Rising to the Challenge

The City of London Corporation's Climate Change Adaptation Strategy

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Project Management

City of London Corporation- Simon Mills, Sustainable Development Coordinator

Acclimatise- Dr Richenda Connell, CTO and co-founder
-

Approved by

The Policy and Resources Committee, City of London Corporation
John Firth, CEO and co-founder, Acclimatise

City of London Corporation
PO Box 270
Guildhall
London
EC2P 2EJ
T: +44 (0) 207 3323598
F: +44 (0) 207 7962621
E: simon.mills@cityoflondon.gov.uk
W: www.cityoflondon.gov.uk

Acclimatise
6 Nursery End,
Southwell,
Nottinghamshire,
NG25 0BY
T: +44 (0) 1636 812868
F: +44 (0) 1636 812702
E: enquiries@acclimatise.uk.com
W: www.acclimatise.uk.com

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Foreword

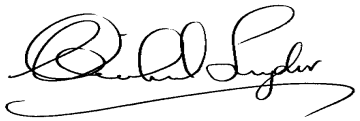
The City of London Corporation has long been aware that a clean environment, quality of life and economic prosperity go hand in hand and from planning and health in the 12th century, to the sponsoring of the Clean Air Act in the 20th Century, we have always had an eye on the welfare of future generations.

This is why we have, for over a decade, been taking a close interest in the issue of climate change.

Initially our interest lay in mitigating the impacts of climate change and in the 1990's we became one of the earliest pioneers in the purchase of renewable energy. In fact to date, we have managed to cut our own CO_2 emissions by over 35% based on a 1997 baseline.

However, we are painfully aware that even if the world was to cut its carbon emissions to zero overnight, we would still face many years of climate change to come, due to the inertia inherent in the climate system.This is why in March 2006 we took the decision to become the first UK local authority to commission a climate change strategy that purely focused on the issue of adaptation.

This is not to say that we do not recognise the crucial importance of continuing to cut emissions, but ultimately, we believe that it is part of our "duty of care" to ensure that the infrastructure and services contained in the Square Mile are appropriately adapted so as to ensure that the City continues to thrive no matter what the future brings.



Michael J Snyder
Chairman of the Policy and Resources Committee
City of London Corporation

Climate change is underway and we are already seeing the impacts of these changes in our daily lives. The heatwave during the summer of 2003 demonstrated how vulnerable we are to a changing climate and that we need to act now to adapt to these growing risks. We need to reduce emissions of greenhouse gases to avoid the worst effects of climate change, but we also need to plan for the inevitable changes that are already locked into the climate system.

I am delighted to see The City of London Corporation leading the way by communicating this message across the Square Mile through its adaptation strategy. The strategy recognises that the Corporation has a responsibility to ensure that its services and infrastructure continue to function well in the face of climate change, and that its residents and workers are protected.

This strategy is a welcome contribution to the work that is going on to ensure the UK is adapted to the impacts of unavoidable climate change. The Government is playing its part by developing a national adaptation policy framework for the UK. But we all need to take responsibility for action. Local Authorities are in a key position to deliver adaptation across a wide range of vital services and this strategy sets out one way of achieving that goal.

By working together we can ensure that the City as a whole continues to maintain its place as the world's premiere international financial centre.

Ian Pearson MP
Minister of State for Climate Change
and Environment

Executive summary

There is widespread scientific consensus that man-made greenhouse gas emissions are leading to rapid and potentially irreversible climate change. The threat that this poses to the UK economy has been well documented in the Stern Review, published by the Treasury at the end of last year. Government policy across a range of issues is beginning to reflect this fact.

The Stern Review highlighted the fact that even if the world were to cease all greenhouse gas emissions tomorrow, we would still face many decades of climate change, due to the length of time that carbon dioxide stays within the atmosphere. To this end it recognised that whilst efforts to cut emissions should continue, it is essential that we begin adapting assets, infrastructure and services to cope with the future impacts of climate change.

The City of London Corporation's climate adaptation strategy uses the UKCIP02 climate change scenarios. The strategy built on the impacts previously identified in the London Climate Change Partnership's publication, London's Warming[1]. This was the first UK climate impact study focused on a large urban area.

The climate change risks for the City are summarised below:

- Hotter, drier summers,
- Milder, wetter winters,
- More frequent extreme high temperatures,
- More frequent heavy downpours of rain,
- Significant decreases in soil moisture content in summer,
- Sea level rise and increases in storm surge height,
- Possible higher wind speeds.

The City of London Corporation's climate adaptation strategy, the first of its kind by a UK local authority, aims to identify the priority risks associated with climate change and proposes adaptation measures which are designed to ensure that the City's infrastructure and services cope under a changing climate.

The strategy was developed in consultation with a large group of stakeholders who represented City of London Corporation departments, external service providers and City businesses, as well as our immediate neighbouring local authorities.

The report identifies risks and opportunities in the following themes:

- Managing flood risks,
- Managing water resources,
- Managing heat risks and air pollution,
- Managing ground conditions,
- Cross-cutting issues,
- Opportunities.

[1] London's Warming. London Climate Change Partnership. Final Report November 2002. http://www.cityoflondon.gov.uk/Corporation/living_environment/sustainability/climate_change/impacts.htm

The adaptation options identified are grouped into research and monitoring, policy and practical actions, which are then categorised under the following criteria:

'No-regrets' measures, delivering benefits that exceed their costs, whatever the extent of climate change,

Low-regrets' measures are low cost, and have potentially large benefits under climate change,

'Win-win' measures contribute to climate adaptation and also deliver other benefits,

'Flexible' measures are useful for dealing with uncertainties in the extent of longer-term climate change.

The principle practical adaptation options recommended in this report are summarised below.

Managing flood risks

The City of London Corporation should encourage businesses to consider relocating flood-sensitive IT equipment and archives out of London to areas with negligible flood risks. Assets and equipment, which need to be on-site, should be moved away from locations at higher risk of flooding, such as basements.

Developers should be encouraged to install sustainable drainage systems and green roofs in targeted flash flood 'hotspots' for new developments, redevelopments or major refurbishments.

The City of London Corporation should consider installing sustainable drainage systems, green roofs or green walls on City of London Corporation-owned car parks and buildings when they are refurbished or replaced.

The City of London Corporation should consider creating spaces for additional temporary flood water storage in City of London Corporation-owned large open spaces, such as Hampstead Heath.

The City of London Corporation should examine a range of incentives to encourage sustainable drainage systems and green roofs.

The City of London Corporation, developers and residents should examine ways of increasing the flood resilience of properties at risk of flooding, using the measures outlined within the strategy.

The City of London Corporation should develop a flood recovery plan, which should form part of the City of London's emergency plan. There should be a nominated officer with responsibility for overseeing flood risk management in the City of London Corporation.

Managing water resources

The City of London Corporation should develop a co-ordinated and sustained awareness-raising campaign aimed at City businesses, property developers and residents regarding water use and water efficiency. The City of London Corporation should in partnership with other organisations, consider initiating a 'Green Plumber Watersaver' training scheme to train plumbers in water conservation.

The City of London Corporation should work with Thames Water Utilities to discuss contingency planning for vital City functions in times of extreme drought.

The City of London Corporation should encourage Transport for London to investigate rainwater harvesting systems for installation on roofs of Network Rail, DLR and tube stations. The City of London Corporation should consider requiring that rainwater harvesting systems are installed on market buildings, gardens and large open spaces. There is an opportunity to explore the feasibility of rainwater harvesting and other water and energy saving options on the LMA (London Metropolitan Archives) roof. The harvested water could be used for cleaning, toilet flushing and irrigation etc. Flood 'hotspots' should be targeted as a priority initially.

The City of London Corporation and developers should where feasible design and install drought-resistant landscaping schemes and 'low water gardens' in open spaces that require minimal irrigation. They should also adopt water-efficient irrigation practices, such as moisture-sensitive and drip systems.

The City of London Corporation should consider the use of 'bio-bombs' or barley straw in water courses when needed to absorb nutrients and prevent algal blooms.

Managing heat risks and air pollution

The City of London Corporation should consider ensuring that enhancements to biodiversity which also provide cooling (including increased planting for shade in open spaces, as well as green roofs and vertical habitats) are made a requirement in the LDF.

The City of London Corporation should liaise with electricity providers to the City with a view to ensuring security of supply for City buildings and infrastructure, taking account of climate impacts on seasonal demands.

The City of London Corporation should encourage Transport for London to create 3-day travel cards to support home-working during heatwaves.

The City of London Corporation should encourage Transport for London to install electronic displays outside tube stations, showing underground temperatures.

The City of London Corporation should encourage Transport for London and tube companies to investigate thoroughly the feasibility of making drinking water freely available on platforms at underground stations.

The City of London Corporation, in partnership with other organisations should examine the provision of 'cool' centres (cooled public buildings) during heatwaves, with extended opening hours for vulnerable people, and should include them in emergency plans.

The City of London Corporation should work with strategic health authorities and primary care trusts to implement the local heatwave plan in the City and to include actions to manage air pollution health risks in these plans, as high air pollution levels often coincide with heatwaves.

Managing ground conditions

The City of London Corporation and developers should ensure that the design of developments addressing geo-physical risks takes account of climate change impacts on subsidence and heave over the lifetime of the development.

When designing landscaping, the City of London Corporation and developers should choose the types and locations of trees carefully, considering how subsidence and root penetration will be affected by climate change.

Developers should, where appropriate, use enhanced or piled foundations capable of withstanding increased risks of subsidence and heave due to climate change, over the lifetime of the development.

When underpinning existing buildings already affected by subsidence, building owners should ensure the underpinning is sufficient to cope with climate change.

Many of the recommendations, regarding flood risk for example, are in line with central and regional government planning guidance, and will be incorporated within the City of London Corporation's new Local Development Framework. Others, which concern managing the City's water budget, or transport issues will require close cooperation and partnership working with other bodies.

To this end an action programme will be developed over the coming year that will seek to implement the recommendations contained within this strategy in partnership with City of London Corporation stakeholders.

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1. Context and purpose

1.1 Adapting to inevitable climate change in the City of London

Our climate is changing due to man-made emissions of greenhouse gases, and we are faced with many years of continuing unavoidable change. Even if we were to make significant reductions in greenhouse gas emissions tomorrow, the inertia in the climate system means that we will need to cope with a changing climate for the next 40-plus years, due to emissions we have already put into the atmosphere.

Organisations and individuals need to grasp the reality we face – that we have to both reduce our emissions and adapt to inevitable climate change. There is no choice between mitigation and adaptation – we have to pursue complementary actions on both.

The Stern Review on the economics of climate change has considerably raised the profile of climate change[2]. It states clearly that climate change is now a mainstream economic and social issue, not simply an 'environmental problem' and demonstrates that climate change has the potential to impact on the whole economy, from financial markets to individual businesses.

It is within this context that the City of London Corporation has developed this climate adaptation strategy. The City of London Corporation wants to understand and manage changing climate risks, to ensure that its services and infrastructure continue to function appropriately and that the City as a whole continues to thrive.

Since climate change will continue to intensify over coming decades and centuries, and much of our infrastructure and assets will be in place for decades or more, this strategy considers climate risks to the end of the 21st century. It emphasises cost-effective measures that can be taken now to minimise risks and maximise opportunities over the longer term.

1.2 'Climate-proofing' the City of London

The overall aim of the City of London Corporation's adaptation strategy is to ensure that the City's services and infrastructure continue to function appropriately in the face of climate change. This aim can be described by the general term 'climate-proofing'[3]. With respect to climate-proofing, the City of London Corporation has several important roles:

- Initiating research and monitoring to help develop appropriate policy and actions on climate adaptation,
- Climate-proofing its own policies,
- Climate-proofing its own practices, assets and infrastructure,
- Working in partnership with others to assist them in addressing climate adaptation, including:
    - Other utility and service providers in the City,
    - City businesses,
    - City residents,

[2] http://www.hm-treasury.gov.uk/Independent_Reviews/stern_review_economics_climate_change/sternreview_index.cfm

[3] Acknowledging that complete 'climate-proofing' can not be achieved - residual climate risks will always remain.

- Other public sector bodies.

The City of London Corporation recognises that some of the adaptation measures required to address climate risks will be the responsibility of these other groups. Some suggested adaptation measures for consideration by these groups are also described in this adaptation strategy, where they are of particular concern to the City of London Corporation.

One of the routes for delivery of this adaptation strategy is the City of London Corporation's Local Development Framework (LDF), which is currently under development (see **Info Point A** below)[4]. City of London Corporation departments also have a major role to play in ensuring that adaptation measures are supported in their policy frameworks and business plans.

Info Point A: The City of London Corporation Local Development Framework (LDF) and key drivers of change

The LDF will replace the City of London Unitary Development Plan (UDP), which was adopted in 2002. The LDF will differ from the UDP in a number of ways as it will draw together the spatial planning aspects of other plans and strategies for the City, such as the Community Strategy. The final LDF document is expected to be adopted in 2008.

The Core Strategy Development Plan Document (DPD) will contain the most important planning policies of the LDF. Currently, consultation and development of the Core Strategy is underway.

Core Strategy Issues and Options for the LDF were published in May 2006, and identified the following as key drivers for change in the City:

- Employment growth,
- Higher density development,
- Better transportation,
- More sustainable environment.

Preparation of DPDs containing more detailed policies and proposals for the implementation of the Core Strategy will start in 2008. Supplementary Planning Documents (SPDs) will explain the policies of DPDs in more detail where this is necessary, and will supersede current Supplementary Planning Guidance.

1.3 How to use this report

This report is organised according to the main climate risks that the City of London will experience, under the following headings:

- Managing flood risks,
- Managing water resources,
- Managing heat risks and air pollution,
- Managing ground conditions,
- Cross-cutting issues.
- Opportunities.

[4] http://www.cityoflondon.gov.uk/NR/rdonlyres/0DA4A82C-50F7-4D7D-ABC3-7E5A8E1F0241/0/DP_PL_UDP_Issues_OptionsMainWeb.pdf accessed on 15.09.06

Each section outlines the highest priority risks and corresponding adaptation measures to manage the risks. Additional information on climate risks and adaptation measures is provided in Appendices 1 and 2 respectively. Two 'climate-proofing checklists' are also provided (see Appendix 3) – one aimed at City of London Corporation staff developing policies and projects, and one specifically for City developers and infrastructure managers.

The methodology used to develop this adaptation strategy is summarised in Appendix 4.

2. Overview of the City of London Corporation[5]

The City of London Corporation provides local government services for the financial and commercial heart of the UK, the 'Square Mile'. Its responsibilities extend far beyond the City boundaries in that it also provides a range of additional facilities for the benefit of the nation, including open spaces such as Epping Forest and Hampstead Heath and art centres such as the famous Barbican Arts Centre.

There are around 300,000 daily commuters into the City, as well as a large number of visitors for business and tourism. Most people travelling to the City are dependent on public transport, and there are 7 mainline stations and 13 DLR/tube stations within the City of London Corporation boundary (see Figure 1). Around 80% of the workforce in the City is employed in the financial and business services sectors. Any disruption to the City has the potential seriously to affect not just the local economy but also national and global economies.

