls and from tidal surges by Thames Barrier	Raising river walls beyond 2030, setting development back from rivers edge, generally on higher ground
Colindale/ Burnt Oak	Relatively small proportion of area within flood plain but contains Silk Stream, a River Brent tributary where localised flooding has been recorded.	Set development back from rivers edge to enable a range of flood risk management options. May warrant consideration for upper catchment flood storage.
Cricklewood/ Brent Cross	Small proportion of area is within floodplain. Limited local flood history on the River Brent.	May warrant consideration for upper catchment flood storage.
Croydon	10% of area is within flood plain	Measures to reduce surface water run-off will be important.
Deptford Creek/ Greenwich Riverside	Intensively developed protected from daily tidal flooding and River Ravensbourne flooding by river walls and from tidal surges by Thames Barrier.	Raising river walls beyond 2030, setting development back from rivers edge.
Earls Court & West Kensington	Close to areas of tidal flood risk	Need to consider the role of multi purpose open spaces and additional drainage attenuation from large roof/hardstanding areas
Elephant & Castle	Intensively developed, protected from daily flooding by river walls and from tidal surges by Thames Barrier	Remote from river.
Euston	No flood plain identified but areas just north of Euston station are known to suffer surface water flooding.	Redevelopment will need to improve surface water management and reduce flood risk
Greenwich Peninsula	Intensively developed, protected from daily flooding by river walls and from tidal surges by Thames Barrier. Contains many shipping related industries requiring	Raising river walls beyond 2030, setting development back from rivers edge.

	operational access to river.	
Heathrow	Relatively small proportion of areas within flood risk zones.	Need to consider the role of multi purpose open spaces and additional drainage attenuation from large roof/hardstanding areas
Ilford	Small proportion of area within River Roding flood plain.	Set development back from rivers edge to enable a range of flood risk management options.
Isle of Dogs	Intensively developed, protected from daily flooding by river walls and from tidal surges by Thames Barrier	Raising river walls beyond 2030, setting development back from rivers edge.
Kensal Canalside	No identified flood plain	
Kings Cross	No flood plain identified	Redevelopment should consider surface water risks especially around main line station
Lewisham/ Catford/ New Cross	Catford and Lewisham have the river Ravensbourne and its tributaries running through them with locally recorded flooding. Intensively developed area protected from daily tidal flooding by river walls and from tidal surges by Thames Barrier	Remote from River Thames but need to consider the role of multi purpose open spaces within a wider development zone.
London Bridge/ Bankside	Intensively developed protected from daily flooding by river walls and from tidal surges by Thames Barrier	Raising river walls beyond 2030, setting development back from rivers edge.
London Riverside	Downstream of the Thames Barrier, protected from daily flooding and storm surges by raised river walls. Contains many shipping-related industries requiring operational access to river. Tributary rivers of Rainham Creek, Rom/Beam, Gores Brook and River Roding. Relatively low incidence of flood history. Flood Risk Assessment carried out for recent development proposals at Barking Riverside	Raising river walls and embankments beyond 2030 for normal tides and tidal surges. Open spaces to be retained for potential flood storage. Set development back from rivers edge to enable a range of flood risk management options. May have a role for strategic flood storage – notably when tributaries become tide locked.
Lower Lee Valley, including Stratford	Intensively developed protected from daily tidal flooding and fluvial flooding by river walls and from tidal surges by Thames Barrier	Raising river walls beyond 2030, setting development back from rivers edge. Interaction of tidal and fluvial flood risk will need consideration. Significant changes to river corridors through Olympics.
Paddington	No flood plain identified	Redevelopment should consider surface water risks especially around main line station
Park Royal/ Willesden Junction	Relatively small proportion of area within flood risk zones.	Need to consider the role of multi purpose open spaces and additional drainage attenuation from large roof/hardstanding

		areas
Royal Docks & Beckton Waterfront	Straddles the Thames Barrier so is partially protected from storm surges by the Barrier and by raised walls downstream.	Raising river walls and embankments beyond 2030 for normal tides and tidal surges. Open spaces to be retained for potential flood storage.
Southall	Close to flood plain of Yeading Brook	Need to ensure that development does not increase flood risk.
Thamesmead & Abbey Wood	Within tidal Thames floodplain with large areas significantly below high tide level. Parts of the areas are dependent on pumping station and storage reservoirs for continuous flood risk management.	New development needs careful consideration, particularly of residual risks and emergency measures.
Tott Ct Rd	No flood plain identified	
Upper Lee Valley	Includes extensive areas of Lee Valley floodplain. Need for Strategic Flood Risk Assessment	Set development back from rivers edge to enable a range of flood risk management options. Need to consider the role of multi purpose open spaces within a wider development zone. May warrant consideration in association with measures further afield in Herts and Essex.
Vauxhall/ Nine Elms/ Battersea	Intensively developed, protected from daily flooding by river walls and from tidal surges by Thames Barrier. Contains several shipping related industries requiring operational access to river.	Raising river walls beyond 2030, setting development back from rivers edge.
Victoria	Intensively developed protected from daily flooding by river walls and from tidal surges by Thames Barrier	Remote from river edge. Redevelopment should consider surface water risks especially around main line station
Waterloo	Intensively developed, protected from daily flooding by river walls and from tidal surges by Thames Barrier	Raising river walls beyond 2030, setting development back from rivers edge. Redevelopment should consider surface water risks especially around main line station
Wembley	Relatively small proportion of area within flood risk zones.	Need to consider the role of multi purpose open spaces and additional drainage attenuation from large roof/hardstanding areas
White City	No flood plain identified	Need to consider the role of multi purpose open spaces and additional drainage attenuation from large roof/hardstanding areas
Woolwich	Downstream of the Thames Barrier,	Raising river walls and

	protected from storm surges by raised river walls but with land lying significantly below high tide levels.	embankments beyond 2030 for normal tides and tidal surges. Open spaces to be retained for potential flood storage.
Intensification Areas		
Canada Water /Surrey Quays	Intensively developed, protected from daily flooding by river walls and from tidal surges by Thames Barrier	Raising river walls beyond 2030, setting development back from rivers edge.
Dalston	No flood plain identified	
Farringdon/ Smithfield	No flood plain identified	
Haringey Heartlands/ Wood Green	No flood plain identified, although includes upper reaches of Moselle brook in culvert	Redevelopment should seek to reduce surface water discharge to Moselle brook.
Harrow & Wealdstone	No flood plain identified	
Holborn	No flood plain identified	
Kidbrooke	Substantial area within the River Quaggy flood plain. A recently completed river restoration scheme has increased flood storage.	Need to consider the role of multi purpose open spaces within a wider development zone.
Mill Hill East	No flood plain identified	
South Wimbledon/ Colliers Wood	Substantial proportion of area is within the Wandle Valley floodplain	May warrant consideration for upper catchment flood storage.
West Hampstead Interchange	No flood plain identified	

Diagram 4 Major Development Locations



Ref	Opportunity Area	Area in Flood Zone (Ha)	Area out of Flood Zone (Ha)	Total Area (Ha)	Portion in Flood Risk
1	Bexley Riverside	1068	576	1645	65%
2	Charlton Riverside	205	38	243	84%
3	City Fringe	87	430	518	17%
4	Colindale/Burnt Oak	21	241	262	8%
5	Cricklewood/Brent Cross	6	318	324	2%
6	Croydon	15	159	174	8%
7	Deptford Creek/Greenwich Riverside	152	37	189	80%
8	Earls Court & West Kensington	22	9	31	72%
9	Elephant & Castle	87	0	88	100%
10	Euston	0	16	16	0%
11	Greenwich Peninsula	313	36	350	90%
12	Heathrow	599	6453	7053	8%
13	Ilford	2	83	85	2%
14	Isle of Dogs	504	14	518	97%
15	Kensal Canalside	0	20	20	0%
16	King's Cross	0	53	53	0%
17	Lewisham/Catford/New Cross	358	466	824	43%
18	London Bridge/Bankside	187	1	187	100%
19	London Riverside	1900	938	2838	67%
20	Lower Lea Valley including Stratford	869	523	1392	62%
21	Paddington	0	38	38	0%
22	Park Royal/Willesden Junction	32	719	751	4%
23	Royal Docks & Beckton Waterfront	1301	80	1380	94%
24	Southall	0	46	46	0%
25	Thamesmead & Abbey Wood	868	105	972	89%
26	Tottenham Court Road	0	19	19	0%
27	Upper Lea Valley	1316	2569	3884	34%
28	Vauxhall/Nine Elms/Battersea	223	5	228	98%
29	Victoria	46	8	54	85%
30	Waterloo	106	0	106	100%
31	Wembley	11	227	239	5%
32	White City	3	105	107	2%
33	Woolwich	45	54	99	45%
	TOTAL	10345	14387	24732	42%

Ref	Intensification Area	Area in Flood Zone (Ha)	Area out of Flood Zone (Ha)	Total Area (Ha)	Portion in Flood Risk
1	Canada Water/Surrey Quays	33	13	46	71%
2	Dalston	0	20	20	0%
3	Farringdon/Smithfield	0	25	25	0%
4	Haringey Heartlands/Wood Green	0	50	50	0%
5	Harrow & Wealdstone	8	169	177	5%
6	Holborn	0	13	13	0%
7	Kidbrooke	41	74	115	36%
8	Mill Hill East	0	48	48	0%
9	South Wimbledon/Colliers Wood	73	49	122	60%
10	West Hampstead Interchange	0	18	18	0%
	TOTAL	155	480	636	24%

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Metropolitan and Major Town Centres

135. Intensification of development at Town Centre locations is generally sustainable, given the high levels of public transport accessibility and concentration of facilities. New development within flood risk zones will still need to be accompanied by a Flood Risk Assessment.

136. Given that development at town centres tends to be high density there are likely to be high run-off rates and limited scope for floodwater or rainwater attenuation in the immediate vicinity. However, the London Plan policies in relation to flood risk management still need to be applied. There may also be opportunities to use some of the development value generated by such schemes to deliver strategic water storage solutions in areas of open space remote from the town centre. There are no examples of this having happened in London so far but such suggestions could arise from either Drain London or Strategic Flood Risk Assessments. A further consideration will be to ensure that critical infrastructure is either located away from flood risk zones 2 and 3 or has a high standard of protection. Diagram 5 illustrates the location of Town Centres in relation to flood zones.