There are a large number of entertainment premises, including restaurants, pubs, clubs and theatres in the area which cater for the residential population and workers and tourists. Wholesale and retail sectors are also important to the local economy. The City also owns the three premier wholesale food markets which supply London and the South East with fresh produce.

Within the Square Mile there are galleries, theatres, museums and concert halls, including the Barbican Centre and the Guildhall. As well as being the third largest sponsor of the arts in the UK, the City of London Corporation owns and cares for a significant number of historic buildings and monuments. The City also has extensive libraries and archives, with approximately 15km of archives and records held underground at the London Metropolitan Archives, another 15km at Guildhall Library and information held at Shoe Lane Library and City Business Library.

The City of London Corporation looks after more than 2,700 properties across six London boroughs and has two housing estates - Golden Lane and Middlesex Street - within the City itself. There are approximately 9,200 residents within the City boundary[6]. The City of London Corporation directly manages commercial property in the City, the West End and Southwark.

The City of London Corporation manages and maintains the highway drainage system and 820 fire hydrants throughout the Square Mile. The City of London Corporation is also responsible for the management and maintenance of 6km of service subways under the highway in which water, gas, electricity and telecommunications companies' apparatus is housed.

Thames Water Utilities employs the City of London Corporation as its sewer management contractor in the Square Mile, with responsibility for the day to day maintenance of 72km of the sewer network, and to look after its interest in any associated planning issues.

The City of London Corporation owns and manages over 10,000 acres of open spaces in and around London for the recreation and enjoyment of the public and as 'breathing spaces' from built-up developments, such as Hampstead Heath.

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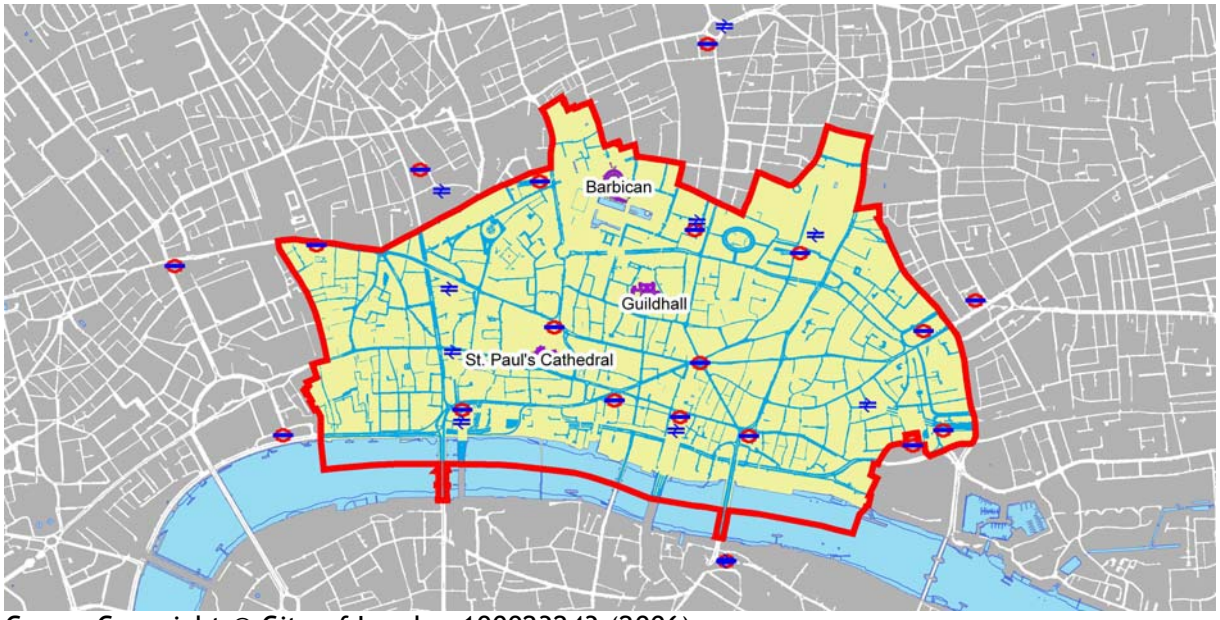
[5] http://www.cityoflondon.gov.uk/Corporation - accessed on 06.11.06
[6] Approximate figure at mid-2005

Figure 1: The City of London Corporation 'Square Mile' showing mainline stations, DLR / tube stations and key buildings



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3. A changing climate for the City of London

3.1 Summary of expected climate changes in London

London will experience significant changes in climate over the coming decades. These changes can be summarised as:

- Hotter, drier summers,
- Milder, wetter winters,
- More frequent extreme high temperatures,
- More frequent heavy downpours of rain,
- Significant decreases in soil moisture content in summer,
- Sea level rise and increases in storm surge height,
- Possible higher wind speeds.

These changes will be more pronounced over London and the South East than in other parts of the UK. The graphs below, from the UKCIP02 climate change scenarios[7], show that:

- Until about the middle of the century, the amount of climate change that will be experienced has largely already been set, due to emissions of greenhouse gases that are already in the atmosphere,

- The extent of changes towards the end of the century depends on present-day and future emissions:
    - the low emissions scenario assumes that global emissions will fall below today's levels by the 2080s,
    - the high emissions scenario assumes that emissions increase at a faster rate than current levels until the 2080s, by when emission rates will be approximately four times today's level,

- Some of the anticipated changes are predicted by climatologists with a high degree of confidence, whereas others are less certain.

A table providing additional information on expected climate change in London over the coming century is provided in Appendix 5.

[7] Hulme, M., Jenkins, G.J., Lu, X., Turnpenny, J.R., Mitchell, T.D., Jones, R.G., Lowe, J., Murphy, J.M., Hassell, D., Boorman, P., McDonald, R. and Hill, S. Climate Change Scenarios for the United Kingdom: The UKCIP02 Scientific Report, Tyndall Centre for Climate Change Research, School of Environmental Sciences, University of East Anglia, Norwich, UK. 2002.

Figure 2: Increase in annual average temperature (°C) in London under the UKCIP02 low and high emissions scenarios

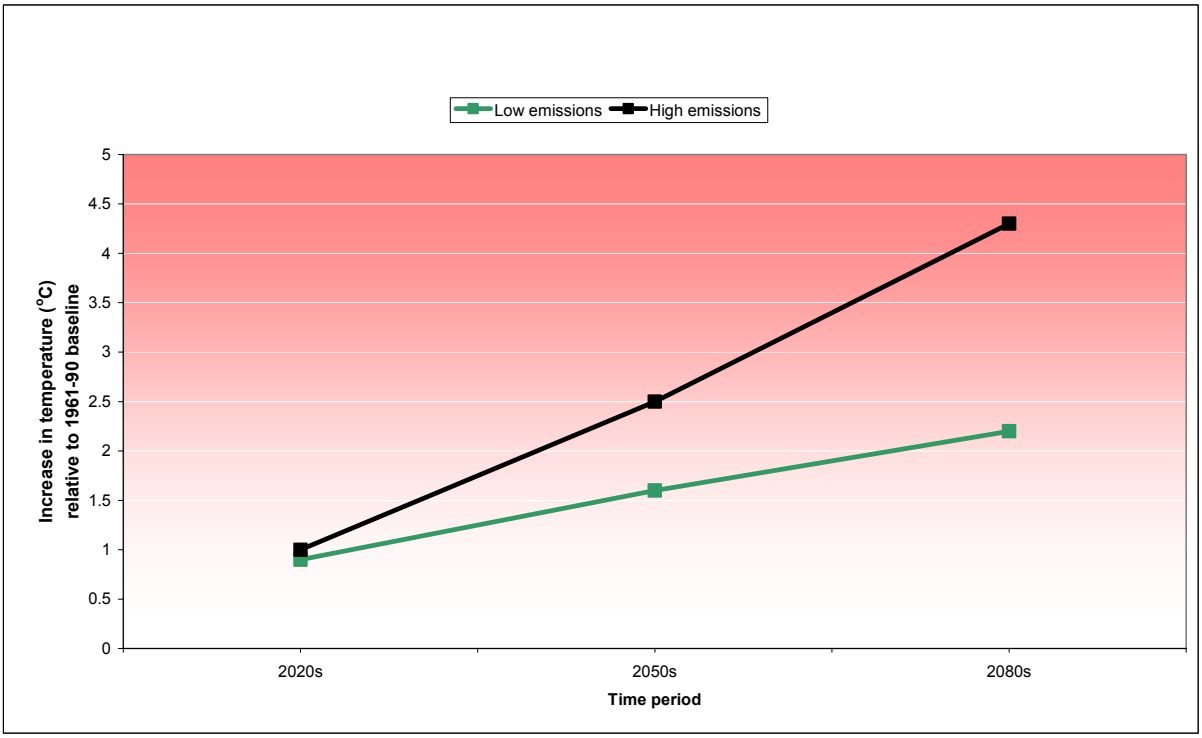


Figure 3: Reduction in average summer precipitation (%) in London under the UKCIP02 low and high emissions scenarios

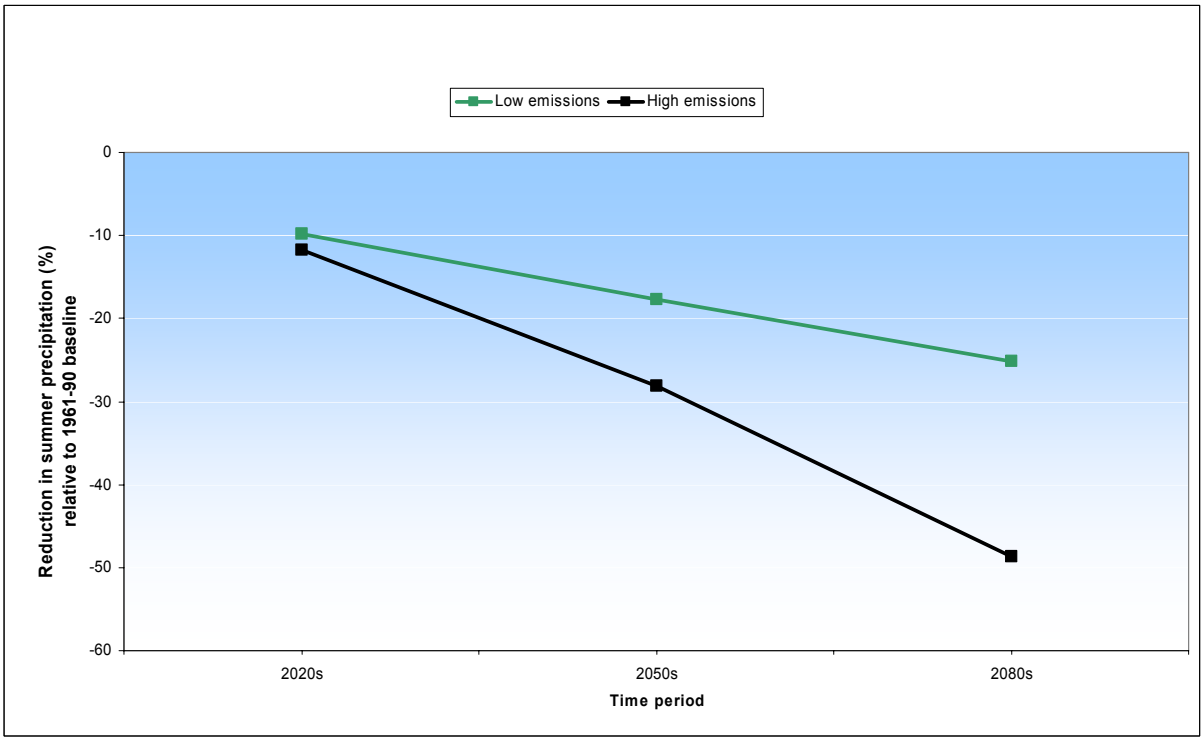
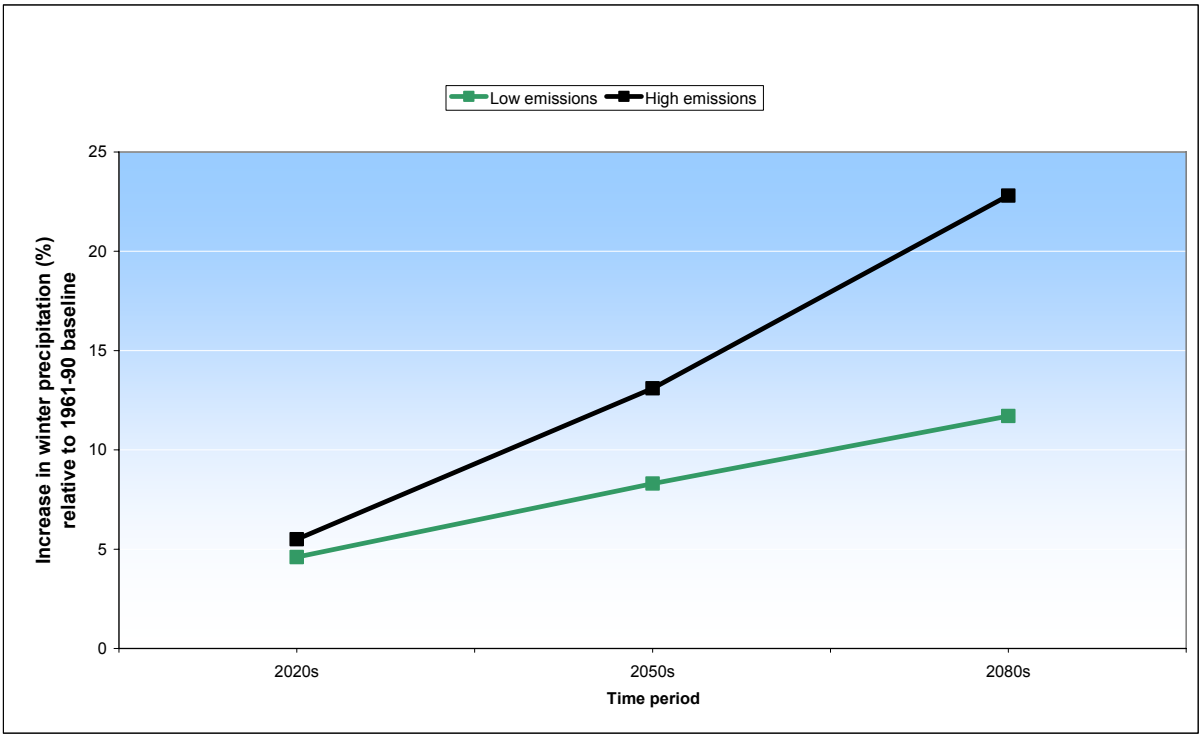


Figure 4: Increase in average winter precipitation (%) in London under the UKCIP02 low and high emissions scenarios



4. Managing flood risks

4.1 Why act now?

It is clear that unless action is taken, flood risks in the City of London will increase. Climate change is increasing the magnitude and frequency of intense rainfall events that cause flash flooding. Rising sea levels mean that risks of tidal flooding from the Thames are increasing. River flood risk is also escalating, as climate change is causing heavier average winter precipitation.

Recent research on flooding events clearly demonstrates the costs and implications of inaction. A report by the London Climate Change Partnership (LCCP) 'Climate change and London's transport systems'[8] looks at the implications of flash flooding on the underground. The report notes that 'between 1992 and 2003, over 1,200 flooding incidents have been recorded on the London Underground, including 200 Underground station closures.' The cost of these closures was estimated at £14.6m in terms of passenger delays, and just one event on 7th August 2002 cost approximately £0.74m.

Other flooding impacts have been experienced in London recently and reported in the media. On 14th September 2006, the 'London Lite' newspaper reported that heavy rainfall caused signal failure on the tube, with commuters stranded and roads under water. The Harrow Times, 15th September 2006 reported that serious flooding had caused two schools in Pinner and Harrow to close.

Existing problems have also been identified within the City. For example, the existing drainage system at the Guildhall Art Gallery can not cope with intense rainfall at times, and this has led to flooding of the basement and thousands of pounds worth of damage.

Before 1990, the Thames Barrier was closed on average once or twice per year. Since 1990, the number of barrier closures required to protect London against tidal surges has increased to an average of about four per year.[9] According to reinsurer Munich Re[10], London is ranked within the top ten 'at risk' cities in the world exposed to catastrophic loss of life and property from natural disasters.

'London will flood, and flood badly'
Norwich Union website [(a)]

Merrycon Ltd, business continuity specialists, warned that a potential devastating flood will affect London in the future. They also claimed that many London-based firms had not taken this risk into account.

They recommend that businesses review their business continuity plans. A resilience exercise demonstrated that extensive flooding had not been considered by businesses and some firms had disaster recovery sites located in the Docklands, which Merrycon pointed out would flood as well.

(a)http://www.nurs.co.uk/news/articles/cms/1157543582212694732706_1.htm accessed 06.11.06

'Commuters stranded as storms bring floods and traffic gridlock'
The Times August 4th, 2004

A flash flood event left hundreds of thousands of commuters stranded as much of the Underground network and major routes out of the capital closed. The capital's tube, bus, rail and road routes were paralysed as flood waters failed to subside. Some homes and offices in West London flooded. Basement flats in Acton were flooded causing significant damage to property and loss of possessions. The Television Centre in the West End was flooded, causing the filming of Newsnight to have to be moved.

[8] Arkell, B and Darch, G. Climate change and London's transport systems. Technical report for the Greater London Authority and London Climate Change Partnership. 2005.
[9] http://www.environment-agency.gov.uk/yourenv/432430/432434/432475/436993/?version=1&lang=_e
[10] Megacities: megarisk. Munich Re. knowledge series. 2004. http://www.munichre.com/publications/302-04271_en.pdf?rdm=22452 accessed on 03.11.06

4.2 What does it mean?

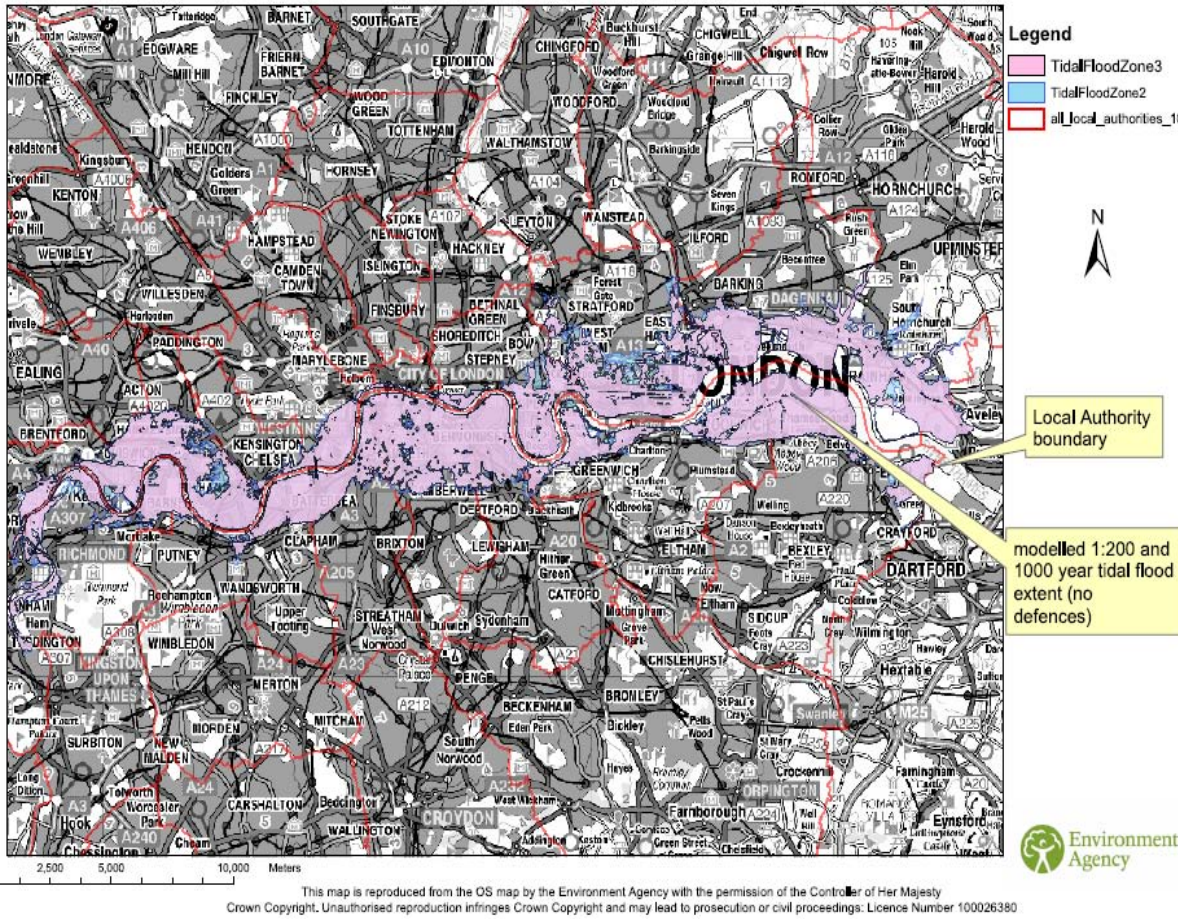
Flash flood risk will increase in the future with climate change, which means there is a greater risk of injury and health risks to the public and City workers. The loss of open rivers and natural infiltration, and exceedance of sewer capacity have exacerbated the risk of flash flooding in London. Flooding also causes damage to property, infrastructure and open spaces.

Transport is disrupted, which in turn affects commuters and deliveries of goods and services. This ultimately leads to business costs and interruption.

Tidal and river flooding has long since been highlighted as a major risk for London. Around 45 square miles of London is at risk of tidal flooding, an area containing 400,000 properties and home to 1.25 million people. Figure 5 shows existing flood risks from river and tidal flooding. River and tidal flooding cause similar impacts to flash flooding, although the floods are more widespread and can last for days, causing far greater damage and disruption. Other specific risks such as rising insurance premiums in high flood risk areas or even withdrawal of insurance cover also need to be considered.

Further details on flood risks to the City due to climate change can be found in Appendix 1.

Figure 5: Map of current risk of river and tidal flooding, showing flood zones 1 - 3



4.3 What actions are already underway?

Action is underway at all levels from national to local authority level to manage flood risks to London.

National action

Flood risk management is addressed at a national level through planning policy. The Department for Communities and Local Government (DCLG) has published a new Planning Policy Statement on flood risk and development (PPS25)[11], which replaces the pre-existing guidance, PPG25. One of the key changes is that the Environment Agency is now a statutory consultee on all planning applications for development in flood risk areas, including those in areas with critical drainage problems, and for any development on land exceeding 1 hectare outside flood risk areas. The full application of PPS25 provides a strong mechanism for addressing current and future flood risk in London in a more sustainable way.

London-wide action

The Thames Barrier and associated defences provide a high standard of protection to London and the Thames Estuary against a combination of tidal and fluvial flood risks, the principal risk being from tidal surge events. A generous allowance for sea level rise was built into the design of the Thames Barrier and associated defences, and today they offer a standard of protection of 0.05% risk of flooding from tidal surge in any one year. As sea level rises, this standard of protection will reduce as planned, to the design standard of 0.1% risk of flooding from tidal surge by the year 2030.

The Environment Agency, with Defra support, is engaged in a number of studies which are reviewing the current and future needs of London's tidal defences, including the overarching Thames Estuary 2100 project (TE2100), which is developing a tidal flood risk management plan for London and the Thames estuary post-2030. An investment of some £300 million in the city's flood defences will be made over the next 15 years.

To help manage flash flood risks, the Mayor's Further Alterations to the London Plan[12], his Supplementary Planning Guidance on Sustainable Design and Construction[13] and the Checklist for Development published with the South East and East of England regions[14] all promote the incorporation of Sustainable Drainage Systems (SuDS) in new developments. For details of SuDs techniques see **Info Point B**.

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[11] For information see the DCLG website http://www.communities.gov.uk/consultations.
[12] Mayor's Further Alterations to the London Plan. See http://www.london.gov.uk/mayor/strategies/sds/further-alts/docs.jsp.
[13] Supplementary Planning Guidance on Sustainable Design and Construction. Greater London Authority. May 2006. http://www.london.gov.uk/mayor/strategies/sds/sustainable_design.jsp
[14] Adapting to climate change: a checklist for development. Guidance on designing developments in a changing climate. Greater London Authority. November 2005.

Info Point B: Sustainable drainage systems [(a)]

Sustainable Drainage Systems (SuDS) offer an alternative to traditional approaches to managing runoff from buildings and hardstanding. SuDS mimic natural drainage patterns and can attenuate surface water runoff, encourage recharge of groundwater, provide amenity and wildlife enhancements, and by employing pollutant trapping and degradation processes, SuDS can protect water quality.

SuDS approaches include:

- Preventive measures including good housekeeping, rainwater harvesting, green roofs and water butts,
- Filter strips and swales - vegetated landscape features with smooth surfaces and a gentle downhill gradient to drain water evenly off impermeable surfaces,
- Infiltration devices like soakaways which allow water to drain directly into the ground,
- Permeable and porous pavements,
- Basins, reed beds and ponds designed to hold water when it rains.

It is important that consideration is given to the future maintenance requirements of SuDS, including the need to remove silt, and that space requirements for this purpose are allowed for in the design.

Green roofs [(b)]

Green Roofs are considered a SuDS technique. They are vegetated roofs, or roofs with vegetated spaces. Modern green roofs have largely developed in the last 50 years, with increasing sophistication to meet a growing range of needs. The main benefits of green roofs include:

- Reduced stormwater runoff, (and hence potential savings to developers, as the number of drainage outlets required on a building can be reduced),
- Reduced urban heat island effect (by reducing building heat loss and increasing evapotranspiration),
- Creating natural green spaces in urban areas,
- Reduced energy consumption and fuel costs, since green roofs provide cooling in summer and thermal insulation in winter,
- Benefits for biodiversity,
- Reduced air pollution,
- Extended roof life, since the green roof protects the roof's waterproofing membrane, almost doubling its life expectancy.

Many of these benefits help to address climate change risks.

There are several examples of green roofs around the City, including the large roof garden above Cannon Street station and the landscaped walkways in the Barbican. Over recent years the City of London Corporation has encouraged developers to include extensive green roofs in their building designs, and several are now under construction.

The City of London Corporation has worked with the British Council for Offices to produce a publication to raise awareness of green roofs[(c)].

(a) South East England Climate Change Partnership, Sustainable Development Round Table for the East of England and London Climate Change Partnership. Adapting to climate change: a checklist for development. GLA, London. 2005.
(b) www.livingroofs.org and www.toronto.ca/greenroofs
(c)http://www.greenroofs.com/pdfs/sg-green_roofs_advice_note_corpoflondon.pdf, accessed on 03.11.06

City of London Corporation action

The City of London Corporation has already implemented a number of actions to manage flood risks. These include:

- The **City of London Corporation Unitary Development Plan** (UDP)[15] has measures in place to manage flood risks. These include refusing development which would adversely affect the stability or continuity of the Thames flood defences; and also requiring that developments in, on or over the river must not impede the free flow of tidal or flood water along or into the river.

- The **City of London Corporation Issues and Options report for the Local Development Framework** (LDF)[16] is considering two options to assist in reducing flood risk. The options are either to *encourage* or to *require* that sustainable urban drainage and green roofs are implemented as part of sustainable design and construction.

- The **City of London Corporation Sustainability Policy**[17] includes the following principle on flood risk management: *"Continue work with partners to counteract and reduce the risk of major flooding."*

Info Point C: Information on flood resilience for home owners and businesses

Information for home owners and businesses on flood resilience is available in the Association of British Insurer's (ABI) fact sheet on Flood Resilient Homes[(a)], ODPM's (now DCLG's) 'Preparing for Floods'[(b)] and the Environment Agency's 'Damage Limitation – how to make your home flood resilient'[(c)]. There is also Agency Standing Advice on flood risk.

CIRIA advice sheets: Improving the flood resistance of your home [(d)]

CIRIA has produced a series of advice sheets on improving the resilience of homes to the damaging effects of flooding. These include advice on assessing risk of flooding to a property. For householders whose property is at risk from flooding, the advice notes provide information on practical steps to prevent, or reduce the impact of, flooding in the future. The sheets are designed for residents who are skilled at DIY or a builder, and are also intended to be useful to a householder working with builders and surveyors if they are unable to carry out the work themselves. The advice sheets include guidance on:

- Using one-way valves in drainage pipes to prevent back-up of water into buildings,
- Using removable flood barriers and other removable flood protection products,
- Using flood-resilient materials,
- Locating electrical services and boilers above likely maximum flood level,
- Raising damp-proof courses.

(a) www.abi.org.uk > publications > flooding
(b) www.communities.gov.uk > building regulations > building regulations approved documents and associated guidance
(c) Damage Limitation – How to make your home flood resistant. www.environment-agency.gov.uk/subjects > flood > floodline >
(d) www.ciria.org/flooding > reducing the impact online flood library > flood factsheets > preparing for a flood

[15] City of London Unitary Development Plan. 2002. http://www.cityoflondon.gov.uk/Corporation/our_services/development_planning/planning/udp/udp_2002.htm
[16] City of London Core Strategy: Issues and Options, Local Development Framework. May 2006.
[17] City of London Sustainability Policy. September 2005. http://cms.cityoflondon.gov.uk/Corporation/living_environment/sustainability/

4.4 What further actions are recommended?

Highest priority actions to manage flood risks recommended by this adaptation strategy are summarised below. A fuller list of actions is provided in Appendix 2.

'No-regrets' measures deliver benefits that exceed their costs, whatever the extent of climate change.