Metropolitan centres	
Town Centre	**Flood Risk Issues**
Bromley	Partially within River Ravensbourne flood plain
Croydon	Partially within River Wandle flood plain and close to culverted river
Ealing	No identified flood risk issues
Harrow	No identified flood risk issues
Hounslow	No identified flood risk issues
Ilford	Small proportion within River Roding flood plain
Kingston	Substantially within flood plains of River Thames and Hogsmill Brook
Romford	Partially within River Rom flood plain, river flows through Town Centre in a culvert
Shepherds Bush	No identified flood risk issues
Sutton	Small proportion within Beverley Brook flood plain
Uxbridge	Small proportion within Frays Riverflood plain
Wood Green	Moselle Brook flows through town centre in culvert. No identified flood risk issues

Major centres	
Town Centre	
Angel	No identified flood risk issues
Barking	Partially within floodplain of River Roding
Bexleyheath	No identified flood risk issues
Brixton	No identified flood risk issues
Camden Town	No identified flood risk issues
Canary Wharf	Wholly Thames tidal flood plain but protected by Thames tidal defences
Catford	Partially within floodplain of River Ravensbourne
Chiswick	Wholly within River Thames flood plain - both tidal and fluvial flood risk
Clapham Jcn	No identified flood risk issues
Dalston	No identified flood risk issues
East Ham	No identified flood risk issues
Edgware	Partially within Silk Stream flood plain
Eltham	Some history of surface water flooding
Enfield Town	No identified flood risk issues
Fulham	Wholly Thames tidal flood plain but protected by Thames tidal defences
Hammersmith	Almost entirely within Thames tidal flood plain but protected by Thames tidal

Major centres	
Town Centre	
	defences
Kensington High Street	No identified flood risk issues
Kilburn	No identified flood risk issues
King's Road E	No identified flood risk issues
Lewisham	Substantially within floodplains of Rivers Ravensbourne and Quaggy
Nags Head	No identified flood risk issues
Orpington	Significantly within River Cray floodplain
Queensway/Westbourne Grove	No identified flood risk issues
Peckham	No identified flood risk issues
Putney	Small proportion within Thames tidal flood plain
Richmond	Small proportion within Thames flood plain
Southall	No identified flood risk issues
Stratford	Partially within River Lee flood plain
Streatham	No identified flood risk issues
Tooting	Significantly within River Graveney floodplain
Walthamstow	No identified flood risk issues
Wandsworth	Significantly within tidal Thames and River Wandle flood plains
Wembley	No identified flood risk issues
Wimbledon	No identified flood risk issues
Woolwich	Small proportion within Thames flood plain

Main rail network and major stations

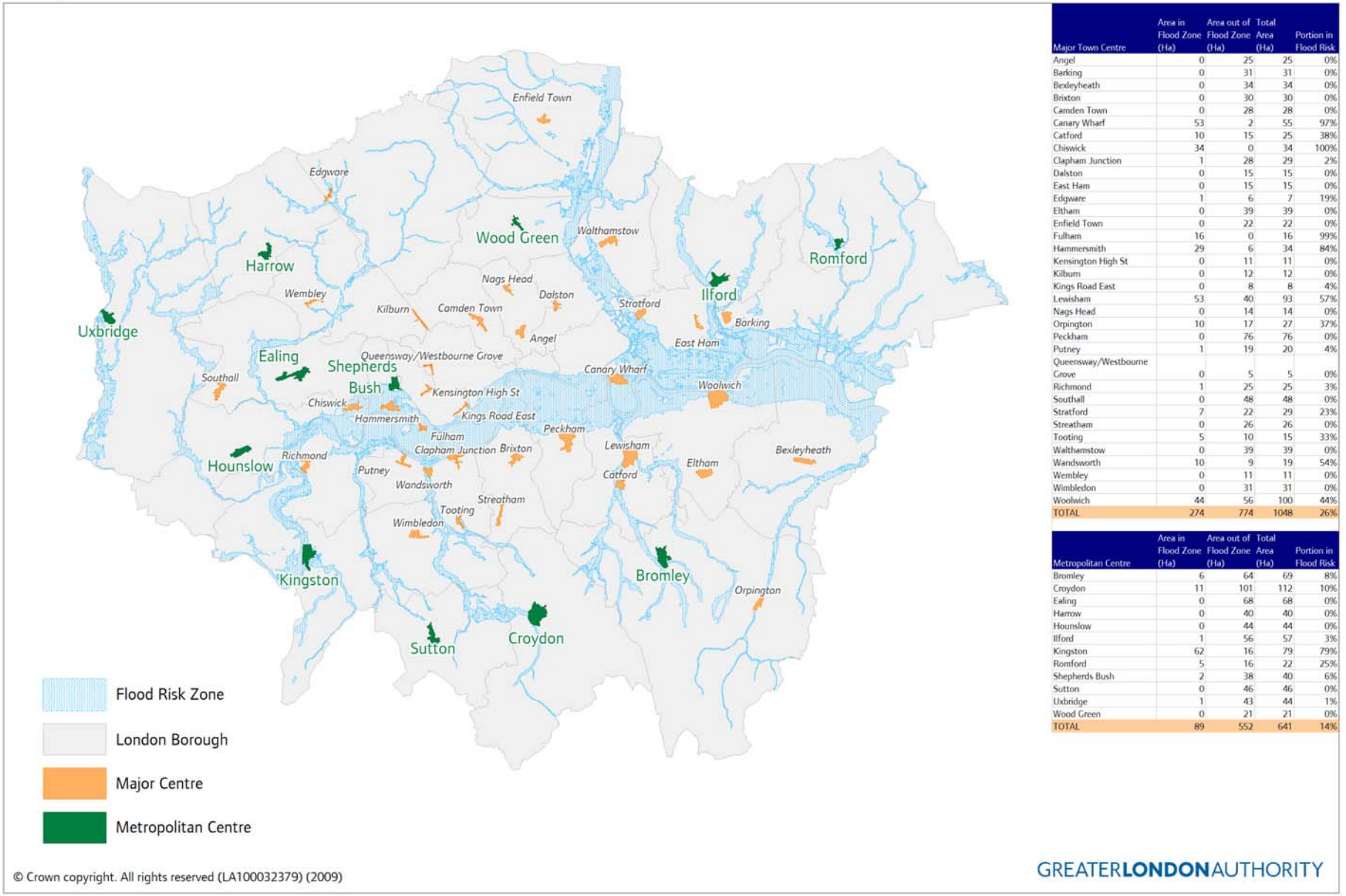
137. Diagram 6 shows that there are a total of 37 mainline stations and 115 km of mainline rail corridor within the floodplains of London. This represents 12% of London's stations and 14% of its rail corridor. A key issue will also be the vulnerability of power supplies, signalling and communications equipment to flood risk.

138. Rail lines that cross rivers do so on bridges, viaducts and embankments meaning that the route is generally at low flood risk. This is demonstrated with the elevated rail lines through London Bridge and into Waterloo, Blackfriars and Victoria. The rail lines into Liverpool Street and Stratford along the Lee Valley and the c2c lines east of Barking travel through the River Lee and Thames floodplains respectively often at ground level. These lines can be expected to have a higher level of flood risk.

139. The High Speed 1 Rail Link is substantially in tunnel through the flood plains of the tidal Thames and River Lee and parts of the line is at ground level and elevated through tidal flood risk zones in the Dagenham and Rainham areas. It is understood that the tunnel portals have been built to a very high standard of flood protection.

140. Of the 37 stations identified as being within a flood zone, the majority are on elevated sections of track and therefore at lower risk. Rail services within cuttings or stations with large roof areas may also be at risk from surface water flooding during heavy storms and these are set to increase in likelihood.

Diagram 5 Town Centres



Major Town Centre	Area in Flood Zone (Ha)	Area out of Flood Zone (Ha)	Total Area (Ha)	Portion in Flood Risk
Angel	0	25	25	0%
Barking	0	31	31	0%
Bexleyheath	0	34	34	0%
Brixton	0	30	30	0%
Camden Town	0	28	28	0%
Canary Wharf	53	2	55	97%
Catford	10	15	25	38%
Chiswick	34	0	34	100%
Clapham Junction	1	28	29	2%
Dalston	0	15	15	0%
East Ham	0	15	15	0%
Edgware	1	6	7	19%
Eltham	0	39	39	0%
Enfield Town	0	22	22	0%
Fulham	16	0	16	99%
Hammersmith	29	6	34	84%
Kensington High St	0	11	11	0%
Kilburn	0	12	12	0%
Kings Road East	0	8	8	4%
Lewisham	53	40	93	57%
Nags Head	0	14	14	0%
Orpington	10	17	27	37%
Peckham	0	76	76	0%
Putney	1	19	20	4%
Queensway/Westbourne Grove	0	5	5	0%
Richmond	1	25	25	3%
Southall	0	48	48	0%
Stratford	7	22	29	23%
Streatham	0	26	26	0%
Tooting	5	10	15	33%
Walthamstow	0	39	39	0%
Wandsworth	10	9	19	54%
Wembley	0	11	11	0%
Wimbledon	0	31	31	0%
Woolwich	44	56	100	44%
TOTAL	274	774	1048	26%

Metropolitan Centre	Area in Flood Zone (Ha)	Area out of Flood Zone (Ha)	Total Area (Ha)	Portion in Flood Risk
Bromley	6	64	69	8%
Croydon	11	101	112	10%
Ealing	0	68	68	0%
Harrow	0	40	40	0%
Hounslow	0	44	44	0%
Ilford	1	56	57	3%
Kingston	62	16	79	79%
Romford	5	16	22	25%
Shepherds Bush	2	38	40	6%
Sutton	0	46	46	0%
Uxbridge	1	43	44	1%
Wood Green	0	21	21	0%
TOTAL	89	552	641	14%

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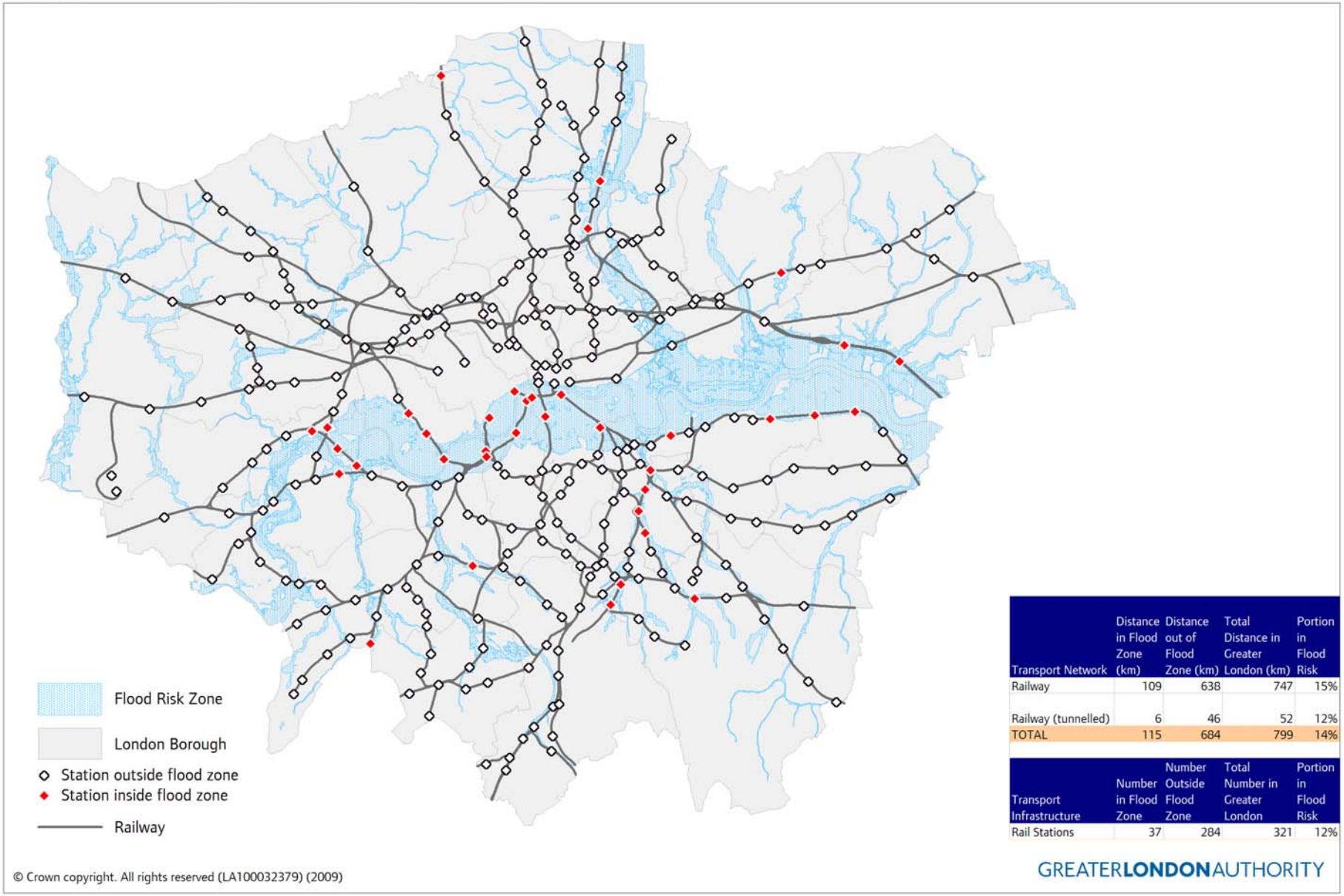
Diagram 6 Mainline Rail Network



Transport Network	Distance in Flood Zone (km)	Distance out of Flood Zone (km)	Total Distance in Greater London (km)	Portion in Flood Risk
Railway	109	638	747	15%
Railway (tunnelled)	6	46	52	12%
TOTAL	115	684	799	14%

Transport Infrastructure	Number in Flood Zone	Number Outside Flood Zone	Total Number in Greater London	Portion in Flood Risk
Rail Stations	37	284	321	12%

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Recommendation 11
Network Rail should examine the London Rail infrastructure for potential flooding locations and flood risk reduction measures. For large stations, solutions should be sought to store or disperse rainwater from heavy storms; this may involve the need for off site storage.