'Low-regrets' measures are low cost, and have potentially large benefits under climate change.

'Win-win' measures contribute to climate adaptation and also deliver other benefits.

Research and monitoring

The City of London Corporation should work with drainage providers to identify and map flash flood 'hotspots' based on where floods have been experienced in recent years and identify the causes of flooding (e.g. lack of drainage capacity, poor maintenance).

The City of London Corporation should work with Thames Water Utilities Ltd to assess the capacity of the 72km of sewers managed by the City of London Corporation to cope with increasing rainfall due to climate change.

Policy

As noted above, the Issues and Options report for the City of London Corporation LDF is considering whether to *encourage* or to *require* that sustainable drainage systems (SuDS) and green roofs are implemented. This adaptation strategy recommends that the LDF requires that sustainable drainage systems, green roofs etc are implemented in flash flood 'hotspots', as part of new developments, redevelopments and major refurbishments. The systems should be designed to achieve at a minimum, no net increase in runoff and should aim for a reduction in runoff. The City of London Corporation should specify within the LDF that S106 planning agreements should be used to secure long-term commitment to the management and maintenance of SuDs.

The City of London Corporation LDF should require that drainage systems in all developments[18] have the capacity to cope with heavier rainfall events expected over their lifetimes, taking account of climate change.

Practical actions

The City of London Corporation should encourage businesses to consider relocating flood-sensitive IT equipment and archives out of London to areas with negligible flood risks. Assets and equipment, which need to be on-site, should be moved away from locations at higher risk of flooding, such as basements.

Developers should be encouraged to install sustainable drainage systems and green roofs in targeted flash flood 'hotspots' for new developments, redevelopments or major refurbishments.

[18] For 'development' please read new developments, redevelopments and major refurbishments throughout this report

Practical actions (cntd)

The City of London Corporation should consider installing sustainable drainage systems, green roofs or green walls on City of London Corporation-owned car parks and buildings, when they are refurbished or replaced.

The City of London Corporation should consider creating spaces for additional temporary flood water storage in City of London Corporation-owned large open spaces, such as Hampstead Heath.

The City of London Corporation should examine a range of incentives to encourage sustainable drainage systems and green roofs.

The City of London Corporation, developers and residents should increase the flood resilience of properties at risk of flooding, using the measures outlined at **Info Point C**.

The City of London Corporation should develop a flood recovery plan, which should form part of the City of London's emergency plan. There should be a nominated officer with responsibility for overseeing flood risk management in the City of London Corporation.

5. Managing water resources

5.1 Why act now?

The summer of 2006 demonstrated that action is needed to improve management of water resources. Due to climate change summers are becoming hotter and drier and winters are getting wetter. Precipitation patterns are also altering, producing more intense, heavy rainfall events. This means the way in which water is captured is affected, as higher temperatures and lower rainfall reduce soil moisture and the chance to replenish groundwater supplies. Climate change is leading to more frequent droughts, with consequent reduced water availability.

The extensive media coverage of this issue in summer 2006 clearly shows the implications of inaction. Reduced water availability in the summer of 2006 led to a hosepipe ban across London. As reported in The Evening Standard on 29th September 2006, London suffered its worst drought in 70 years after lower than average rainfall almost every month since October 2004. This not only affected individuals but also businesses. On 22nd May 2006, the Independent reported that the Horticultural Trades Association, which represents the garden industry, estimated that the hosepipe ban will cost its members £300m this year in lost sales.

The prolonged drought in the summer of 2006 also led to a spate of fires in the South East with thirty acres of grassland lost in East London. The fires also caused traffic chaos as flames encroached on to roads and smoke was blown across major routes. On the 19th July 2006, the Evening Standard reported that the London Fire Brigade had to attend an increasing number of 'bush fires'.

'Better weather for the ducks as worst of the drought is over'
The Daily Telegraph, August 18th, 2006

At the beginning of April 2006, hosepipe bans were imposed on 13 million people across the South East of England. Some water companies banned watering of sports grounds, washing cars and filling pools.
The heatwave triggered the hottest July on record and the driest July in seven years, causing the hosepipe bans to be put in place as water resources were low.
After 20 months of below-average rainfall in the South East, supplies were at 70% of average for the time of year. Reservoirs were at 77% capacity and groundwater levels were 27% lower than average.
Water UK [(a)] said that twice the normal rainfall was needed during the winter of 2006 to replenish groundwater levels fully.
Sales of water butts soared and aerial photographs of the South East showed that many gardeners did not attempt to keep their lawns green.

[(a)] Water UK is the industry association that represents UK water suppliers

5.2 What does it mean?

The UKCIP02 climate change scenarios indicate that summers may become drier by 20% to 40% by the 2050s in London and the South East. This will have far-reaching consequences, as there could be restrictions on water use for industrial, commercial and public use. Impacts also include a higher risk of fire on scrub and heathland. Lower rainfall, combined with rising temperatures, mean that river flows are likely to be lower in summer which will raise water temperatures and affect water quality.

There is already pressure on water resources across the South East. As shown in Figure 6, the majority of Greater London has no additional water available, meaning that summer surface water is already fully committed. The supply-demand balance of water in London currently stands in deficit. The increasing impacts of climate change, as well as the likely increase in population in the London area will compound these problems unless actions are taken to manage water resources more wisely.

'Help call over climate-change fires'
London Lite August 11th, 2006

Climate change is increasing pressure on the fire and rescue services. Rescue services are facing additional pressures and substantial costs from the increase in the number of major fires due to dry conditions this summer. Resources were further stretched as the dry period was then followed by torrential rain causing flash flooding. The Union called for an immediate end to cuts in personnel and for an immediate cash injection of £60 million.

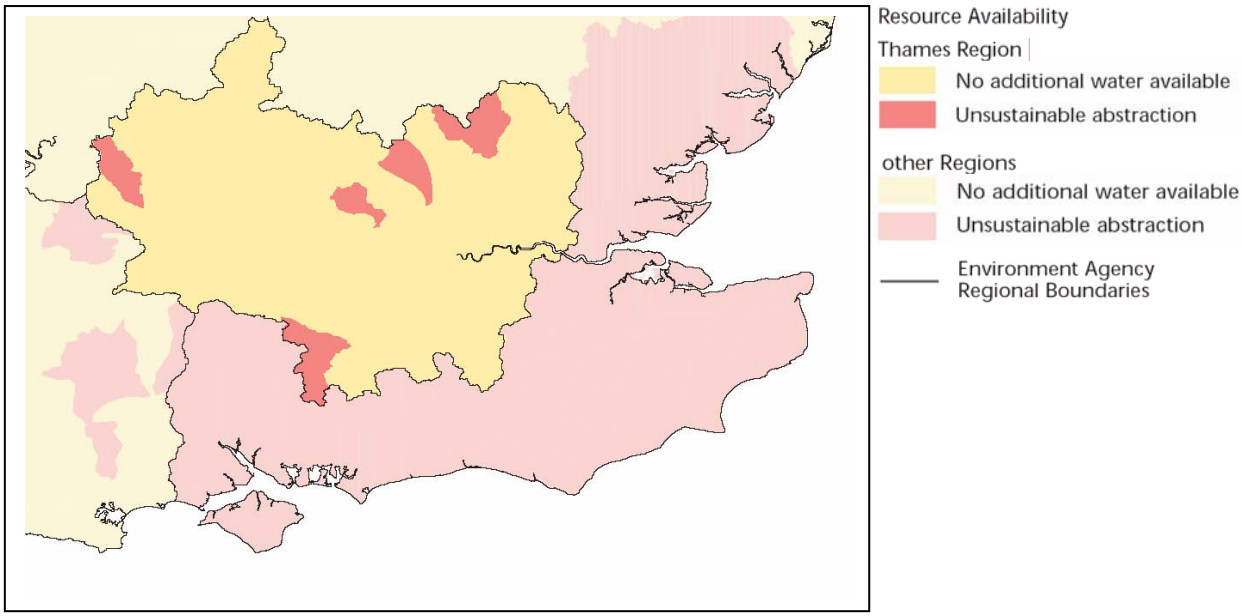
The Environment Agency has estimated that without further action to manage water demand, new strategic water resources may be required for London, under some scenarios, by 2020[19].

Water comes from a variety of sources including directly from rivers, water captured and stored in reservoirs, and water pumped up from aquifers beneath the ground. Climate change is causing a reduction in rivers flows and groundwater recharge of aquifers is occurring later in the season. Less water is being captured, as rainfall is occurring in more intense, heavy precipitation events. This runs rapidly off dry ground, rather than infiltrating and replenishing ground water resources. This may lead to a change in how water is captured and stored.

In order to relieve London's water crisis, Thames Water Utilities has plans to build a new reservoir costing £1bn, which will supply an extra 350 million litres of water a day by 2020. However, building this reservoir will not solve all the South East's water resources problems - other action is also required to reduce this risk.

Further details on water resource risks to the City due to climate change can be found in Appendix 1.

Figure 6: Summer water resource availability[20]



5.3 What actions are already underway?

Action is underway at all levels from national to local authority level to manage water resources more efficiently.

National action

[19] Water Resources for the Future. A summary of the strategy for Thames Region. Environment Agency. March 2001.
[20] Water Resources for the Future. A summary of the strategy for Thames Region. Environment Agency. March 2001.

Under the Water Act 2003, all water companies have to prepare water resources plans which include water efficiency measures. The Environment Agency has published several advice notes on water efficiency measures. The Agency also has responsibility for ensuring the proper and efficient use of water resources.
The Government's Water Saving Group is looking to improve the understanding and delivery of metering. All new houses in England are metered, and about one in every five households in London currently has a water meter.

London-wide action

Thames Water Utilities has measures in place to manage water resources including:

- A four-tier drought response approach,
- Fines of £1,000 for failing to adhere to water restrictions (hosepipe and sprinkler bans),
- Water efficiency campaigns for both domestic and business customers, which have been significantly stepped up in response to the drought of 2006,[21]
- Education initiatives.

Thames Water has already started work across London through its Network Improvement Programme (NIP) to stabilise and reduce pressures within the water distribution network. The benefits of this work will be to reduce the numbers of bursts and supply interruptions, allowing the system to be operated more effectively, and also significantly reducing the level of leakage.

The Mayor of London is developing a Water Framework and has established a Water Resources Working Group. The Mayor's spatial strategy, the London Plan[22] already calls for the increased used of grey water and rainwater harvesting, and detailed advice on this is given in his Supplementary Planning Guidance[23] (SPG) on Sustainable Design and Construction.

City of London Corporation action

The City of London Corporation has already implemented a number of actions to manage water resources more effectively. These include:

- The **City of London Corporation Unitary Development Plan** (UDP)[24] has measures in place for water conservation. These include encouraging development that incorporates water conservation and water efficiency measures.

- The **City of London Corporation Issues and Options report for the Local Development Framework** (LDF)[25] is considering two options to assist in water conservation. The options are either to *encourage* or to *require* that water conservation measures, such as those outlined in **Info Point D** are implemented as part of sustainable design and construction.

[21] http://www.thameswateruk.co.uk/waterwise
[22] http://www.london.gov.uk/mayor/strategies/sds/index.jsp
[23] http://www.london.gov.uk/mayor/strategies/sds/spg.jsp
[24] City of London Unitary Development Plan. 2002.
www.cityoflondon.gov.uk/Corporation/our_services/development_planning/planning/udp/udp_2002.htm
[25] City of London Core Strategy: Issues and Options, Local Development Framework. May 2006.

- The **City of London Corporation Sustainability Policy**[26] includes the following principle on water resource management: *"Reduce the excessive use of water in City of London buildings and operations and encourage others to do likewise."*

Info Point D: Techniques for improving efficient use of water resources

Rainwater harvesting systems [(a)]

Rainwater harvesting captures and diverts rainwater. The captured water can be used for irrigation purposes, car washing or toilet flushing and is beneficial for two reasons:

- It reduces water demand and eases pressure on the mains water supply, reducing upstream energy and environmental costs,
- It helps to reduce the risk of flooding during storms by storing rainwater and buffering run-off before it reaches the drainage system.

Typically, rainwater is collected from rooftops and is diverted into barrels or large storage tanks. The amount of rainwater collected from a rooftop can be significant. A 93 m^2 (1,000 square feet) roof can catch 568 litres of water from rainfall of just 6 mm. A soakaway is sometimes used in conjunction with rainwater harvesting, rather than a storage tank. This is a low-lying area filled with stones, shingle or gravel, to allow water to drain away.

A rainwater harvesting system has been installed at a new community resource centre 'The Hub' in London. The rainwater is collected from the roof and is stored in an underground tank for future use. It can then be redistributed for toilet flushing and plant irrigation and is expected to contribute to a saving in mains water of around 50% per year [(b)].

Greywater recycling[(c)]

Domestic water from baths, showers and washbasins can be re-used for toilet flushing but requires filtration and disinfection. The benefits include reducing household water demand and easing pressure on the mains water supply, reducing upstream energy and environmental costs. These systems require maintenance to ensure that they function correctly.

Reducing water use[(c)]

The following measures reduce water use:

- Install dual-flush and low-flush toilets. This can save more than half the water used for flushing toilets and cut household water use by up to 20%,
- Install waterless urinals,
- Install water efficient showers and smaller baths,
- Use water-efficient devices, such as 'A-rated' washing machines and dishwashers,
- Install spray taps,
- Minimise the amount of piping between boiler/hot water tank and tap, to reduce the need to 'run' the water,
- Install leak detection systems for major supplies.

(a) London Climate Change Partnership. Adapting to climate change: Lessons for London. GLA, London 2006.
(b) http://www.arup.com/DOWNLOADBANK/download401.pdf, accessed 06.11.06
(c) South East England Climate Change Partnership, Sustainable Development Round Table for the East of England and London Climate Change Partnership. Adapting to climate change: a checklist for development. GLA, London 2005

[26] City of London Sustainability Policy. September 2005. http://cms.cityoflondon.gov.uk/Corporation/living_environment/sustainability/

5.4 What further actions are recommended?

Highest priority actions to manage water resource risks recommended by this adaptation strategy are summarised below. A fuller list of actions is provided in Appendix 2.

'No-regrets' measures deliver benefits that exceed their costs, whatever the extent of climate change.

'Low-regrets' measures are low cost, and have potentially large benefits under climate change.

'Win-win' measures contribute to climate adaptation and also deliver other benefits.

Policy

As noted above, the Issues and Options report for the City of London Corporation LDF is considering whether to *encourage* or to *require* that water conservation measures, such as those shown in **Info Point D**, are implemented in developments. This adaptation strategy recommends that the City of London Corporation LDF requires that best practice in water efficiency is implemented for all developments as part of sustainable design and construction.

The City of London Corporation LDF should require rainwater harvesting and greywater recycling, where appropriate, in all developments.

Practical actions - the City of London Corporation:

Should develop a co-ordinated and sustained awareness-raising campaign aimed at City businesses, property developers and residents regarding water use and water efficiency. The City of London Corporation should in partnership with other organisations, consider initiating a 'Green Plumber Watersaver' training scheme to train plumbers in water conservation.