London Underground & DLR networks
141. Diagram 7 shows that there are a total of 72 London Underground and DLR stations within the floodplains of London. The majority of these are within the tidal Thames floodplain through central London and most had flood doors fitted prior to the construction of the Thames Barrier. It is not currently clear whether these doors remain effective. The stations on the DLR branch to Stratford and Jubilee line from Stratford to Canning town are also within the River Lee Fluvial floodplain. There are also three outlying stations which are in flood risk areas: Burnt Oak on the Northern Line is within the Silk Stream floodplain, Colliers Wood on the Northern Line is within River Wandle floodplain and Tottenham Hale on the Victoria Line is within River Lee floodplain. It is notable that most of the DLR network within flood zones are elevated on raised tracks.

142. Clearly flood water getting into underground stations presents a particular hazard and a very major engineering problem if the flood waters were to enter tube tunnels. This risk is extended geographically as tunnel portals could act as a conveyance route for flood water from a wide variety of locations, especially in the event of a tidal flood.

143. There may also be other potential flood routes including emergency access points and ventilation shafts.

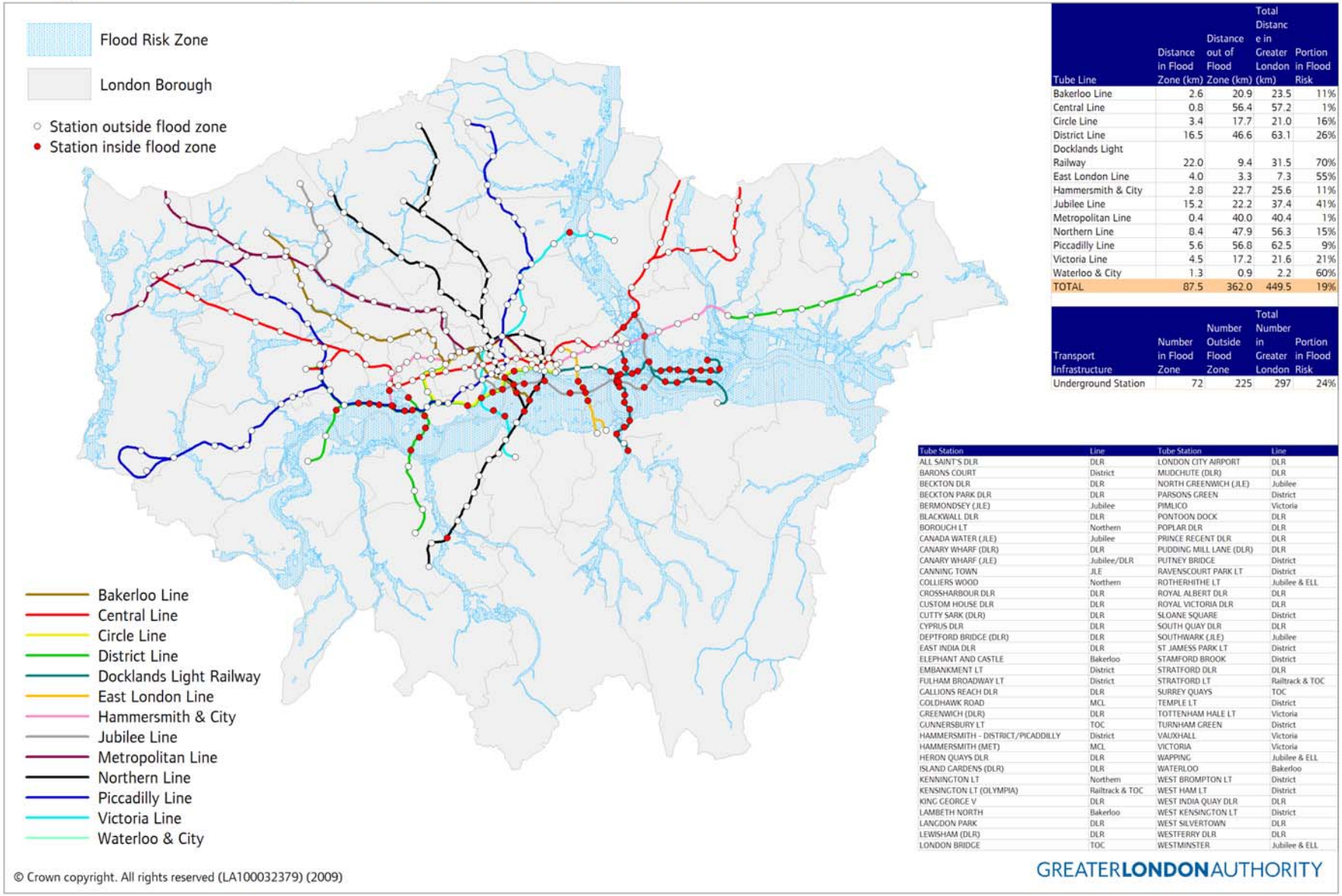
144. London Underground has undertaken extensive flood risk assessments of its infrastructure and keeps them up to date. However should a major tidal flood occur it is likely to overwhelm any local flood control measures.

145. The following tube and DLR lines have tunnel portals within flood plains:

Tube Line	Tunnel Portal	Flood plain
Central Line	Eastern Portal	River Lee
East London Line	Southern Portal	Tidal Thames
Jubilee Line	Eastern Portal	Tidal Thames
Victoria Line	Northern Portal	River Lee
DLR Lewisham branch	Thames Tunnel both portals	Tidal Thames
DLR Woolwich branch	Thames tunnel both portals	Tidal Thames

Recommendation 12
London Underground and DLR should keep potential flood risks to their infrastructure and flood risk reduction measures under review and up to date.

Diagram 7 Underground and DLR Networks



Tube Line	Distance in Flood Zone (km)	Distance out of Flood Zone (km)	Total Distance in Greater London (km)	Portion in Flood Risk
Bakerloo Line	2.6	20.9	23.5	11%
Central Line	0.8	56.4	57.2	1%
Circle Line	3.4	17.7	21.0	16%
District Line	16.5	46.6	63.1	26%
Docklands Light Railway	22.0	9.4	31.5	70%
East London Line	4.0	3.3	7.3	55%
Hammersmith & City	2.8	22.7	25.6	11%
Jubilee Line	15.2	22.2	37.4	41%
Metropolitan Line	0.4	40.0	40.4	1%
Northern Line	8.4	47.9	56.3	15%
Piccadilly Line	5.6	56.8	62.5	9%
Victoria Line	4.5	17.2	21.6	21%
Waterloo & City	1.3	0.9	2.2	60%
TOTAL	87.5	362.0	449.5	19%

Transport Infrastructure	Number in Flood Zone	Number Outside Flood Zone	Total Number in Greater London	Portion in Flood Risk
Underground Station	72	225	297	24%

Tube Station	Line	Tube Station	Line
ALL SAINT'S DLR	DLR	LONDON CITY AIRPORT	DLR
BARONS COURT	District	MUDCHUTE (DLR)	DLR
BECKTON DLR	DLR	NORTH GREENWICH (JLE)	Jubilee
BECKTON PARK DLR	DLR	PARSONS GREEN	District
BERMONDSEY (JLE)	Jubilee	PIMLICO	Victoria
BLACKWALL DLR	DLR	PONTOON DOCK	DLR
BOROUGH LT	Northern	POPLAR DLR	DLR
CANADA WATER (JLE)	Jubilee	PRINCE REGENT DLR	DLR
CANARY WHARF (DLR)	DLR	PUDDING MILL LANE (DLR)	DLR
CANARY WHARF (JLE)	Jubilee/DLR	PUTNEY BRIDGE	District
CANNING TOWN	JLE	RAVENSCOURT PARK LT	District
COLLIERS WOOD	Northern	ROTHERHITHE LT	Jubilee & ELL
CROSSHARBOUR DLR	DLR	ROYAL ALBERT DLR	DLR
CUSTOM HOUSE DLR	DLR	ROYAL VICTORIA DLR	DLR
CUTTY SARK (DLR)	DLR	SLOANE SQUARE	District
CYPRUS DLR	DLR	SOUTH QUAY DLR	DLR
DEPTFORD BRIDGE (DLR)	DLR	SOUTHWARK (JLE)	Jubilee
EAST INDIA DLR	DLR	ST JAMESS PARK LT	District
ELEPHANT AND CASTLE	Bakerloo	STAMFORD BROOK	District
EMBANKMENT LT	District	STRATFORD DLR	DLR
FULHAM BROADWAY LT	District	STRATFORD LT	Railtrack & TOC
GALLIONS REACH DLR	DLR	SURREY QUAYS	TOC
GOLDHAWK ROAD	MCL	TEMPLE LT	District
GREENWICH (DLR)	DLR	TOTTENHAM HALE LT	Victoria
GUNNERSBURY LT	TOC	TURNHAM GREEN	District
HAMMERSMITH - DISTRICT/PICADDILLY	District	VAUXHALL	Victoria
HAMMERSMITH (MET)	MCL	VICTORIA	Victoria
HERON QUAYS DLR	DLR	WAPPING	Jubilee & ELL
ISLAND GARDENS (DLR)	DLR	WATERLOO	Bakerloo
KENNINGTON LT	Northern	WEST BROMPTON LT	District
KENSINGTON LT (OLYMPIA)	Railtrack & TOC	WEST HAM LT	District
KING GEORGE V	DLR	WEST INDIA QUAY DLR	DLR
LAMBETH NORTH	Bakerloo	WEST KENSINGTON LT	District
LANGDON PARK	DLR	WEST SILVERTOWN	DLR
LEWISHAM (DLR)	DLR	WESTFERRY DLR	DLR
LONDON BRIDGE	TOC	WESTMINSTER	Jubilee & ELL

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Main road network

146. The road network is a critical element of London's infrastructure. The bus network transports in excess of 4 million people per day and much of the network is heavily used by private passenger and goods vehicles. The road network is also of critical importance to emergency services. The road network is managed by a combination of the Highways Agency for motorways and some trunk roads, TfL for the Transport for London road network (TLRN) and local boroughs for local roads. The density of the road network in London is likely to mean that alternative routes will be available in localised flood situations. However the volume of traffic is likely to lead to significant congestion.