Should work with Thames Water Utilities to discuss contingency planning for vital City functions in times of extreme drought.

Should encourage Transport for London to investigate rainwater harvesting systems for installation on roofs of mainline, DLR and tube stations. The City of London Corporation should require that rainwater harvesting systems are installed in its market buildings, gardens and large open spaces. There is an opportunity to explore the feasibility of rainwater harvesting and other water saving options on the London Metropolitan Archives (LMA) roof. The harvested water could be used for cleaning, toilet flushing and irrigation etc. Flood 'hotspots' should be targeted as a priority initially.

And developers should, where feasible, design and install drought-resistant landscaping schemes and 'low water gardens' in open spaces that require minimal irrigation. They should also adopt water-efficient irrigation practices, such as moisture-sensitive and drip systems.

Should consider the use of use 'bio-bombs' or barley straw in water courses when needed to absorb nutrients and prevent algal blooms.

6. Managing heat risks and air pollution

6.1 Why act now?

Climate change is leading to increasing temperatures – higher average temperatures are being experienced and also many more extremely hot days. Summer heatwaves are becoming more frequent and more intense, along with less severely cold winter weather. Research by the Met Office has demonstrated that temperatures experienced in the summer 2003 heatwave will be about average by the 2040s and will be considered 'cool' by the 2060s[27]. Air quality is also a concern as increasing temperatures and prolonged hot periods are associated with summer ozone episodes[28]. The effects of prolonged temperatures were seen across the capital during the summer of 2006 and demonstrate the need to take action to manage heat risks.

On July 20th 2006, the Guardian reported that temperatures on board London buses had exceeded 50°C. Scores of schools closed early including ten in central London and hundreds of schools cancelled sports day amid fears for children's health. Transport disruption was also reported on July 20th 2006 in the Times, when trains were delayed as speed restrictions were imposed and a bridge refused to close after its metal parts expanded. On July 18th 2006, the Evening Standard recorded temperatures of 52°C on buses and 47°C on the Underground system.

Business is also greatly affected - UK employers lost an estimated £154m a day in productivity during one week of the July 2006 heatwave, due to travel disruption and staff arriving late, according to the Centre for Economics and Business Research. It is estimated that work levels dropped by almost a third when temperatures soared to more than 30°C. Occupational health provider Active Health Partners (AHP) estimated that UK businesses lost £119m through absenteeism when temperatures topped 35°C on 19 July 2006.

The most significant effects of the 2003 heatwave in London were the number of deaths, especially amongst the elderly. Overall, there were approximately 600 all-age extra deaths in London[29] (see Figure 7 below).

There is still some uncertainty regarding the link between climate change and air quality but reports from the summer of 2006 have certainly shown that asthma sufferers were particularly badly affected during the heatwave.

'The city that couldn't sleep'
The Evening Standard, July 19th, 2006

The heatwave caused roads to melt and gritting lorries had to be dispatched to spread crushed rock on recently laid roads to stop tarmac sticking to cars.
The London Fire Brigade said it had to attend an increasing number of 'bush fires'.
Speed restrictions caused disruption on the Metropolitan and District lines. These were put in place to reduce the risk of tracks buckling in the heat.
The Department for Environment, Food and Rural Affairs issued a smog warning as smog levels had reached dangerously high levels.
The Department of Health said all hospitals had put their hot weather plans into action and GPs should have identified people most at risk from the heat and should have made

[27] Climate change and the greenhouse effect. A briefing from the Hadley Centre. The Met Office Hadley Centre. December 2005.
[28] Health effects of climate change on the UK. Department of Health. 2001.
[29] London Urban Heat Island: A summary for decision makers. Greater London Authority. October 2006.

On 10th August 2006, the Evening Standard reported that 434,000 of the capital's population are now being treated for asthma. The article reported that asthmatics suffered badly during the heatwave of summer 2006 as asthma attacks were triggered by increased pollution and thunderstorms. Doctors advised some workers in London who suffer from asthma that they should move out of the city. The cost to the NHS of treating asthma sufferers is £889m a year.

6.2 What does it mean?

Temperatures are increasing due to climate change, which means there are greater health risks, risks of damage to assets and infrastructure, transport disruption and business costs. Temperatures in the centre of London are several degrees higher than at the edge of the city due to the Urban Heat Island (UHI) effect, as Figure 8 shows. This makes London particularly vulnerable to increasing temperatures since during heatwaves the UHI prevents the city from cooling down. As a result, night time temperatures are maintained at a level that affects human health and comfort. This is a huge factor in heat mortality and morbidity, especially for certain 'at risk' groups such as the young, the elderly and those with certain health conditions.

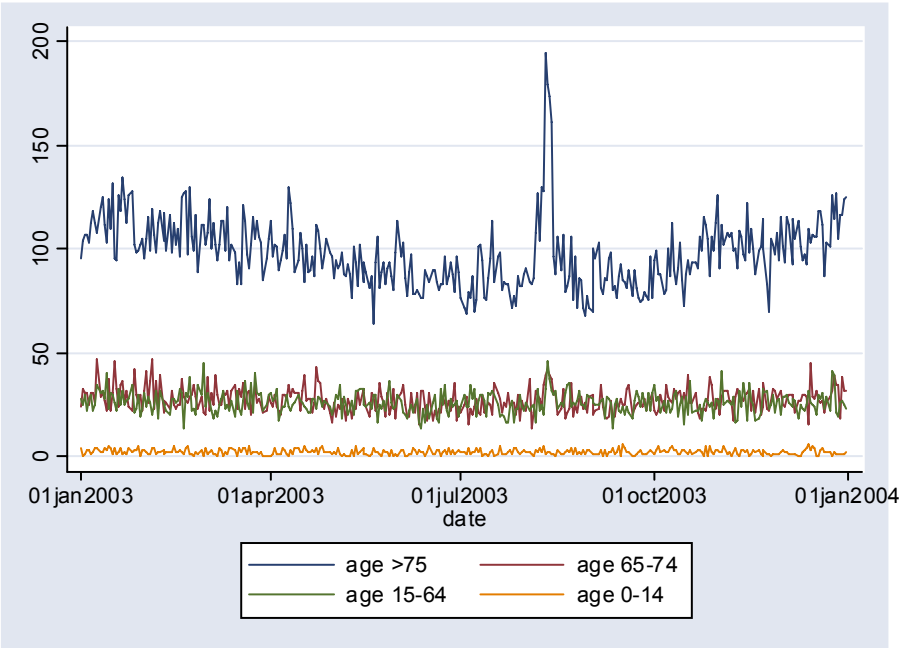
Increasing temperatures have wider implications for the business community. They can lead to passenger discomfort on public transport together with health and safety concerns for passengers. Transport can be disrupted as hotter summers cause damage to assets and infrastructure, such as buckled railway lines and melting roads. The knock-on impact of this to business can be significant as commuters are disrupted. More frequent heatwaves increase risks of heat stress, dehydration, heat-related mortality, skin cancer and eye cataracts for outdoor workers. For indoor workers, building thermal comfort and consequent heat risks to occupants is becoming more of an issue. Increased temperatures will reduce comfort of occupants in commercial and public buildings, leading to discomfort, lower productivity, potential business disruption and heat stress.

There will be an increase in demand for essential services such as social, health and emergency services to cope with these impacts. The Environmental Services Department at the City of London Corporation will likely have to cope with increases in vermin and food poisoning due to increasing temperatures. Energy demands for cooling will increase in hotter weather, potentially causing overload of the electricity grid and power black-outs.

Heatwaves can also create the conditions for high air pollution levels which are exacerbated in the city as the heat and pollution gets trapped. Exposure to ozone and smog can irritate and cause inflammation of airways and can also increase a person's susceptibility to respiratory conditions.[30]

Further details on heat and air pollution risks to the City due to climate change can be found in Appendix 1.

Figure 7: Daily mortality in Greater London in 2003[31]



'Climate change blamed for Legionnaires' disease surge'

The Independent, October 18th, 2006

Record levels of Legionnaires' disease have been reported by the Health Protection Agency in the summer of 2006.

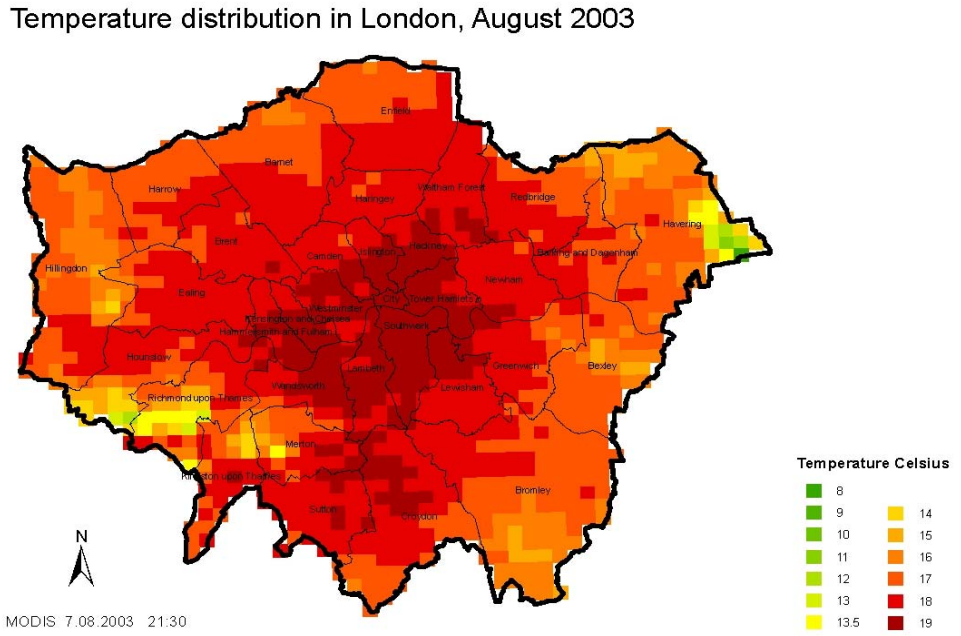
The Health Protection Agency believes this is the first example of an increase in infectious disease in Britain driven by climate change.

Ideal breeding conditions for the Legionella bacteria were thought to have been provided by a hot July followed by a wetter than normal August.

There were 128 cases of Legionnaires' in August 2006. This is the highest since records began in 1980, and more than double the total number of cases in August 2005.

[30] London's Urban Heat Island. A summary for decision makers. Greater London Authority. October 2006.
[31] Sari Kovats, Centre on Global Change and Health, London Schools of Hygiene and Tropical Medicine. GLA Urban Heat Island Project presentation. March 2006.

Figure 8: London's Urban Heat Island: Distribution of surface temperature across London at 21:30 during the heatwave on August 7th, 2003[(a)].



(a) London's Urban Heat Island: A summary for decision makers. Greater London Authority. October 2006.

6.3 What actions are already underway?

Action is underway at all levels from national to local authority level to manage heat risks and air pollution.

National action

In 2005, the UK's National Heatwave Plan was introduced by the Department of Health. The UK Met Office provides weather forecasting for the Heatwave Plan. Strategic health authorities, primary care trusts and local authorities then develop plans for their local setting.

The National Air Quality Strategy was published in 2000 and describes the plans drawn up by the government to improve and protect air quality in the UK in the medium-term. Local authorities under local air quality management (LAQM) need to work towards achieving the objectives within the strategy by reducing levels of seven key air pollutants.

London-wide action

The Greater London Authority (GLA) has published research on how to manage the intensification of London's Urban Heat Island[32]. The research supports the need for more green roofs and street trees. Green roofs provide multiple benefits including reducing the Urban Heat Island effect and keeping buildings cool (see **Info Point E** below). The GLA has published a paper on green roofs and there is encouragement for them in new buildings in the Further Alterations to the London Plan, the Supplementary Planning Guidance on Sustainable Design and Construction and the Checklist for Development published with the

[32] London's Urban Heat Island. A summary for decision makers. Greater London Authority. October 2006.

South East and East of England regions. The GLA is currently identifying and mapping 'areas of deficiency', where the public does not have access to good quality green space.

The Mayor's Air Quality Strategy sets out policies and proposals to reduce air pollution. The Mayor's aim is to improve London's air quality to the point where pollution no longer poses a significant risk to human health. The GLA's air quality and cleaner transport initiatives should reduce emissions from transport and improve general air quality, and consequently reduce environmental stress on Londoners.

The London Air Quality Network (LAQN) was formed in 1993 to coordinate and improve air pollution monitoring in London. The network covers thirty-three London local authorities and provides bulletins on air pollution levels[33].

Action by the City of London Corporation

The City of London Corporation is implementing a number of actions which can help to manage overheating risks and air pollution. The actions include:

- The **City of London Corporation Issues and Options report for the Local Development Framework** (LDF)[34] is considering two options related to sustainable buildings – whether to *encourage* or to *require* sustainable design and construction. The Issues and Options report explains that sustainable buildings need to take account of predicted climate change, though it does not detail specific measures to promote reduction of overheating risks.

- The **City of London Corporation Issues and Options report for the Local Development Framework** (LDF)[35] is considering two options to assist with nature conservation objectives. The options are either to *encourage* or to *require* the enhancement and promotion of biodiversity. This includes a range of measures such as climber-covered walls and green roofs, which can also be effective in reducing overheating.

- The **City of London Corporation Sustainability Policy**[36] includes principles to improve air quality, reduce air pollution and also to protect, maintain and enhance open spaces and other areas with landscape, wildlife or historical interest.

The City of London was declared an Air Quality Management Area in January 2001, due to levels of the pollutants nitrogen dioxide and fine particulate matter (PM_{10}). An action plan has been put in place detailing the steps that will be taken to improve air quality in the City[37]. The City of London Corporation has also signed up to being involved in the airTEXT project, where individuals who are sensitive to poor air quality, and who live or work in the City, will be invited to register for a free message service that will advise them when air quality is due to be poor the following day. The alert will enable the individuals to take remedial actions on the day in question, such as avoiding busy, polluted streets, remembering to take medication or increasing their medication dose.

In addition, the City of London is committed to a major Combined Heat and Power (CHP)/District heating and cooling scheme at Smithfield in the heart of the City, which generates and distributes chilled water for use in air conditioning systems.

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[33] http://www.londonair.org.uk/london accessed on 06.11.06
[34] City of London Core Strategy: Issues and Options, Local Development Framework. May 2006.
[35] City of London Core Strategy: Issues and Options, Local Development Framework. May 2006.
[36] City of London Sustainability Policy. September 2005.
http://cms.cityoflondon.gov.uk/Corporation/living_environment/sustainability/ accessed on 06.11.06
[37] http://www.cityoflondon.gov.uk/Corporation/our_services/health_safety/Environmental_Health/Pollution_Control/air+quality.htm accessed on 06.11.06

Info Point E: Adaptation measures to manage heat risks and air pollution

Adaptation measures should be considered for individual buildings and also at the wider urban scale.

Building design [(a)]

Building design can assist in reducing temperatures. Shading windows by installing shutters or blinds reduces solar gain and so internal heat build-up is reduced. Extending roofs can also provide shading to a building. Heavier weight building materials like concrete and stone have a tendency to keep buildings cooler in the day, by virtue of their thermal mass. Chilled ceilings and chilled beams can also be used.

Green roofs

Green roofs provide multiple benefits, including reducing the urban heat island effect and helping to keep buildings cool. (See Info Source B above for further details on green roofs.)

Cool roofs

A cool roof or 'white roof' can reduce the temperature of a building's roof dramatically, and hence also reduce the Urban Heat Island effect. Cool roofs have a coating of light-coloured water sealant, which can last 10 to 20 years, depending on the quality of the coating and the thickness applied. These white surfaces reflect and radiate a lot more heat than dark roof surfaces, and in the US they have been demonstrated to stay up to 40ºC cooler [(b)]. By limiting the amount of absorbed solar energy, damage from ultraviolet radiation and daily temperature fluctuations – which cause repeated contraction and expansion – can be reduced. Both flat and sloping roofs can be made into cool roofs.

Cool roofs do not offer all the advantages of green roofs related to stormwater runoff, air quality and nature conservation, but they demand less investment. Furthermore, cool roofs are most effective on buildings with high roof-to-volume ratios, such as one or two storey buildings.

Cool pavements[(c)]

Many of London's roofs, streets and pavements are typified by dark surfaces. 'Cool pavements' are comprised of light coloured material with high solar reflectivity and good water permeability. This is potentially a very effective way of reducing high urban temperatures as the amount of solar energy absorbed is decreased. 'Cool pavements' also encourage water storage and thus allow evaporative cooling.

Planting trees and vegetation

Trees can provide significant benefits in urban areas as they not only provide shade but can also reduce air pollution and the urban heat island effect. Trees and vegetation are natural cooling systems as they convert water contained within their foliage into water vapour which is released into the atmosphere by evapotranspiration. It has been estimated that evaporatranspiration, in certain locations, can result in the reduction of peak summer temperatures by 1 – 5ºC[(c)].

However, trees will need to be selected very carefully in the face of climate change, for example drought-resistant trees should be planted. Sufficient rooting space and an adequate water supply also need to be considered, as trees can aggravate or cause subsidence in certain soils [(d)].

(a) Beating the heat: keeping UK buildings cool in a warming climate. Hacker, J, Belcher, S and Connell, R. UKCIP Briefing report, 2005

Info Point E: Adaptation measures to manage heat risks *continued*

Heat Health Warning Systems (HHWS) [(e)]

Heat Health Warning Systems predict the risk of dangerous heatwaves using meteorological information. Health departments and other agencies then implement intervention activities with the public. Philadelphia has introduced a HHWS which alerts the city's population when weather conditions pose risks to health. Measures that are put in place include a buddy system where media announcements encourage friends, relatives and other volunteers to make daily visits to vulnerable people during the hot weather. Television and other communication media networks publicise the weather conditions, along with information on how to avoid heat-related illnesses. A 'Heatline' was also created to provide information and counselling to the general public on avoidance of heat stress. Other adaptation measures included creating 'cool' centres in air conditioned public buildings for vulnerable people.

(e) London Climate Change Partnership. Adapting to climate change: Lessons for London. Greater London Authority, London. 2006.

6.4 What further actions are recommended?

Highest priority actions to manage heat and air pollution risks recommended by this adaptation strategy are summarised below. A full list of actions is provided in Appendix 2.

'No-regrets' measures deliver benefits that exceed their costs, whatever the extent of climate change.

'Low-regrets' measures are low cost, and have potentially large benefits under climate change.

'Win-win' measures contribute to climate adaptation and also deliver other benefits.

Research and monitoring

The City of London Corporation should investigate risks of heat stress to residents of City of London Corporation-owned housing. The City of London Corporation should identify residents who are most vulnerable to heat stress (elderly, young and those with existing health problems) and ensure that they are regularly visited during heatwaves.

The City of London Corporation should work with the Emergency Services to undertake an analysis of the relationship between weather conditions and fire risk in open spaces and parks and investigate the prevalence of these conditions now and in the future with climate change.

Policy

As noted above, the Issues and Options report for the City of London Corporation LDF is considering whether to *encourage* or to *require* options for sustainable building development. This adaptation strategy recommends that the City of London Corporation LDF requires that sustainable design and construction is implemented in development. As part of sustainable design, buildings should be designed to provide a comfortable internal environment with the least use of energy over their lifetimes, taking account of rising temperatures due to climate change. Cooling systems should maximise use of natural ventilation and low-carbon cooling techniques.

Policy (cntd)

The City of London Corporation should encourage Transport for London, Network Rail and transport service providers to review and revise maintenance regimes for transport systems to take account of rising temperatures, for instance ensuring that seasonal pre-stressing of tracks is undertaken in good time.

The City of London Corporation should ensure that its risk register adequately ranks the risk of heatwaves and air pollution episodes.

Practical actions

The City of London Corporation should ensure that where possible enhancements to biodiversity which also provide cooling (including increased planting for shade in open spaces, as well as green roofs and vertical habitats) are made a requirement in the LDF.

The City of London Corporation should liaise with electricity providers to the City to ensure security of supply for City buildings and infrastructure, taking account of climate impacts on seasonal demands.

The City of London Corporation should encourage Transport for London to create 3-day travel cards to support home-working during heatwaves.

The City of London Corporation should encourage Transport for London and tube companies to install electronic displays outside tube stations, showing underground temperatures.

The City of London Corporation should encourage Transport for London and tube companies to investigate thoroughly the feasibility of making drinking water freely available on platforms at underground stations.

The City of London Corporation, in partnership with other organisations should examine the provision of 'cool' centres (cooled public buildings) during heatwaves, with extended opening hours for vulnerable people, and should include them in emergency plans.

The City of London Corporation should work with strategic health authorities and primary care trusts to implement the local heatwave plan in the City and to include actions to manage air pollution health risks in these plans, as high air pollution levels often coincide with heatwaves.

7. Managing ground conditions

7.1 Why act now?

Subsidence and heave are already problems in parts of London and the risks are increasing due to climate change. The major cause of subsidence is clay shrinkage, which happens as the ground dries, as summers get hotter and drier. It can be exacerbated by tree roots sucking moisture out of the soil. Heave occurs when soils absorb water and swell, causing ground movements, and is likely to be worsened in wetter winters due to climate change. The number of incidents of subsidence and heave is rising dramatically in the UK, particularly in the South East. Alternate wetting of clays in winter and drying of clays in summer may cause increased ground movement, resulting in increased potential for damage. This not only damages buildings but can also affect roads, underground pipes and cables.

In 2003, when the UK experienced a prolonged heatwave, insurers were left with close to £400 million in subsidence claims. The Halifax's subsidence team reported that during the summer of 2003, subsidence claims rose by about a quarter.

Over the past 30 years, subsidence claims following summer droughts have been increasing steadily, accounting for £3.3 billion of insurance claims over the 1990s[38]. Figures from the Association of British Insurers show that it anticipates household insurance costs to rise by between £3 billion and £12 billion by the 2080s as claims increase due to climate change.

7.2 What does it mean?

Subsidence is being aggravated by the hot, dry summers brought by climate change. Subsidence and heave of clay-based soils leads to damage to assets and infrastructure above and below ground. There is a risk that there may be an increase in the mobility of contaminants in the ground caused by changes in soil behaviour due to drying out and/or changing groundwater levels. Other specific risks such as rising insurance premiums or rising insurance policy excesses in insurance schedules also need to be considered in high risk areas.

As noted above, trees can enhance subsidence risks. As a result, it is important to know how to plant the 'right tree in the right place', considering issues such as subsidence, root penetration, water use, longevity and growth under a changing climate[39]. These issues need to be balanced against the benefits of trees in providing cooling, shade and reduction of air pollution.

As climate change intensifies, adaptation measures to manage subsidence and heave will be required and some new buildings may require deeper foundations. However, this does not necessarily mean more expensive buildings in the long-term. According to research, climate-proofing new buildings in southern England against subsidence may only cost £32 million, compared to a possible annual cost of £200 - 400 million from damage claims if no action is taken. [40]

Further details on risks to ground conditions in the City due to climate change can be found in Appendix 1.

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[38] UKCIP Climate change and local communities: How prepared are you? An adaptation guide for local authorities. UKCIP. 2003.
[39] London Climate Change Partnership. Adapting to climate change: Lessons for London. GLA, London. 2006.
[40] Adapting to climate change: a checklist for development. South East Climate Change Partnership, London Climate Change Partnership and Sustainable Development Roundtable for the East of England. November 2005.

7.3 What actions are already underway?

Action is underway nationally and across London to manage ground conditions.

National action

The government upgraded Building Regulation Structure A in 2004 to take account of climate change. It now requires new buildings on clay soils to have foundations to a depth of 0.75m, revised from 0.5m previously.

Research[41] suggests that if the foundation depth was 1m then this would be sufficient to eliminate subsidence risk in the face of climate change until 2100.

London-wide action

Thames Water Utilities has already started work across London through its Victorian Mains replacement scheme, through which underground metal Victorian water pipes are being replaced with flexible plastic piping. This will reduce leakage and burst associated with old, metal pipes.[42]

The Mayor's Supplementary Planning Guide (SPG) on Sustainable Design and Construction addresses subsidence risk by stating that consideration needs to be given to the design of foundations and to the positioning and choice of trees[43].

7.4 What further actions are recommended?

Highest priority actions to manage ground conditions risks recommended by this adaptation strategy are summarised below. A fuller list of actions is provided in Appendix 2.

'No-regrets' measures deliver benefits that exceed their costs, whatever the extent of climate change.

'Low-regrets' measures are low cost, and have potentially large benefits under climate change.

'Win-win' measures contribute to climate adaptation and also deliver other benefits.

Research and monitoring

The City of London Corporation should undertake a review of City of London Corporation assets to determine which are most at risk from subsidence and heave in the face of climate change.

Practical actions

The City of London Corporation and developers should ensure that the design of developments addressing geo-physical risks takes account of climate change impacts on subsidence and heave over the lifetime of the development.

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[41] Driscoll and Crilly. Subsidence damage to domestic buildings: Lessons learned and questions remaining. BRE and FBE. 2000.
[42] http://www.thameswater.co.uk/en_gb/Downloads/PDFs/Network_Upgrade_-_Replacing_London_Victorian_Mains_FINAL_July05.pdf accessed on 02.11.06
[43] http://www.london.gov.uk/mayor/strategies/sds/docs/spg-sustainable-design.pdf accessed on 02.11.06

Practical actions (cntd)

When designing landscaping, the City of London Corporation and developers should choose the types and locations of trees carefully, considering how subsidence and root penetration will be affected by climate change.

Where necessary, developers should use enhanced or piled foundations capable of withstanding increased risks of subsidence and heave due to climate change, over the lifetime of the development.

When underpinning existing buildings already affected by subsidence, building owners should ensure the underpinning is sufficient to cope with climate change.

8. Cross-cutting issues

8.1 Why act now?

Climate change has impacts for all sectors and the impacts often have far-reaching consequences. Public sector decision-makers have a responsibility to ensure that a holistic approach is taken to address these risks, to ensure that adaptation measures in one area do not have unintended consequences elsewhere.

8.2 What actions are already underway?

Action is underway at all levels to address the cross-cutting nature of climate risks.

National action

Government has sought to address climate change (both mitigation and adaptation) through a number of planning policy initiatives. Addressing climate change is identified as a priority in PPS1: Delivering Sustainable Development[44].

The Department for Communities and Local Government (DCLG) is consulting on a new policy statement, 'Planning and climate change', a supplement to PPS1, which will cover both climate adaptation and mitigation. DCLG has also published a Code for Sustainable Homes which outlines better management of surface water, sets minimum standards for water efficiency, and also covers energy efficiency.

The Department for Environment Food and Rural Affairs (Defra) is developing an Adaptation Policy Framework (APF), to provide a more strategic approach to climate adaptation, identifying key risks and opportunities common across a number of policy areas, and coordinating approaches where departments and other bodies in the public sector (and beyond) will need to work together.

London-wide action

The Mayor is preparing a Climate Change Adaptation Strategy for London, the first for a world city. The adaptation strategy will help London and Londoners prepare for the challenges and opportunities presented by inevitable climate change through providing strong policy directions on flood risk, water resources and overheating. The strategy also considers the urban microclimate and how cities may intensify the impacts of climate change through urban feedbacks such as Urban Heat Island effect. The government is considering whether the Mayor should have a statutory duty to prepare an adaptation strategy, and will make an announcement in the GLA Bill in May 2007.

[44] http://www.communities.gov.uk/index.asp?id=1143804 accessed on 26.10.06

The Mayor has also published Supplementary Planning Guidance on Sustainable Design and Construction, which includes detailed advice on addressing climate adaptation[45].

The London Climate Change Partnership has been set up to help ensure that London is prepared for its changing climate. It comprises key stakeholders across different sectors of London governance and business, including the City of London Corporation.

City of London Corporation action

The **City of London Corporation Sustainability Policy**[46] includes the following cross-cutting principles that address climate risks:

"Assist businesses in the Square Mile and the City Fringe to become more stable and competitive by improving understanding of climate change, its potential impacts and how to prepare for and adapt to them."

"Adapt infrastructure and services to prepare for the likely impacts of climate change."

"Ensure sustainable development principles are at the heart of the City of London's planning system."

8.3 What further actions are recommended?

Highest priority actions to manage cross-cutting impacts recommended by this adaptation strategy are summarised below. A fuller list of actions is provided in Appendix 2.

'No-regrets' measures deliver benefits that exceed their costs, whatever the extent of climate change.

'Low-regrets' measures are low cost, and have potentially large benefits under climate change.

'Flexible' measures are useful for dealing with uncertainties in the extent of longer-term climate change.

Policy

The City of London Corporation should thoroughly address climate adaptation in the Sustainability Appraisal of the LDF.

The City of London Corporation should review the existing measures that it has in place to manage existing climate or weather risks to see whether they provide sufficient protection against changing climate risks. In some cases, additional allowances may need to be made to build in 'headroom' for climate change.

The City of London Corporation should review design standards and codes of practice for assets, infrastructure and services, to identify those that include climatic factors. Based on the outcome of the review, the City of London Corporation should consider upgrading design standards and codes of practice where required to take account of predicted climate changes.

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[45] http://www.london.gov.uk/mayor/strategies/sds/docs/spg-sustainable-design.pdf accessed on 02.11.06
[46] City of London Sustainability Policy. September 2005.
http://cms.cityoflondon.gov.uk/Corporation/living_environment/sustainability/ accessed on 02.11.06

Policy (cntd)

The City of London Corporation should request that developers address climate change risks and adaptation measures as part of Environmental Impacts Assessments (EIA), explaining that if the EIA does not take account of climate change, the development will not perform as intended over its lifetime. In particular, the risk management measures proposed in the EIA may not deliver their intended benefits, and damage to the environment could occur as a result.