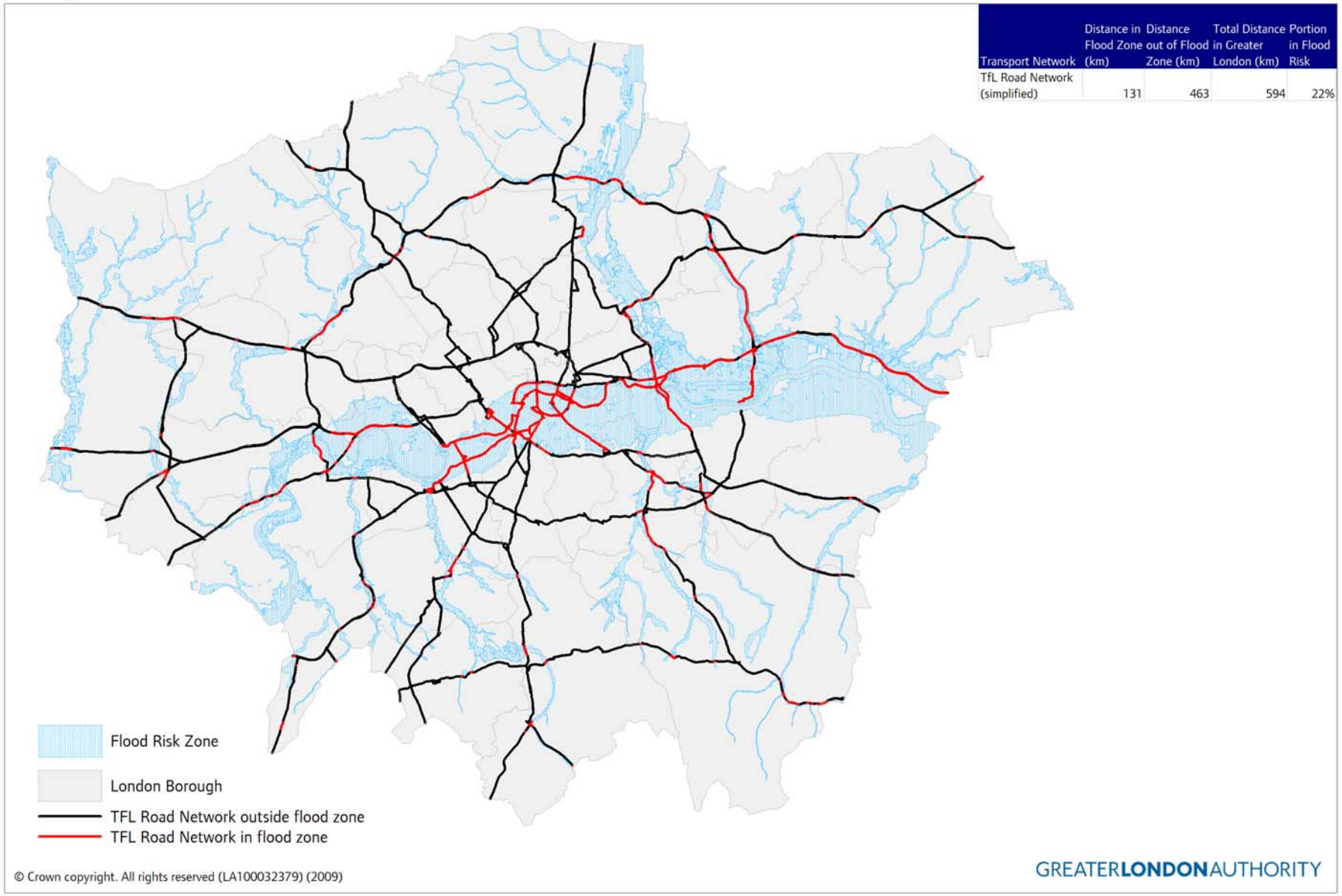
147. This RFRA has made an initial scoping of locations on the TLRN where flooding may present a potential risk. TfL has a pro-active monitoring programme of its network to report on flooding incidents, assess risks and implement remedial measures. Diagram 8 shows that some significant lengths of the TLRN is located within a flood zone.

148. Tunnels under the Thames have a particular risk as their portals are all within the tidal Thames flood plain. In a similar way to tube tunnels, ventilation shafts or emergency shafts may also present potential routes for the conveyance of flood water. Other underpasses are low points within the network and are more likely to be at risk of surface water flooding although a few are also within a flood zone.

Subterranean river crossings (road and pedestrian)
Rotherhithe Tunnel
Limehouse Link Tunnel
Greenwich Foot Tunnel
Blackwall Tunnel x2
Woolwich Foot Tunnel
Road Underpasses
A501 Euston Road
A406 Edmonton – River Lee Floodplain
A406 Stonebridge Park
A406 Crooked Billet
A12 Wanstead/Green Man junction
A102/A11 Bow – River Lee Floodplain
A13 Movers Lane – River Thames Floodplain
A113/A1400 Charlie Browns Roundabout – River Roding Floodplain
A4088 Neasden Lane /A406 underpass
A4 Hyde Park Corner underpass
A214 Trinity Road/East Hill Underpass
A3 Tibbetts Corner underpass
A3 Tolworth Underpass
A3 Hook Road underpass
Heathrow Access Road

149. There are around 90 bus garages serving London's bus operators. Some of these are within flood risk areas. A flood affecting a garage may have the direct impact of putting buses out of action or may have other indirect impacts for example the loss of electricity supply rendering fuel pumps inactive or employees who are unable to reach work.

Diagram 8 TfL Road Network



Recommendation 13
TfL, Highways Agency and London boroughs should continue to monitor the flood risk and flood risk reduction measures at these locations and any others with a potential flood risk.

Recommendation 14
Bus operators should examine bus garages for potential flood risks and put in place remedial or mitigation measures where there is a significant risk.

Airports
150. Heathrow Airport is largely free from flood risk, although some of the peripheral areas to the west of the airport could be affected by large floods on the River Colne system. The airport has large surface water attenuation areas.

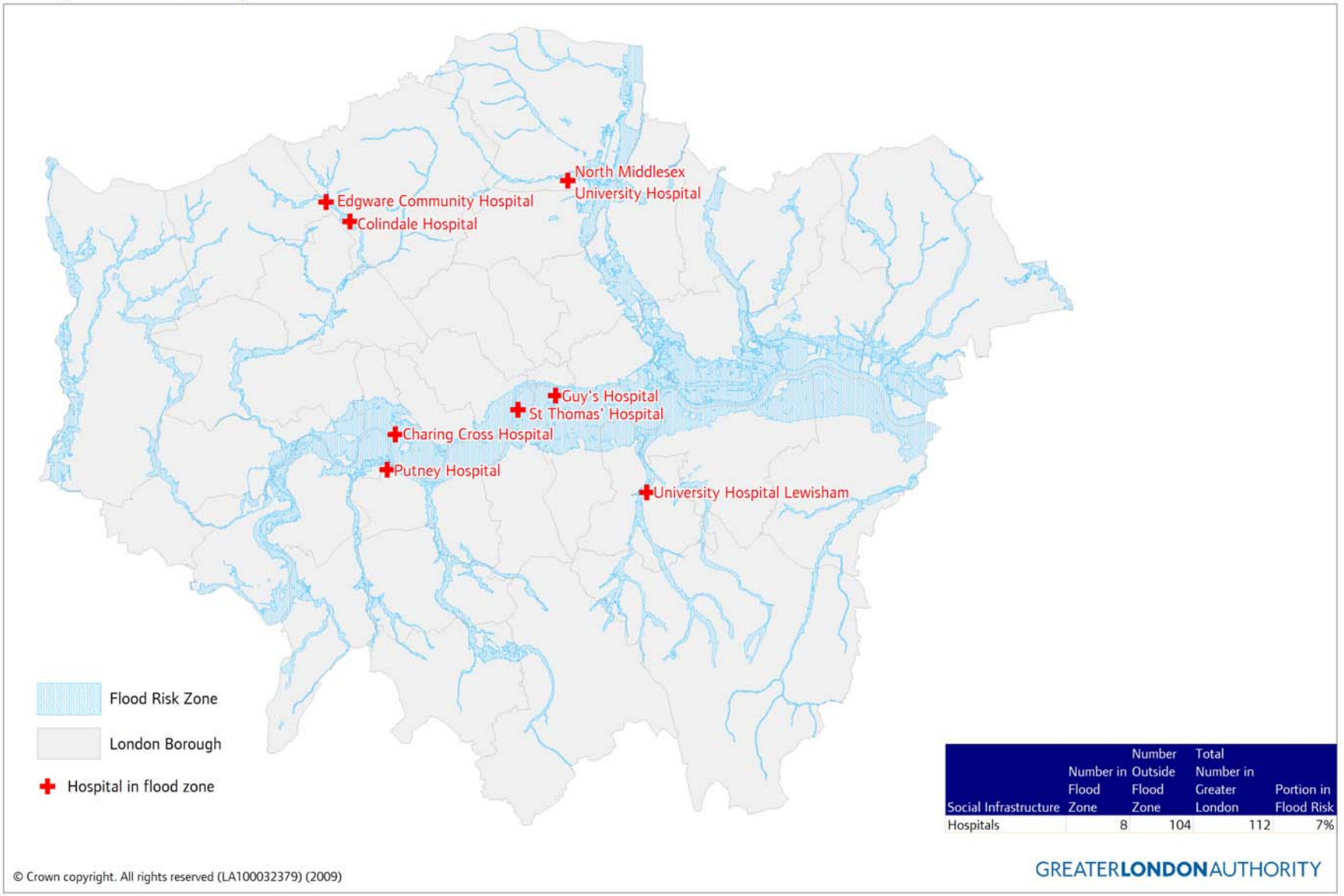
151. London City Airport is wholly within the Tidal Thames Floodplain. It is in an area that straddles the Thames Barrier but is protected by the existing flood defences to a standard of at least 1 in 1000 years.

Emergency Services
152. The London Resilience Team has launched the London Strategic Flood Plan. It is important for emergency services to remain operable during major flood events. Localised flooding events should be able to be managed by other supporting emergency services. Major flood events affecting either the Tidal Thames or the major tributaries will need consideration and co-operation between several services. This RFRA has carried out an initial examination to identify whether there are any potentially vulnerable concentrations of emergency service facilities within flood risk areas.

Main Hospitals
153. There are three major hospitals within the tidal flood plain of the River Thames, see diagram 9. These are all upstream of the Thames Barrier and therefore are protected to a high standard. It is even less likely that all would be flooded at once. There are no major hospitals within the flood risk areas of the Tidal Thames downstream of the Thames Barrier. Four hospitals have been identified as being within the floodplains of tributary rivers. The hospitals concerned are listed below:

Hospital	Flood Risk
Guys Hospital	Within Tidal Thames floodplain but protected by Thames Barrier
St Thomas's Hospital	Within Tidal Thames floodplain but protected by Thames Barrier
Charing Cross Hospital	Within Tidal Thames floodplain but protected by Thames Barrier
Putney Hospital	On the edge of Tidal Thames floodplain
North Middlesex Hospital	Within Pymmes Brook/River Lee floodplain
Lewisham Hospital	Partially within River Ravensbourne floodplain
Ealing Hospital	Adjacent to River Brent floodplain
Colindale Hospital	Partially within Silk Stream Floodplain
Edgware Hospital	Wholly within Silk Stream Floodplain

Diagram 9 Hospitals



Social Infrastructure	Number in Flood Zone	Number Outside Flood Zone	Total Number in Greater London	Portion in Flood Risk
Hospitals	8	104	112	7%

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Recommendation 15
Edgware Hospital should carry out a flood risk assessment of its current premises and determine any mitigation works necessary to ensure that the hospital can continue to operate in the event of a flood on the Silk Stream.