The City of London Corporation should encourage Transport for London to consider the impacts of climate change over the lifetime of Crossrail as part of the design process.

The City of London Corporation should work with City businesses to encourage the development of tried and tested business continuity plans that fully address current and evolving climate risks.

The City of London Corporation should encourage emergency planners, emergency services, and other stakeholders to assess and prioritise extreme events risks (e.g. flood, heatwave) taking account of climate change, and develop and implement contingency plans.

The City of London Corporation should encourage adaptation of habitats and natural colonisation by species suited to changing climatic conditions through the London Biodiversity Action Plan, the City Biodiversity Action Plan and the various Habitat Action Plans. Many of the Corporation's open spaces lie outside the Square Mile, within other authority areas and the Corporation will need to work closely with other organisations and local authorities within the larger BAP framework to ensure that this work is coordinated effectively. In the longer term, the London Biodiversity Action Plan, the City Biodiversity Action Plan and the various Habitat Action Plans may have to be reviewed and revised based on increasing understanding of the impacts of climate change and guidance from the England Biodiversity Strategy. This may include accepting loss of some habitats where this can not be avoided in the face of climate change (e.g. accepting loss of some land to sea level rise) and providing alternative habitats elsewhere.

9. Opportunities

Climate change presents opportunities to develop new markets, products and services in response to changing customer expectations and needs.

Those organisations that are first to act on these opportunities can gain an 'early mover' advantage on their competitors. If opportunities are not realised then there could be loss of market share. Evidence of 'climate-proofing' enhances an organisation's reputation with its stakeholders, provides security for investment and opportunity for reduced insurance premiums.

Some of the opportunities are highlighted below and additional examples are provided in Appendix 1.

- In terms of health benefits, increasing winter temperatures will mean a reduction in winter cold-related morbidity and mortality,
- There is a potential for an increase in visitors and tourists to London as other destinations in southern Europe become less attractive in the height of summer due to climate change,
- The construction industry could benefit from an increased number of available construction days, as summer rainfall reduces and frosts in winter become rarer,
- The insurance sector has started to consider that consumer preferences and needs for insurance products will be different as climate change intensifies. A report commissioned by CERES[47] explores the opportunities for new products and services[48].

'Starbucks blames setback on frappuccinos queues'

The Guardian, August 4th, 2006

Starbucks struggled to cope with long queues of customers who wanted iced frappuccinos in the record hot weather. Starbucks announced in July 2006 its like-for-like sales rose 4% which was below the usual trend of 6%. This reduction resulted in Starbuck shares falling by 11% on the Nasdaq.

'A sweltering day that outshone the glory of July 1911'

The Times, July 20th, 2006

Thousands flocked to the beaches. Bournemouth was one of the busiest, with about 15,000 bathers.

HSS, Britain's largest equipment hire chain, issued 7,581 air-conditioning units that week which was up 38 per cent from the same time last year.

Comet sold one fan every two seconds yesterday, its fastest rate ever.

[47] Ceres is a national network of investment funds, environmental organisations and other public interest groups working to advance environmental stewardship on the part of businesses.
[48] Availability and affordability of insurance under climate change: a growing challenge for the US. CERES. August 2006.

10. Next steps in implementing this climate adaptation strategy

This adaptation strategy identifies the highest priority measures to manage climate risks that should be addressed as soon as possible. It also identifies additional actions within the adaptation tables within Appendix 2, many of which are no- or low-regret measures. The following steps will be undertaken to take forward the strategy:

- As a first step, each City of London Corporation Department will develop adaptation action plans, with options and costings, over the next 6 months.
- The City of London Corporation will incorporate the adaptation measures into the LDF, policy frameworks, and business plans of each of the City of London Corporation Departments.
- To communicate the City of London Corporation Department's actions plans and to facilitate engagement with external stakeholders, the City of London Corporation Town Clerk's department will run a series of seminars on this adaptation strategy.
- The City of London Corporation will take a leadership role in rolling this strategy out across the Square Mile. The City will work in partnership with the external stakeholders highlighted in this report, including utility and service providers, businesses, City residents and other public sector bodies, to ensure they understand and recognise the importance of the need for urgent action.
- The City of London Corporation will undertake a review and will report on how successfully this strategy has been implemented in March 2008.

Figure 10: Next steps in implementing this adaptation strategy

Appendices

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Appendix 5: Summary of expected climate changes in London for the UKCIP02 low and high emissions scenarios App - 46

Appendix 1: Climate risks to the City of London

Reference no.	Table A1.1 Asset and infrastructure risks	Risks will impact on: CoL department								External stakeholders			Risk rating	
		City Surveyor's	Planning and Transportation	Economic Development Office	Environmental Services	Community & Children's Services	Open Spaces	Town Clerk's	Markets	Residents	Business	Supporting services	Likelihood	Impact
	Very high													
A1	Flash flooding as drainage systems are overwhelmed by heavy downpours, affecting assets and infrastructure	X	X	X	X	X	X	X	X	X	X	X	4	5
A2	Changes in rainfall patterns with wetter winters and drier summers increasing risks of subsidence and heave, affecting the built environment including; buildings, (especially tall buildings), underground cables, electricity pylons, underground utilities, escalators	X	X	X	X	X	X	X	X	X	X	X	4	4
A3	Increase in demand for electricity for air conditioning in summer leading to overburden of grid and power cuts, with consequent impacts on business.	X	X	X	X	X	X	X	X	X	X	X	4	4
A4	Increased temperatures on the London Underground, exacerbated by the urban heat island effect, is already leading to increased passenger discomfort and health and safety concerns for passengers	X	X	X	X	X	X	X	X	X	X	X	5	4
	High													
A5	Subsidence and heave of clay based soils leading to damage to underground Victorian water pipes (which are currently being replaced with flexible plastic piping)											X	3	3

A6	Increasing water demand when resources are already under stress due to changing precipitation patterns and increasing temperatures could lead to operation of Drought Management Plans, with restrictions on water use for public, commercial and industrial use	X	X	X	X	X	X	X	X	X	X	X	4	3
A7	Contaminated land: Increase in the mobility of contaminants in the ground caused by the changes in soil behaviour due to drying out and/or changing groundwater levels	X	X		X		X				X		3	3
A8	Hotter summers may damage elements of transport infrastructure with attendant disruption and repair costs e.g. buckled rails, rutted roads, cracking of bridge expansion joints										X	X	4	3
A9	Lower river flows in summer will raise water temperatures and aggravate water quality problems in the Thames and its tributaries, especially following heavy summer storms, which can cause combined sewer overflows to discharge pollutants into rivers				X		X					X	5	3
A10	Increased electricity demand for cooling will affect the City's ability to meet energy/emission reduction targets	X	X	X	X	X	X	X	X	X	X	X	5	3
A11	Tidal / river flooding would cause significant damage to assets and infrastructure in the City		X									X	1	5
A12	Higher summer temperatures leading to lower productivity of workers	X	X	X	X	X	X	X	X	X	X	X	4	2
	Medium													
A13	Higher levels in the Thames mean more frequent barrier closures and therefore freight restrictions. The shutting of the Thames barrier is a problem as it means other gates have to be closed. This could disrupt waste transport using the river. As the EA adapts and increases the height of the flood defence then access to the river from the banks will need to adapt to this.		X		X				X		X	X	4	2
A14	Inundation of docks from both riverine flooding and sea level rise		X		X				X		X	X	3	2
A15	Higher levels in the Thames mean that the barges lie higher and offloading is a problem												3	2
A16	Impact of storminess on electricity and communications infrastructure - increased stresses and fatiguing of power lines, pylons, radio masts and mobile phone masts										X	X	3	2
A17	Strong winds causing roof and structural damage to housing stock					X					X	X	3	2
A18	Strong winds causing damage to commercial and industrial property										X	X	3	2
A19	Low river flows in summer, affecting passenger and freight movements on the Thames		X		X				X		X	X	2	3

A20	Street Cleaning: Need for more gully cleaning as debris collected after heavy downpours following extended dry periods				X								3	2
	Low													
A21	Rising water tables may mean that construction sites do not drain properly	X	X								X		3	1
	Opportunities													
A22	Higher winter temperatures should reduce leakage as less pipes burst as a result of freezing											X	N/A	N/A
A23	Less transport disruption due to bad weather as winter temperatures increase and less precipitation falls as snow		X									X	N/A	N/A
A24	Saving for local authority in cleansing costs in winter as more rain means less cleansing is required				X								N/A	N/A
A25	Saving for local authority as reduced resources and costs of road maintenance in winter e.g. salting, gritting		X		X								N/A	N/A
A26	Opportunity to explore the feasibility of rain water harvesting and other water and energy saving options on the LMA (London Metropolitan Archives) roof.	X												

Reference no.	Table A1.2 Business risks	Risks will impact on: CoL department								External stakeholders			Risk rating	
		City Surveyor's	Planning and Transportation	Economic Development Office	Environmental Services	Community & Children's Services	Open Spaces	Town Clerk's	Markets	Residents	Business	Supporting services	Likelihood	Impact
	Very high													
B1	Equity markets could fall, e.g. due to property and infrastructure damage due to climate risks			X							X		3	5
B2	London's insurance industry could be exposed to an increased volume of worldwide claims from wind storms, subsidence and heave, and flood events worldwide			X							X		3	5
	High													
B3	Transport disruption due to extreme events (e.g. flash flooding, heatwaves), leading to disruption to commuters and business interruption		X								X	X	3	3
B4	Increase in transport disruption for goods/freight due to heatwaves, floods, especially for 'just in time' deliveries		X								X	X	3	3
B5	Damage to reputation of developers if houses / offices are not 'climate-proofed', with consequent effects on share prices / profits	X	X	X						X	X		2	4
B6	Resource availability (e.g. water and wastewater provision and utilities) may not be sufficient to support an increase in tourism in summer			X								X	3	3

B7	Insurance premiums or excesses could rise within higher risk areas with possible impacts on availability of mortgages thus leading to loss of customers					X				X	X		3	3
B8	Some insurance companies may withdraw from the market in some areas										X		5	3
B9	Impact of climate risks elsewhere in the world could affect London business especially those 'offshoring' to vulnerable locations	X	X	X	X	X	X	X	X		X	X	4	3
B10	Building suitability and consequent heat risks to occupants: Increased temperatures will reduce comfort of occupants in commercial and public buildings, leading to discomfort, lower productivity, potential business disruption and potential heat stress	X	X	X	X	X	X	X	X		X	X	4	3
B11	Assets in basements at increased risk of damage/loss from flooding		X					X			X		4	3
B12	Health and safety of outdoor workers – increased incidence of heat stress, skin cancer in sunnier summers, leading to losses through sickness and potential claims	X	X	X	X	X	X	X	X		X	X	4	3
B13	Tidal / river flooding could mean business disruption lasting for days and occurring in different areas than flash floods			X							X	X	1	5
	Medium													
B14	Downturn of global economy – recession. Impacts on GDP and increase in interest rates (economic impacts on portfolios)			X							X		1	5
B15	Excessive summer heat may delay construction activities e.g. health and safety restrictions can vary seasonally and curing of concrete in high temperatures affects its strength	X	X								X		2	3
B16	Floods on and off site may delay construction activities	X	X								X		2	3
B17	Decrease in businesses moving into the area as buildings are viewed as 'not fit for purpose/climate'.			X							X		2	3
B18	Risks to outdoor workers from flood and possible increased storminess	X	X	X	X	X	X	X	X		X	X	3	2
B19	Increase in summer energy costs for cooling	X	X	X	X	X	X	X	X	X	X	X	4	2
B20	Leisure and recreational facilities and tourist attractions fail to provide a pleasant environment for visitors e.g. overheating			X							X		3	2
B21	Possible higher winds may cause difficulties for construction equipment e.g. cranes and scaffolding	X									X		2	3
B22	High temperatures could lead to residents leaving London in search of a more comfortable environment on holidays or breaks			X						X	X		3	2

	Low													
B23	Potential shifts in consumer demand may affect the way planners encourage the local economy and how they approach retail policy, e.g. Decrease in clothing and footwear market as experienced in summer of 1995; Increase in fruit and vegetable markets due to changes in eating habits as experienced in summer of 1995		X						X				4	1
B24	Shift of working times to earlier /late in the day, to avoid peak temperatures, leading to a change in asset usage patterns	X	X	X	X	X	X	X	X	X	X	X	2	2
B25	Increasing heat will impact on the cooling of IT systems (City trading systems etc) and Internet hotels										X	X	3	1
B26	Construction industry will have reduced water available for site management e.g. dust suppression										X		3	1
B27	Price increases in some foodstuffs, as agriculture worldwide is affected by climate change			X					X				3	1
	Opportunities													
B28	Increase in visitors and tourists as other destinations become less attractive under climate change		X	X							X	X	N/A	N/A
B29	Opportunities for increase in pavement cafes / restaurants attracting more visitors to the city			X							X		N/A	N/A
B30	Reduced energy costs in winter due to need for less heating	X	X	X	X	X	X	X	X	X	X	X	N/A	N/A
B31	Opportunity to develop new products e.g. insurance catastrophe bonds and weather derivatives or physical products e.g. floorboards, warning systems, cooling systems.										X		N/A	N/A
B32	Construction industry could benefit from an increased number of available construction days, as summer rainfall reduces and frosts in winter become more rare	X									X		N/A	N/A

Reference no.	Table A1.3 People risks	Risks will impact on: CoL department								External stakeholders			Risk rating	
		City Surveyor's	Planning and Transportation	Economic Development Office	Environmental Services	Community & Children's Services	Open Spaces	Town Clerk's	Markets	Residents	Business	Supporting services	Likelihood	Impact
	Very high													
P1	Increased incidence of heat stress, dehydration, heat-related mortality, skin cancer and eye cataracts in hotter, sunnier summers for outdoor workers and other members of society, especially the elderly, sick and young. Health risks to vulnerable population groups in housing that overheats significantly. Risk of death in heatwaves.					X				X	X	X	4	4
P2	Greater impact on asthma sufferers and potential for acute asthma epidemics due to: dust mites surviving longer in drier air; more dust raised in dry areas; poorer air quality and more frequent air pollution episodes				X	X				X	X	X	4	4
P3	Flash flooding leading to increased risk of injury, disease, mental health problems and potentially death	X	X	X	X	X	X	X	X	X	X	X	3	4
	High													
P4	Severe water restrictions which could be put in place under a worst case scenario (e.g. standpipes) could pose access difficulties for vulnerable populations					X				X		X	2	4
P5	Increase in outdoor lifestyles will increase levels of exposure to air pollution				X	X	X			X		X	3	3