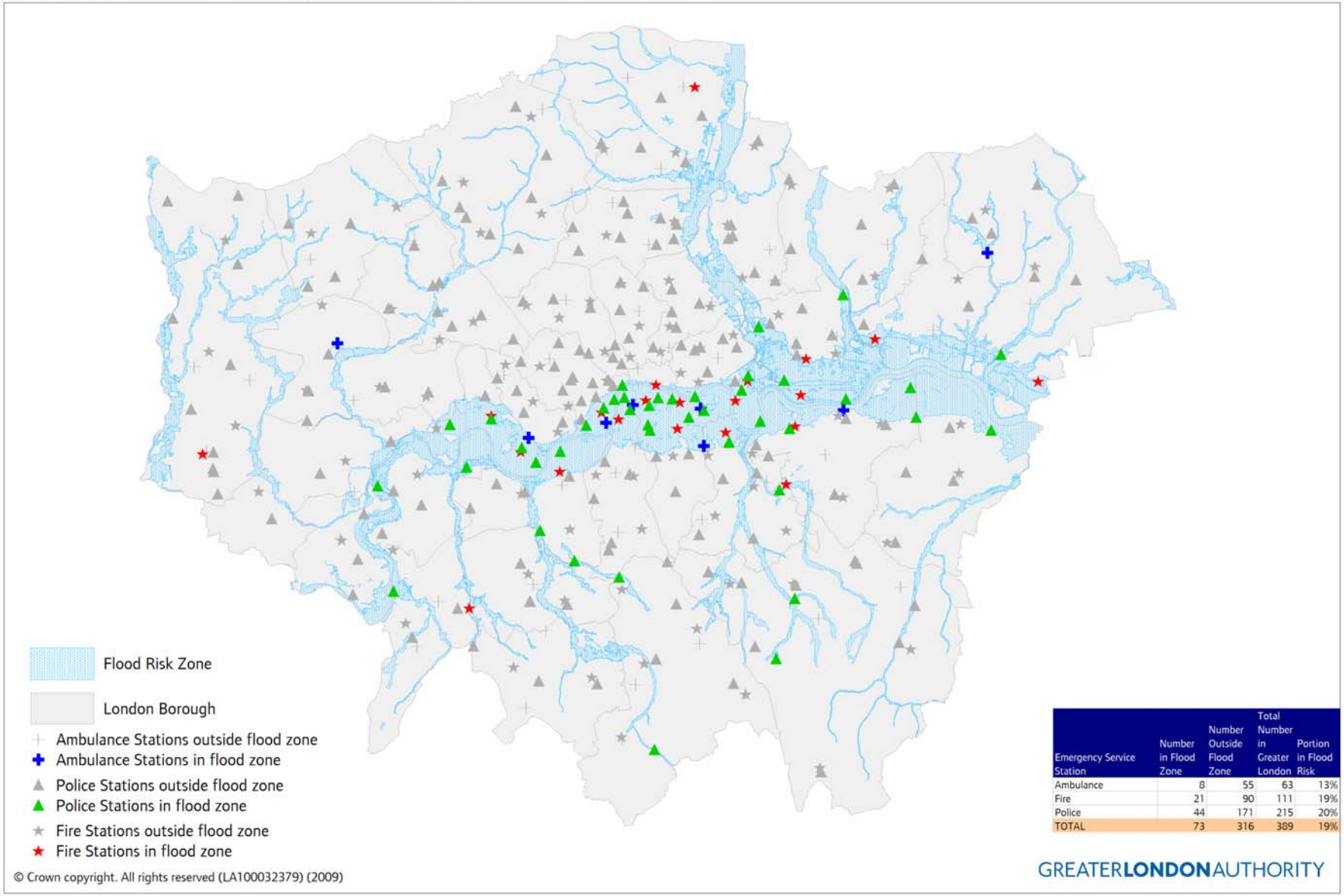
Recommendation 16
Other hospitals in the above table should examine how they may cope in the event of a major flood.

Fire Stations
154. Fire stations are likely to be important bases during flood events. Diagram 10 indicates that 21 Fire Stations from a total of 111 within London (19%) are within flood zones. The majority of these are in central/inner London Thames tidal flood plain and as such have a high degree of flood protection. They are also generally well covered by other fire stations just outside the flood zone.

Ambulance Stations
155. Diagram 10 indicates that 8 of London's 63 Ambulance stations (13%) are within flood zones. The majority of these are in central/inner London Thames tidal flood plain and as such have a high degree of flood protection. They are also generally well covered by other ambulance stations just outside the flood zone.

Police Stations
156. Diagram 10 indicates that 44 of London's 215 Police stations (20%) are within flood zones. The majority of these are in central/inner London Thames tidal flood plain and as such have a high degree of flood protection. They are also generally well covered by other police stations just outside the flood zone. The Metropolitan Police Service are embarking on a programme or re-organising their estate. This is likely to mean that some back office functions will be moved away from traditional police stations. Care will be needed to ensure that this does not reduce the resilience of the service through a lack of back up options that are at low flood risk.

Diagram 10 Police, Fire and Ambulance Stations



Emergency Service Station	Number in Flood Zone	Number Outside Flood Zone	Total Number in Greater London	Portion in Flood Risk
Ambulance	8	55	63	13%
Fire	21	90	111	19%
Police	44	171	215	20%
TOTAL	73	316	389	19%

Prisons

157. London has eight prisons/detention centres. These present particular challenges in the event of a flood as issues of safety and security will arise.

Prison	Flood Risk
Pentonville	No flooding issue
Holloway	No flooding issue
Wormwood Scrubs	No flooding issue
Brixton	No flooding issue
Wandsworth	No flooding issue
Belmarsh	Wholly within the Thames Tidal flood plain
Feltham Young Offenders	No flooding issue
Latchmere House, Richmond	No flooding issue
Downview/High Down, Sutton (just outside Greater London boundary)	No flooding issue

158. Of London's prisons only Belmarsh has any significant flood risk. It is within the Tidal Thames flood plain but is currently protected to a standard of 1 in 1000 years by the existing flood defences. Given the nature of this facility thorough emergency plans should be in place in the event of a flood.

Recommendation 17

The National Offender Management Service should ensure that there is an emergency plan for Belmarsh Prison in the event of a major flood.

Recommendation 18

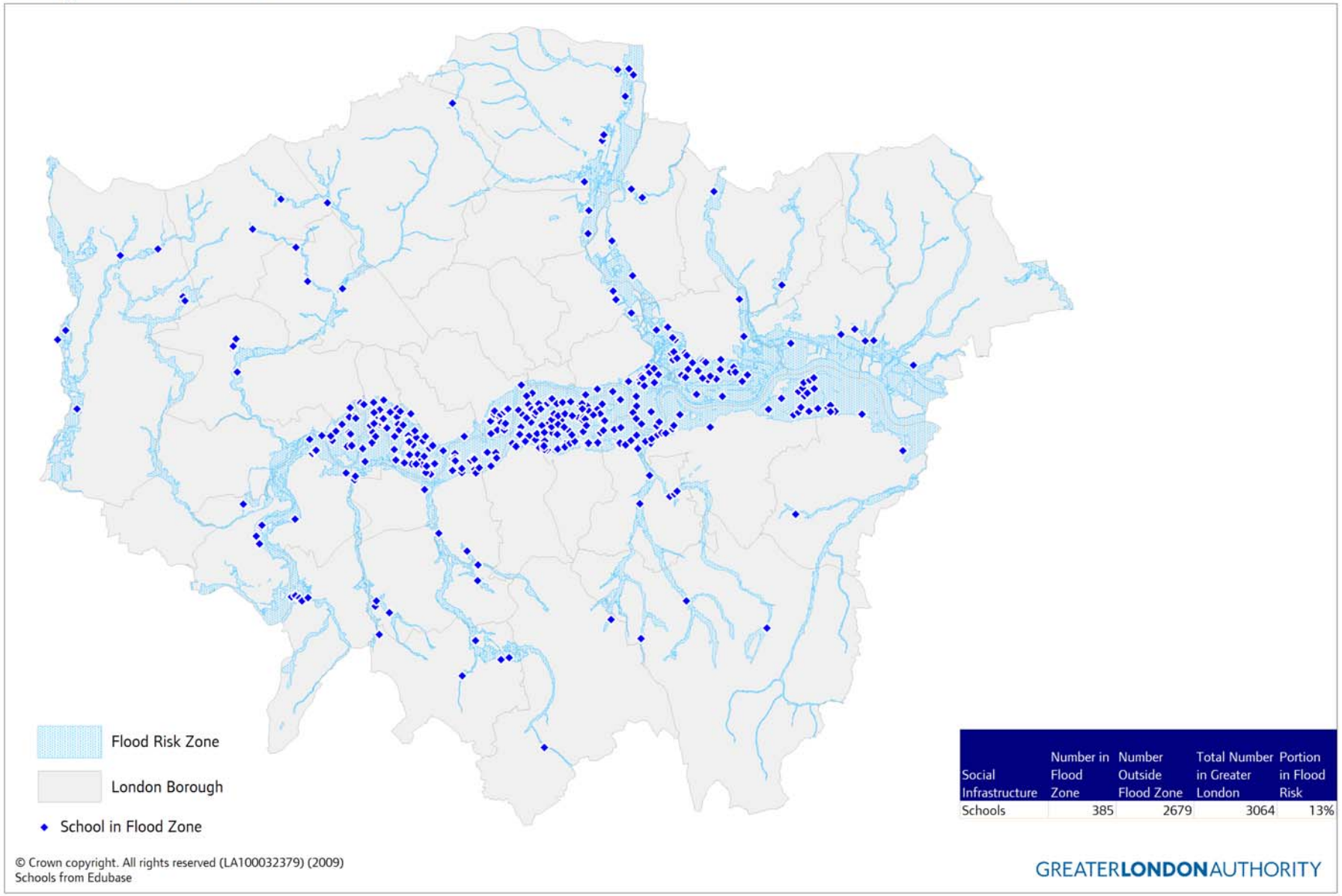
Operators of London's emergency services should ensure that emergency plans for flooding incidents are kept up to date and suitable cover arrangements are in place in the event of a flood effecting operational locations.

Schools

159. Schools need to serve their local population. Diagram 11 indicates that 385 of London's 3064 schools (13%) are either wholly or partially within flood zones, although for some of them it may only be to a minor extent, for example within playing fields. The majority of schools affected are in central/inner London part of the Thames tidal flood plain and as such have a high degree of flood protection. Clearly a flood would represent a direct risk to the pupils and staff at schools and would cause longer term disruption whilst any repairs are made. The analysis has examined both public sector and private schools including further education, six form colleges. It has not included pre schools and nurseries.

160. Schools are also important in terms of managing civil emergencies as they are often used as emergency shelter, food and supply bases. If the emergency is a flood, then this may mean that the school cannot fulfil this function.

Diagram 11 Schools



Social Infrastructure	Number in Flood Zone	Number Outside Flood Zone	Total Number in Greater London	Portion in Flood Risk
Schools	385	2679	3064	13%

Schools from Edubase

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Major Electrical Installations

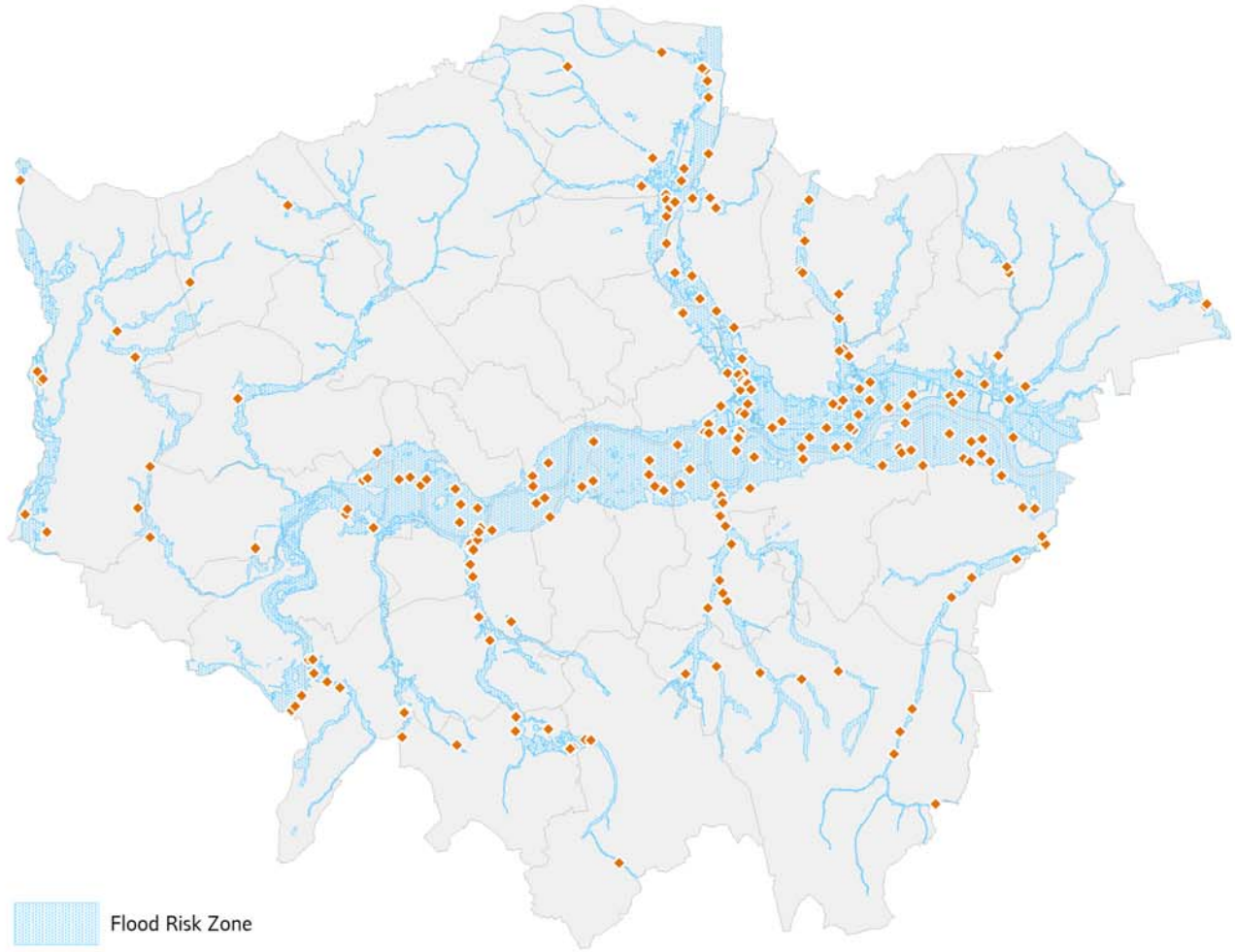
161. Many power generation plants are located near rivers or the sea as they require large volumes of water for cooling purposes. It is therefore not surprising that they have an associated flood risk. Most of London's electricity supply is generated outside London and transmitted to London via high voltage power lines, either on pylons or underground. London does have some energy generation capability and also has many switching and transformer stations. Major installations are listed in the table below and a fuller list of installations over 1000m^2 is given in Appendix 1.

Installation	Flood Risk Zone
Brimsdown Power Station	Adjacent to River Lee floodplain
Barking Power Station	Wholly within the Thames Tidal flood plain
Greenwich Power Station	Wholly within the Thames Tidal flood plain
Park Royal Power Station	Not within a flood zone
Hayes Power Station	Not within a flood zone
City Road Switching Station	Not within a flood zone
St Johns Wood Switching Station	Not within a flood zone
Croydon/Beddington Switching Station	Partially within River Wandle floodplain
Edmonton Waste to Energy	Wholly within River Lee floodplain
SELCHP Waste to Energy	Wholly within the Thames Tidal flood plain
Belvedere Waste to Energy (operational from 2010)	Wholly within the Thames Tidal flood plain

Major Gas installations

162. Gasholders and pipelines are unlikely to be directly affected by a flood given that they are gas tight containers and therefore will not let water in. There may however be issues such as ancillary power and access to gas sites. The known gas sites over 1000m^2 are listed in Appendix 1.

Diagram 12 Utilities Infrastructure



Borough	Sites Intersecting Flood Zone	Sites Outside Flood Zone	Total Sites	Portion with Flood Risk
Barking and Dagenham	10	6	16	56%
Barnet	0	28	28	0%
Bexley	16	9	25	56%
Brent	0	18	18	0%
Bromley	9	32	41	10%
Camden	0	20	20	0%
City of London	0	3	3	0%
Croydon	3	20	23	9%
Ealing	2	30	32	6%
Enfield	14	17	31	26%
Greenwich	12	10	22	45%
Hackney	2	6	8	0%
Hammersmith and Fulham	11	4	15	67%
Haringey	2	12	14	14%
Harrow	2	13	15	13%
Havering	10	18	28	25%
Hillingdon	10	19	29	10%
Hounslow	4	28	32	9%
Islington	0	12	12	0%
Kensington and Chelsea	0	8	8	0%
Kingston upon Thames	10	9	19	42%
Lambeth	2	16	18	11%
Lewisham	11	9	20	50%
Merton	3	9	12	25%
Newham	29	5	34	82%
Redbridge	5	8	13	23%
Richmond upon Thames	3	12	15	20%
Southwark	8	12	20	35%
Sutton	8	9	17	18%
Tower Hamlets	11	8	19	47%
Waltham Forest	10	10	20	40%
Wandsworth	13	7	20	65%
Westminster	3	10	13	23%
TOTAL	223	437	660	34%

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Water treatment plants

163. The nature of water treatment plants is that they are located close to major rivers in order to abstract water from them. It is therefore to be expected that the plants will have a certain level of flood risk. PPS25 allocated water treatment works within the "Less Vulnerable" land use classification. This means that new water works development should not be located within the functional flood plain (flood zone 3b), this may present difficulties as there will be a need to propose new development at existing works in order to improve the capacity or quality of the water treatment. Government is currently consulting on a proposal to transfer water treatment works into the Essential Infrastructure classification meaning that it would be possible to locate new development within Flood Zone 3b providing the Exceptions Test was passed. This appears to be a sensible alteration.

Water treatment pant	Flood Risk Zone
Hampton	Substantially within River Thames floodplain
Coppermills	Partially within River Lee floodplain
Hornsey	Not within a flood zone
Walton (outside London but supplying parts of London)	Partially within River Thames floodplain
Chigwell (outside London but supplying parts of London)	Not within a flood zone

164. A significant flood at a water treatment plant could result in the contamination of drinking water supplies by flood water, the risk of this would lead to the shutting down of the plant. The operation of the plant may also be affected by ancillary power losses. The London Ring Main means that water supplies can be flexibly managed and supplies derived from several works. Given the geographical spread of the above works they are unlikely all to be affected by one flood. In addition to the above listed water works there may also be pumping stations and other installations that relate to water supplies and distribution infrastructure, see Appendix 1. Four water companies supply London with drinking water and all have operational plans to cope with flooding.

Sewage treatment works

165. The nature of sewage treatment plants is that they are located close to rivers in order to discharge treated sewage effluent to them. It is therefore to be expected that the plants will have a certain level of flood risk. PPS25 allocated sewage treatment works within the "Less Vulnerable" land use classification. This means that new sewage works development should not be located within the functional flood plain (flood zone 3b). The Government's current consultation on changes to PPS25 applies to sewage treatment works in the same way as water treatment works and again appears to be a sensible change.

Sewage Works	Flood Risk Zone
Beckton	Wholly within the Thames Tidal flood plain
Crossness	Wholly within the Thames Tidal flood plain
Mogden	Not within a flood zone
Riverside	Wholly within the Thames Tidal flood plain
Deephams	Substantially within River Lee floodplain
Beddington Farm	Partially within River Wandle floodplain
Hogsmill	Substantially within Hogsmill Brook floodplain
Luxborough Lane (outside London but treats sewage from parts of London)	Wholly within River Roding floodplain
Long Reach (outside London but treats sewage from parts of London)	Wholly within the Thames Tidal flood plain

166. Thames Water operate all the above works and has operational plans to cope with flooding. A significant flood at a sewage treatment plant could result in the contamination of rivers and land as the flood spreads untreated or partially treated sewage and effluent from the works. The operation of the works may also be affected by ancillary power losses.

Pumping Stations

167. In addition to the above listed sewage works there are also pumping stations and other installations that relate to sewerage infrastructure, see Appendix 1. There are also a number of pumping stations to manage surface water. These are particularly relevant to low lying areas, Thamesmead being the prime example.

Recommendation 19

Operators of electricity, gas, water and sewerage utility sites should maintain an up to date assessment of the flood risk to their installations and considering the likely impacts of failure, programme any necessary protection measures, this may include secondary flood defences.

Reservoirs

168. Under the Reservoirs Act 1975 and Water Act 2003 the owner/operator of any reservoir of greater than 25 000m^3 capacity must prepare a contingency plan. These have all been prepared. Given this, the RFRA does not address reservoirs, however site specific Flood Risk Assessments will need to consider flood risk from reservoirs where developments sites would be affected by overtopping or embankment failure. Emergency Plans also need to consider the impacts of these flood risks.

Other sites

169. This RFRA is not intended to provide a comprehensive list of all vulnerable infrastructure. Some of the other vulnerable land uses include nursing homes where the safety and ability to evacuate residents may be difficult and council/benefits offices where closure would have an immediate impact on the welfare of local communities, particularly the most vulnerable. COMAH sites, petrol stations and other sources of pollution are also particular risks as flood water may liberate and spread polluting and/or dangerous substances that will have further impacts over and above the physical impacts of the flood waters.

Specific Sites

170. It is not the role of this RFRA to assess the flood risk to specific sites. However there area two areas which warrant particular mention owing to the scale of development proposed within them. In both cases, as with other developments within flood risk zone 2 or 3, site specific flood risk assessments will be required to accompany planning applications.

London 2012 Olympics and Paralympics Games

171. The construction of facilities for the Olympic and Paralympic Games in 2012 in the Lower Lee Valley around Stratford is well underway. As the name suggests, parts of this area are a river valley and as such have a degree of flood risk.

172. A Strategic Flood Risk Assessment was carried out for the outline planning permission for the Olympics in 2004. This has subsequently been updated to inform the planning applications submitted in February 2007. The proposals are being developed with flood risk in mind and with the specific aim of reducing flood risk and improving the sustainability of the river channels within the Games site. Proposals for the Olympic Legacy developments are currently being worked up. It would not be possible to have a sustainable Legacy for this part of East London with a high degree of residual flood risk.

Thames Gateway

173. The Thames Gateway is identified by Central Government and the Mayor as a key regeneration area. This will entail a large amount of development – up to 160,000 dwellings and other land uses to be built on previously used land in London, Kent and Essex. Much of the area is within what would have been the 1 in 1000 year tidal floodplain. This area, within London at least, is defended from that level of risk by the Thames Barrier and associated other barriers, gates, walls and embankments. The area also includes several tributary rivers, each of which has its own associated flood risks.

174. Development in the Thames Gateway is being carried out in the knowledge of the existing flood risk and how the flood risk is likely to change in the future. The Environment Agency TE2100 project is particularly valuable here. Each development proposal will have to be accompanied by a Flood Risk Assessment, and these should make reference to the East London Strategic Flood Risk Assessment completed by Thames Gateway London Partnership. It is not sufficient to rely on the presence of flood defences; the FRA must consider the implications of a breach or overtopping of the defences and how that would be managed. It is expected that new developments will, where necessary, be sited and designed to manage flood risk. This may be done through flood resilient construction, buildings that can quickly recover from flooding, flood warning and evacuation procedures. In addition the new development will integrate the principles of "Making Space for Water" and the East London Green Grid to give an overall aim of improving the sustainability of flood management in the Thames Gateway.

Conclusions

175. Flood Risk is a serious consideration for London. It is important that London's future is planned for and delivered in the fullest knowledge of flood risk and how it is likely to change in future. That knowledge is advancing rapidly and it will be important to keep this RFRA under regular review.

176. Through the proper implementation of PPS25, London Plan policies and flood risk assessments, flood risk can be sustainably managed through new development. Indeed, as this Strategic Appraisal shows, new development is one of the key opportunities to reduce overall flood risk, notably through improved management of surface water and allowing/creating space for future maintenance and upgrade of flood defences.

177. Even sites not directly affected by flooding may experience impacts through loss of power, water or communications, problems with access or the knock on demand of people seeking services from facilities that have been affected by flooding.

178. This RFRA has made 19 recommendations to help to focus attention on the strategic issues relating to flood risk in London. The document has also highlighted the range and scale of infrastructure which is at risk of flooding. This will be useful to emergency planners in considering the wider context of their activities and in focusing the minds of spatial planners in relation to the location of new facilities.

List of recommendations

Recommendation 1
All Thames-side planning authorities should consider in their SFRAs and put in place DPD policies to promote the setting back of development from the edge of the Thames and tidal tributaries to enable sustainable and cost effective upgrade of river walls/embankments, in line with Policy 5.12, CFMPs and TE2100.

Recommendation 2
The London Boroughs of Richmond, Kingston, Hounslow and Wandsworth should put in place policies to avoid development that would prejudice the implementation of increased channel capacity between Teddington Lock and Hammersmith Bridge in line with TE2100 findings.

Recommendation 3
The London Boroughs of Havering and Bexley should put in place policies to prevent development that would prejudice the use of Rainham/Wennington Marshes, Erith Marshes and Dartford/Crayford Marshes for emergency flood storage in line with TE2100 findings. Although outside London, Thurrock and Dartford should also consider this aspect of flood risk management.

Recommendation 4
Boroughs at confluences of tributary rivers with the River Thames should pay particular attention to the interaction of fluvial and tidal flood risks. These are Havering, Barking & Dagenham, Newham, Tower Hamlets, Greenwich, Lewisham, Wandsworth, Hounslow, Richmond and Kingston.

Recommendation 5
Developments all across London should reduce surface water discharge in line with the Sustainable Drainage Hierarchy set out in Policy 5.13 of the draft replacement London Plan.

Recommendation 6
Regeneration and redevelopment of London's fluvial river corridors offer a crucial opportunity to reduce flood risk. SFRAs and policies should focus on making the most of this opportunity through appropriate location, layout and design of development as set out in PPS25 and the Thames CFMP. In particular opportunities should be sought to:

- Set back of development from the river edge to enable sustainable and cost effective flood risk management options
- Ensure that the buildings with residual flood risk are designed to be flood compatible or flood resilient
- Use open spaces within developments which have a residual flood risk to act as flood storage areas

Recommendation 7
Once funding is confirmed Drain London will investigate and plan for long term management of London's surface water infrastructure in order to reduce surface water flood risk.

Recommendation 8
Organisations responsible for development with large roof areas should investigate providing additional surface water run-off storage.

Recommendation 9
Thames Water to continue the programme of addressing foul sewer flooding.

Recommendation 10
That groundwater flood risk is kept under review.

Recommendation 11
Network Rail should examine the London Rail infrastructure for potential flooding locations and flood risk reduction measures. For large stations, solutions should be sought to store or disperse rainwater from heavy storms; this may involve the need for off site storage.

Recommendation 12
London Underground and DLR should keep potential flood risks to their infrastructure and flood risk reduction measures under review and up to date.

Recommendation 13
TfL, Highways Agency and London boroughs should continue to monitor the flood risk and flood risk reduction measures at these locations and any others with a potential flood risk.

Recommendation 14
Bus operators should examine bus garages for potential flood risks and put in place remedial or mitigation measures where there is a significant risk.

Recommendation 15
Edgware Hospital should carry out a flood risk assessment of its current premises and determine any mitigation works necessary to ensure that the hospital can continue to operate in the event of a flood on the Silk Stream.

Recommendation 16
Other hospitals in the above table should examine how they may cope in the event of a major flood.

Recommendation 17
The National Offender Management Service should ensure that there is an emergency plan for Belmarsh Prison in the event of a major flood.

Recommendation 18
Operators of London's emergency services should ensure that emergency plans for flooding incidents are kept up to date and suitable cover arrangements are in place in the event of a flood effecting operational locations.

Recommendation 19
Operators of electricity, gas, water and sewerage utility sites should maintain an up to date assessment of the flood risk to their installations and considering the likely impacts of failure, programme any necessary protection measures, this may include secondary flood defences.

Glossary

BW	British Waterways
CFMP	Catchment Flood Management Plan
EA	Environment Agency
FALP	Further Alterations to the London Plan
FRA	Flood Risk Assessment
GLA	Greater London Authority
LB	London borough(s)
LDA	London Development Agency
LSFP	London Strategic Flood Plan
ODA	Olympic Delivery Authority
PLA	Port of London Authority
PPS25	Planning Policy Guidance Statement 25 Development and Flood Risk
RFRA	Regional Flood Risk Appraisal
SFRA	Strategic Flood Risk Assessment
TE2100	Thames Estuary 2100 project
TfL	Transport for London

Appendix 1 Utility Infrastructure within Flood Risk Zones

Borough	Ref	Street	Post Code	Type	Comment	
Barking & Dagenham	1	Merrielands Crescent	RM9	unknown		
Barking & Dagenham	2	Chequers Lane	RM9	Electricity	Barking Power Station	
Barking & Dagenham	3	Chequers Lane	RM9	Fuel	Oil Storage Depot	
Barking & Dagenham	4	Hindmans Way	RM9	Fuel	Oil Storage Depot	
Barking & Dagenham	5	River Road	IG11	unknown	Apparently disused site	
Barking & Dagenham	6	Rewick Road	IG11	Electricity	former Power Station/sub station	
Barking & Dagenham	7	Barking Barrier East	IG11	Flood Defence	Tidal barrier	
Barking & Dagenham	8	Kingsbridge Road	IG11	Sewage	Gascoigne Road Pumping Station	
Barking & Dagenham	9	west of Northern Relief Road, Barking	IG11	Drainage	Pumping Station	
Barking & Dagenham	10	Hertford Road	IG11	Unknown		
Barnet	0	None found				
Bexley	1	Belvedere Road	SE2	Sewage	Crossness Sewage Treatment Works	
Bexley	2	Norman Road	DA17	Electricity	Belvedere Sub station note Disused Belvedere Power Station/proposed waste to energy plant not included yet	
Bexley	3	Norman Road	DA17	unknown	Likely Fuel/gas use	
Bexley	4	Yarnton Way	DA17	Gas		
Bexley	5	Station Road North	DA17	unknown		
Bexley	6	Crabtree Manorway	DA17	unknown		
Bexley	7	Viking Way	DA8	unknown	possible telecommunications	
Bexley	8	West Street/Maxim Road	DA8	unknown		
Bexley	9	Slade Green Road	DA8	unknown	possible electricity	
Bexley	10	Hollywood Way	DA8	unknown	possible pumping station	
Bexley	11	Industrial estate, north of River Cray	DA1	unknown	possible waste/council depot	
Bexley	12	South of Thames Road	DA1	unknown		
Bexley	13	South of Thames Road	DA1	unknown		
Bexley	14	Station Road	DA1	Drainage	Pumping Station	
Bexley	15	Weir Road	DA5	unknown		
Bexley	16	Riverside Road	DA14	Water	Pumping Station and covered reservoir	
Brent	0	None found				
Bromley	1	Beck Lane	BR3	Council	Council Depot	
Bromley	2	Kelsey Park Road	BR3	unknown	possible telecommunications	
Bromley	3	Valley Road	BR2	Drainage	Pumping Station	
Bromley	4	Liddon Road	BR1	Gas		
Bromley	5	Coates Hill Road	BR1	unknown	possible telecommunications	
Bromley	6	Bridge Rd/Cray Avenue	BR5	Electricity	Sub station	
Bromley	7	Orpington High Street	BR6	Post	Sorting Office	
Bromley	8	Tower Road/Sevenoaks Road	BR6	Drainage	Pumping station	
Bromley	9	north of Sevenoaks	TN14	unknown	possible drainage use	

		Road/A21				
Borough	**Ref**	**Street**	**Post Code**	**Type**	**Comment**	
Camden	0	None found				
City	0	None found				
Croydon	1	Godstone Road	CR8	unknown		
Croydon	2	Factory Road	CR0	Gas		
Croydon	3	Factory Road	CR0	Electricity	Sub Station	
Ealing	1	Ruislip Road East	W7	Drainage	Pumping Station	
Ealing	2	Warple Way	W3	Sewage	Acton Pumping Station	
Enfield	1	Leeside Road	N18	Gas		
Enfield	2	Albany Road	N18	Gas		
Enfield	3	Bolton Road	N18	unknown		
Enfield	4	Balham Road	N9	unknown		
Enfield	5	Lee Park Way	N18	Waste	North London Waste to Energy	
Enfield	6	Picketts Lock Lane	N9	Sewage	Deephams Sewage Treatment Works	
Enfield	7	Woodhall Road	EN3	Gas		
Enfield	8	Edison Road	EN3	Electricity		
Enfield	9	Brancroft Way	EN3	Electricity	Brimsdown Power Station	
Enfield	10	Lee Valley Reservoirs	EN3	Water	Reservoirs including pumping stations	
Enfield	11	Brancroft Way	EN3	Electricity	Sub Station	
Enfield	12	Hadley Road	EN2	Drainage	Pumping Station	
Enfield	13	Station Road	N11	Gas		
Enfield	14	Dendridge Close	EN3	unknown		
Greenwich	1	Borthwick Street	SE8	Electricity	Deptford Grid	
Greenwich	2	Stowage	SE8	Electricity	Disused ?	
Greenwich	3				Deleted	
Greenwich	4	Maze Hill/Greenwich Park Street	SE10	Telecomms	Training and exchange on upper floors	
Greenwich	5	Boord Street	SE10	Gas		
Greenwich	6	Barrier Approach	SE7	Flood Defence	Thames Barrier	
Greenwich	7	White Hart Road	SE18	unknown	possible waste use	
Greenwich	8	Nathan Way/Eastern Way	SE28	Council office		
Greenwich	9	Nathan Way	SE28	Council depot		
Greenwich	10	Sewell Road	SE2	Electricity	unknown	
Greenwich	11	west of Wilton Road	SE2	unknown	possible telecommunications	
Greenwich	12	Thamesmere	SE28	Drainage	pumping station	
Greenwich	13	Old Woolwich Rd	SE10	Electricity Generation	Greenwich Power Station - Back up to London Underground and grid	
Greenwich	14	Greenwich High Rd	SE10	Water	Thames Water Pumping Station	
Hackney	1	Millfields Road	E5	Electricity		
Hackney	2	Millfields Road	E5	Waste		
Hammersmith and Fulham	1	west of Weltje Road/great West Road	W6	unknown		
Hammersmith and Fulham	2	south of Riverside Gardens	W6	unknown		
Hammersmith and Fulham	3	Chancellor Road	W6	unknown		
Hammersmith and	4	north of Yeldham	W6	unknown		

Fulham		Road				
Borough	**Ref**	**Street**	**Post Code**	**Type**	**Comment**	
Hammersmith and Fulham	5	south of Thaxton Road	W6	unknown		
Hammersmith and Fulham	6	Pulton Place	SW6	Post		
Hammersmith and Fulham	7	Peterborough Road	SW6	unknown		
Hammersmith and Fulham	8	Townmead Rd adj Swedish Wharf	SW6	unknown		
Hammersmith and Fulham	9	south of Townmead Rd, west of superstore	SW6	unknown		
Hammersmith and Fulham	10	Townmead Road	SW6	Electricity		
Hammersmith and Fulham	11	Imperial Road	SW6	Gas		
Haringey	1	Leeside Road	N17	Electricity		
Haringey	2	Marsh Lane	N17	Drainage	Pumping Station	
Haringey	3	Reform Row	N17	unknown		
Harrow	1	Wolverton Road	HA7	Electricity		
Harrow	2	Canon Lane	HA5	unknown	not the disused gas works	
Havering	1	South of Coldharbour Lane	RM13	unknown	appears to be Tilda Rice plant	
Havering	2	Manor Way	RM13	Sewage	Riverside Sewage Treatment Works	
Havering	3	Rainham Road opp Dominion Way	RM13	unknown	possible telecommunications	
Havering	4	Dagenham Road	RM13	Drainage	Pumping Station	
Havering	5	South Street	RM1	Unknown	opp Gloucester Road	
Havering	6	Exchange Street	RM1	Electricity		
Havering	7	St Mary's Lane	RM14	Sewage	Sewage Treatment Works Anglian Water	
Havering	8	Cortina Drive, off Thames Avenue	RM9	unknown		
Hillingdon	1	Former Perry Oaks Sewage Works	TW6	Sewage	now disused	
Hillingdon	2	Bath Road adj Moor Bridge	TW19	unknown	possible pumping station	
Hillingdon	3	Bath Road adj White Hart Pub	TW6	Electricity		
Hillingdon	4	North Hyde Gardens	UB3	Electricity	sub station	
Hillingdon	5	north of Charvill Rd south of A40	UB10	unknown	possible waste use	
Hillingdon	6	east of Tavistock Road	UB10	unknown	possible waste use	
Hillingdon	7	Cowley Mill Road	UB8	Post	Also former Gas use	
Hillingdon	8	Waterloo Road	UB8	Electricity		
Hillingdon	9	west of Springwell Lane	WD3	unknown		
Hillingdon	10	Slough Road	SL0	Electricity	sub station just outside London boundary	
Hillingdon	11	Maple Lodge Close	WD3	Sewage	Maple Lodge Sewage Treatment Works just outside London boundary	
Hounslow	1	Heathfield Terrace	W4	unknown		
Hounslow	2	Sutton Court Road	W4	unknown		

Borough	Ref	Street	Post Code	Type	Comment	
Hounslow	3	North of Kew Bridge Road	TW8	unknown		
Islington	0	None found				
Kensington and Chelsea	0	None found				
Kingston	1	north of Kingshill Avenue	KT17	Gas	Motspur Park	
Kingston	2	Lower Marsh Lane	KT1	Sewage	Hogsmill Sewage Treatment Works	
Kingston	3	Dawson Road	KT1	Post	Sorting Office	
Kingston	4	Ashdown Road	KT1	unknown		
Kingston	5	Downhall Road	KT2	Electricity	Sub station	
Kingston	6	Skerne Road	KT2	Gas		
Kingston	7	Portsmouth Road opp Grove Road	KT5	unknown		
Kingston	8	Portsmouth Road	KT5	Water	Seething Wells filter beds	
Lambeth	1	Vauxhall Street	SE11	Gas	Kennington Gas Works	
Lambeth	2	Kennington Park Road/Kennington Way	SE11	unknown		
Lewisham	1	Chilton Grove	SE16	unknown		
Lewisham	2	Landmann Way	SE14	Waste	SELCHP	
Lewisham	3	Copperas Street	SE8	unknown		
Lewisham	4	Brookmill Road, opp Stricland St	SE8	unknown	possible Council Depot	
Lewisham	5	Beck Close	SE13	unknown		
Lewisham	6	Armoury Road	SE13	Electricity		
Lewisham	7	Engate Street	SE13	unknown		
Lewisham	8	Canadian Avenue	SE6	unknown		
Lewisham	9	Barmeston Road	SE6	unknown	possible Post use	
Lewisham	10	Callander Road	SE6	unknown		
Lewisham	11	Selworthy Road	SE6	unknown	possible disused sewage site	
Merton	1	Bye Grove Road	SW19	Sewage	operational sewage site	
Merton	2	Plough Lane	SW17	Electricity	Sub Station	
Newham	1	Jupp Road	E15	unknown	possible telecommunications	
Newham	2	Abbey Lane	E15	Gas		
Newham	3	Abbey Lane	E15	Post		
Newham	4	Abbey Lane	E15	Sewage	Abbey Mills Pumping Station	
Newham	5	Channelsea Island	E15	unknown	Apparently disused site	
Newham	6	Crows Road/Canning Road	E15	unknown	Apparently disused site	
Newham	7	Twelvetrees Crescent	E3	Gas	Bromley By Bow Gas Works	
Newham	8	Stephenson Street	E16	Post		
Newham	9	Cody Road	E16	Electricity		
Newham	10	Western Gateway	E16	unknown	Possible Jubilee Line Vent Shaft	
Newham	11	Coolfin Road	E16	unknown		
Newham	12	south of North Woolwich Road	E16	Flood Defence	Thames Barrier	
Newham	13	Connaught Road	E16	Electricity		

Borough	Ref	Street	Post Code	Type	Comment	
Newham	14	Royal Albert Way south of Beckton Park DLR	E16	unknown		
Newham	15	Factory Road	E16	Drainage	Pumping Station also add adjacent satellite station as a new site	
Newham	16	Woolwich Manor Way adj Royal Victoria Gdns	E16	Drainage	Pumping Station	
Newham	17	Gallions Roundabout	E16	Drainage	Pumping Station	
Newham	18	Gallions Road	E16	unknown		
Newham	19	east of Royal Docks Road	E6	Gas	Beckton Gas Works	
Newham	20	Alpine Way	E6	unknown		
Newham	21	Woolwich Manor Way east of Alpine Way	E6	Drainage	Pumping Station	
Newham	22	Northern Outfall Sewer	E6	Sewage	apparently part of NOS	
Newham	23	Jenkins Lane	IG11	Sewage	Beckton Sewage Treatment Works	
Newham	24	Jenkins Lane	IG11	Waste	waste Transfer Station and possible Council Depot	
Newham	25	Watson Avenue	E6	Gas		
Newham	26	Grantham Road	E12	Electricity	Also former Gas use	
Newham	27	Barking Barrier West	IG11	Flood Defence	Tidal barrier	
Redbridge	1	Cranbrook Road/The Drive	IG1	Telecommunications		
Redbridge	2	Royston Gardens	IG1	Drainage	Pumping Station	
Redbridge	3	Redbridge Lane West	E11	unknown		
Redbridge	4	Roding Lane South	IG4	Electricity	Sub Station	
Redbridge	5	Snakes Lane East	IG8	Gas		
Richmond	1	London Road/Aragon Road	TW1	unknown		
Richmond	2	Brew Lane	TW1	Post	Sorting Office	
Richmond	3	Mellis Avenue	TW9	Sewage		
Richmond	4	Mellis Avenue	TW9	unknown		
Richmond	5	Mortlake high Street	SW14	unknown		
Southwark	1	Old Kent Road	SE15	Gas	South Eastern Gas Works	
Southwark	2	Verney Road	SE16	Electricity	sub station	
Southwark	3	Lynton Road/Monnow Road	SE17	Telecommunications		
Southwark	4	Dockley Road	SE16	Post		
Southwark	5	Salter Road	SE16	Gas		
Southwark	6	Hatfields	SE1	unknown		
Sutton	1	Beddington Lane	CR0	Electricity	Switching Station	
Sutton	2	Beddington Lane	SM6	Sewage	Beddington Sewage Treatment Works	
Sutton	3	Water Mead Lane	SM5	unknown	possible sewage use	
Sutton	4	Buckhurst Avenue	SM5	unknown	possible pumping station	
Sutton	5	Grove Road	SM1	unknown	possible post use	

Borough	Ref	Street	Post Code	Type	Comment	
Sutton	6	Crown Road	SM1	Gas		
Sutton	7	Green Lane	KT4	unknown	possible telecommunications	
Tower Hamlets	1	Three Colt Street	E14	unknown		
Tower Hamlets	2	Ontario Way	E14	unknown		
Tower Hamlets	3	West India Dock Road	E14	unknown	possible police use	
Tower Hamlets	4	Castor Lane	E14	Electricity		
Tower Hamlets	5	Watts Grove	E3	unknown		
Tower Hamlets	6	Leven Road	E14	Gas		
Tower Hamlets	7	Aspen Way	E14	Vent Shaft	Blackwall Tunnel	
Tower Hamlets	8	Law Street	E14	Vent Shaft	Blackwall Tunnel	
Tower Hamlets	9	Yabsley Street	E14	Waste	Northumberland Wharf	
Tower Hamlets	10	Stewart Street	E14	Drainage	Pumping Station	
Waltham Forest	1	Westdown Road	E15	unknown		
Waltham Forest	2	Osier Way	E10	Sewage	Auckland Road Pumping Station	
Waltham Forest	3	Clementina Road	E10	Gas		
Waltham Forest	4	South Access Road	E17	Council Depot		
Waltham Forest	5	Coppermill Lane	E17	Water	Coppermills Waterworks	
Waltham Forest	6	South of Lockwood Reservoir	E17	Water	Pumping Station	
Waltham Forest	7	west of Chingford Road	E4	Electricity		
Waltham Forest	8	May Road	E4	unknown		
Waltham Forest	9	Harbert Road	E4	Water	Pumping Station	
Waltham Forest	10	Lee Valley Reservoirs	E4	Water	Reservoirs	
Wandsworth	1	Longmead Road	SW17	unknown		
Wandsworth	2	Lynden Grove	SW18	unknown		
Wandsworth	3	Mapleton Road	SW18	Electricity		
Wandsworth	4	Morie Street	SW18	unknown		
Wandsworth	5	Armoury Way	SW18	Gas		
Wandsworth	6	The Causeway	SW18	Electricity		
Wandsworth	7	Smugglers Way	SW18	Waste	Riverside Waste Transfer Station and Council Depot	
Wandsworth	8	Paveley Drive	SW11	unknown	Possible Aggregates Depot	
Wandsworth	9	York Road/Plough Road	SW11	unknown	Within York Gardens	
Wandsworth	10	Prince of Wales Drive	SW8	Gas		
Wandsworth	11	Kirtling Street	SW8	unknown		
Wandsworth	12	Stewarts Road	SW8	Telecommunications		
Westminster	1	Gatliff Road	SW1	unknown	Former Grosvenor Dock waste transfer station	
Westminster	2	Ebury Bridge	SW1	unknown		
Westminster	3	Francis Street	SW1	unknown		