P6	Transmission of diseases may alter as there is a potential for increased risk of mosquitoes and other disease bearing insects, vermin and pest. Those in overcrowded accommodation are more susceptible to the spread of infectious diseases					X	X			X		X	3	3
P7	Increase in demand for social services supporting community care for vulnerable clients in heatwaves					X				X		X	4	3
P8	Waste storage may become more of a problem in higher temperatures, which may bring about a potential increase in vermin with associated local health risks.				X	X	X		X	X	X	X	4	3
P9	Increased risk of overheating in school classrooms - extreme temperatures affect children's ability to concentrate	X				X							3	3
P10	Increased heat stress risk and sun exposure to children in school playgrounds	X				X							3	3
P11	Increase in instances of food poisoning as increased temperatures facilitate bacterial growth				X				X	X	X	X	4	3
P12	Greater demands on emergency services, who may have insufficient resources to deal with more floods, fires, heat waves							X				X	4	3
P13	Increased risk of tidal / river flooding leading to increased risk of injury, disease, mental health problems and death	X	X	X	X	X	X	X	X	X	X	X	1	4
	Medium													
P14	Less water available could mean more water restrictions e.g. hosepipe bans	X	X	X	X	X	X	X	X	X	X	X	2	3
P15	Overcrowding of open spaces e.g. picnic rage may become a problem						X			X			3	2
P16	Increased incidence of traffic accidents (including bicycle related accidents) in hotter weather		X										4	2
P17	Increased disruption to waste collection and street cleaning services due to greater risk of flooding and extreme events				X					X	X		3	2
P18	Climate impacts on frontline cleansing services will affect: rotas (e.g. changes to working hours if too hot during the day); equipment (e.g. overheating may necessitate change); suitable clothing (e.g. for coping with temperature increases); maintenance requirements etc				X								4	2
P19	Increase in use of outdoor spaces will lead to an increase in street litter				X								4	2
P20	Food health risks with wholesale markets and need to provide additional cooling to cope with increased temperatures				X				X				2	3
P21	Different and more vermin and pests, leading to the need to use more pesticides / fly killers etc				X								3	2

P22	School playgrounds tend to have a greater risk of flooding, particularly because of blocked drains					X							2	3
P23	Lower income households may find it more difficult to access adequate insurance cover in the face of increased flood risk			X		X				X			4	2
	Low													
P24	Changing waste profile as a result of changes in eating habits due to climate change, which needs to be considered in the context of the push for greater recycling		X		X								2	1
P25	Increased public demonstrations and riots in hot weather					X							3	1
P26	Stress to flood victims					X						X	4	1
P27	Street cleaning: Reduced summer rainfall means less dilution for road run-off, resulting in higher concentrations of pollutants				X								3	1
P28	Changing patterns of leaf fall affecting street cleaning operations				X								3	1
P29	Increased illness / possible epidemics transmitted through increased use of indoor ventilation systems					X				X	X	X	3	1
P30	Increased noise problems as people are outside more, especially at night, and residents open windows to stay cool					X				X			3	1
P31	Planning consideration for better noise control required as conflicts exist already between residents and business community e.g. avoid mixing incompatible uses such as flats over pubs		X							X	X		3	1
P33	Recreational fishing may suffer, due to low river flows in summer				X								3	1
P34	Emotional impacts of extreme events affect public mental health and especially children's educational performance					X				X		X	4	1
	Opportunities													
P35	Reduced winter cold-related morbidity and mortality					X						X	N/A	N/A
P36	Outdoor living may be more favoured, although some members of society may be less able to take advantage of this due to lack of facilities locally, fear of crime or other forms of social exclusion		X			X				X			N/A	N/A

Reference no.	Table A1.4 Open spaces and heritage risks	Risks will impact on: CoL department								External stakeholders			Risk rating	
		City Surveyor's	Planning and Transportation	Economic Development Office	Environmental Services	Community & Children's Services	Open Spaces	Town Clerk's	Markets	Residents	Business	Supporting services	Likelihood	Impact
	Very high													
	None identified													
	High													
S1	Overcrowding in City open spaces at lunchtimes leading to increased damage during summer months						X			X	X		4	3
S2	Increased likelihood of algal blooms on watercourses, with implications for nature conservation, aesthetics and human health				X		X						3	2
S3	Increase in flash flood risk in open spaces						X						3	3
S4	Higher risk of fires on scrub and heath land						X					X	4	3
S5	Loss or damage to freshwater, riparian, foreshore and wetlands habitats				X		X			X		X	3	3
	Medium													
S6	Increased winter rainfall may raise water tables enough to kill roots, thereby reducing effective rooting depth and making trees more vulnerable to increasing temperatures, summer drought and windthrow						X						4	2
S7	Water shortages could lead to restrictions on water use for open spaces management - when demand for water for irrigation is higher						X						4	2

S8	Greater odour problems associated with standing water bodies				X		X						3	2
S9	Green and open spaces will be used more intensively requiring increased maintenance and management						X			X			4	2
S10	Pest species won't die in winter as temperatures rise, so may need more pesticide control				X								4	2
S11	Warmer weather would favour conditions for increased competition from exotic species as well as the spread of disease and pests, affecting both fauna and flora						X						5	2
S12	Earlier springs, longer frost-free seasons and reduced snowfall could affect dates of bird egg-laying, as well as the emergence, first flowering and health of leafing or flowering plants						X						5	2
S13	Historic buildings and archaeological remains more exposed to risk of water damage and flooding – some sites may need to be abandoned	X	X		X								2	3
S14	Destruction of historic remains uncovered during re-development if affected by extreme events e.g. floods	X	X		X								2	3
S15	Damage to historic buildings, libraries and archives and their fabric caused by: Increasing temperatures; Increase in pest species such as cockroaches and termites; Drainage systems in heritage buildings could be overwhelmed, leading to flooding; Increase in winter rainfall and more intense rainfall, leading to rain penetration and damp problems, and could increase biological attack or other forms of decay such as salt mobilisation; Greater risk of subsidence and heave on clay-based soils; Increase in photochemical smog.	X	X		X								4	2
	Low													
S16	Increased tourism and leisure pressure at conservation sites			X			X					X	3	1
S17	Increased soil erosion associated with more intense winter rainfall				X		X						3	1
S18	Expectation of higher visitor numbers to outdoor environments - associated increase in dog visitors affects biodiversity						X			X			2	1
S19	Higher temperatures make historic buildings more unsuitable for occupation	X	X	X							X		2	1

Appendix 2: Adaptation options to manage climate risks

Identifying and appraising climate adaptation measures

The adaptation measures in this appendix are organised according to the main climate risks that the City of London will experience, under the following headings:

- Managing flood risks,
- Managing water resources,
- Managing heat risks and air pollution,
- Managing ground conditions,
- Cross-cutting issues.

Adaptation measures to manage the 'Very high' and 'High' priority climate risks have been identified through:

- Reviews of best practice emerging elsewhere in the UK and internationally,
- Workshops hosted by the City of London Corporation (see Appendix 4),
- Acclimatise's knowledge and expertise.

There are two main approaches to climate adaptation that the City of London Corporation and others can adopt, as recommended by the UK Climate Impacts Programme[49]:

- Building adaptive capacity,
- Delivering adaptation actions.

The adaptation measures for the City of London Corporation have been split up into these categories.

Building adaptive capacity

'Building adaptive capacity' involves creating the conditions (regulatory, institutional etc) that are needed before adaptation actions can be undertaken. It includes the measures listed in Table A2.1 below.

As is clear from the table below, 'building adaptive capacity' includes organisational change management processes, which have been shown to be vital in bringing about adaptation[50]. Work at Hampshire County Council demonstrates that awareness-raising alone is not sufficient to stimulate change – it needs to happen with three other factors:

- **Agency**: Change depends on developing a sense that there are meaningful responses that people can make to an issue as big as climate change.

- **Association**: Efforts are more effective and last longer, if people work together.

- **Action and reflection**: Action is needed, but it is important also to reflect on outcomes so that efforts can be refocused. Change involves 'unlearning' habits and reflection is key to doing this successfully.

[49] West, C.C. and Gawith, M.J. (Eds.) Measuring progress: Preparing for climate change through the UK Climate Impacts Programme. UKCIP Technical Report. UKCIP, Oxford. 2005.
[50] Alexander, Ballard & Associates and Rosslyn Research Ltd. How can local authorities stimulate & support behavioural change in response to climate change? A report for Hampshire County Council undertaken as part of the ESPACE project. July 2005.

Table A2.1: Measures for building adaptive capacity	
BAC1	Research, data collection and monitoring to better understand climate risks and vulnerabilities, and to evaluate the most appropriate adaptation measures.
BAC2	Changing or developing policies, plans, standards, codes of practice, regulations and legislation to take account of changing climate risks. This should be informed by research, data collection and monitoring (BAC1).
BAC3	Awareness-raising and organisational learning, both within the organisation and with external stakeholders.
BAC4	Working in partnership to identify and co-ordinate climate adaptation activities.

Delivering adaptation actions

'Delivering adaptation actions' involves taking actions that will help to avoid or reduce climate risks, or to exploit opportunities. It includes the risk management measures in Table A2.2 below.

Table A2.2: Measures for delivering adaptation actions	
DAA1	Avoiding risks – such as avoiding development in high risk locations and implementing contingency plans.
DAA2	Reducing risks – for instance by making technical or structural changes to infrastructure.
DAA3	Reducing vulnerability by: • Diversifying – for instance, developing business areas that are not sensitive to climate risks, • Identifying others willing to share the risk – such as through insurance.
DAA4	Bearing some losses, where they can not be avoided.
DAA5	Exploiting opportunities.

Who can deliver the adaptation measures?

The adaptation measures will need to be delivered by a range of organisations and individuals including:

- City of London Corporation departments,
- Other public sector bodies,
- Other utility and service providers in the city providing water resources, transport, energy, waste management, telecommunications, emergency services, health care and education,
- City businesses – including developers and owners of City property,
- City residents.

Managing flood risks

Table A2.3: Description of measures to be considered for managing flood risks	City of London	Other public sector	Water resources	Transport	Energy	Waste	Telecoms	Emergency services	Health care	Education	Property developers/owners	City businesses	City residents
BAC1: Research, data collection and monitoring													
Identify and map flash flood 'hotspots' based on where floods have been experienced in recent years and identify causes of flooding (e.g. lack of capacity, poor maintenance).	X	X		X	X	X	X		X	X	X	X	
Investigate methods of securing long term management and maintenance of sustainable drainage systems (SuDS).	X												
Undertake research to evaluate the effects of climate change on groundwater levels under the City.	X												
Assess the capacity of the 72km of sewers managed by the City of London to cope with increasing rainfall due to climate change.	X		X										
Identify spaces in City-owned large open spaces (e.g. Hampstead Heath) that can be used for additional temporary flood water storage at times of flood – learning lessons from Chinbrook Meadows, Lewisham.	X												
Investigate all opportunities for installing sustainable drainage systems along Riverside Walk, learning from good practice at Tate Modern.	X										X		

Table A2.3: Description of measures to be considered for managing flood risks	City of London	Other public sector	Water resources	Transport	Energy	Waste	Telecoms	Emergency services	Health care	Education	Property developers/owners	City businesses	City residents
BAC2: Changing or developing policies, standards etc													
LDF policy to **require** sustainable drainage systems, green roofs etc in targeted flash flood 'hotspots'. Sustainable drainage systems to be designed to cope with anticipated changes in rainfall due to climate change.	X												
LDF policy to **require** at a minimum, no net increase in runoff when re-developing in targeted flash flood 'hotspots' and to aim for a reduction in runoff.	X												
Specify within the LDF that S106 should be used to secure long-term commitment to the management and maintenance of SuDs.	X												
LDF policy to **require** that drainage systems in new developments have the capacity to cope with heavier rainfall events expected over their lifetimes, taking account of climate change.	X												
Review maintenance regimes for drains and establish whether more frequent clearing of drains is required.	X	X		X	X	X	X		X	X	X	X	X
Ensure that flood risk management options being developed through TE2100 programme are integrated into the	X	X											

Table A2.3: Description of measures to be considered for managing flood risks	City of London	Other public sector	Water resources	Transport	Energy	Waste	Telecoms	Emergency services	Health care	Education	Property developers/owners	City businesses	City residents
development of the LDF as soon as possible.													
BAC3: Awareness-raising and organisational learning													
Undertake a proactive door-to-door awareness programme of SuDS and green roofs for all City of London Corporation buildings.	X												
BAC4: Working in partnership to co-ordinate activities													
Join the new forum for surface water drainage being established by the Mayor – to identify opportunities and delivery agencies for managing flood risk.	X	X	X										
Develop a flood recovery plan, and incorporate it into the City of London's emergency plan. There should be a nominated officer with responsibility for overseeing flood risk management in the City of London Corporation.	X							X					
Review current arrangements for surface water drainage between Thames Water Utilities and the City of London Corporation to identify whether any action is required in the light of climate change risks.	X		X										
DAA1: Avoiding risks													
For every development, plan routes for evacuation and for	X	X		X	X	X	X	X	X	X	X	X	X

Table A2.3: Description of measures to be considered for managing flood risks	City of London	Other public sector	Water resources	Transport	Energy	Waste	Telecoms	Emergency services	Health care	Education	Property developers/owners	City businesses	City residents
emergency vehicles to have secure access in event of flood.													
Develop a flood recovery plan, which should form part of the City of London's emergency plan. There should be a nominated officer with responsibility for overseeing flood risk management in the City of London Corporation.	X	X	X	X	X	X	X	X	X	X	X	X	X
Consider relocating flood-sensitive IT equipment and archives out of London to areas with negligible flood risk.	X	X	X	X	X	X	X	X	X	X	X	X	
Move valuable assets / equipment out of basements. Consider storage of the City of London Corporation's archives and libraries.	X	X	X	X	X	X	X	X	X	X	X	X	X
DAA2: Reducing risks													
Install sustainable drainage systems, green roofs etc in targeted flash flood 'hotspots' as part of redevelopment or major refurbishment.	X	X		X	X	X	X		X	X	X	X	
Install permeable surfaces or green roofs on City of London Corporation-owned car parks.	X												
Install green roofs and green walls on City of London Corporation-owned buildings.	X												

Table A2.3: Description of measures to be considered for managing flood risks	City of London	Other public sector	Water resources	Transport	Energy	Waste	Telecoms	Emergency services	Health care	Education	Property developers/owners	City businesses	City residents
Examine incentives to encourage sustainable drainage systems and green roofs.	X												
Create spaces for additional temporary flood water storage in City of London Corporation-owned large open spaces (e.g. Hampstead Heath).	X												
Increase resilience to properties at risk of flooding by: • Using one-way valves in drainage pipes to prevent back-up of water into buildings, • Using de-mountable flood barriers, • Using flood-resilient materials, • Locating electrical services and boilers above likely maximum flood level, • Increasing capacity of drainage systems (e.g. guttering), • Installing damp courses.	X	X		X	X	X			X	X	X	X	X

Managing water resources

Table A2.4: Description of measures to be considered for managing water resource risks	City of London	Other public sector	Water resources	Transport	Energy	Waste	Telecoms	Emergency services	Health care	Education	Property developers/owners	City businesses	City residents
BAC2: Changing or developing policies, standards etc													
LDF policies to **require** best practice in water efficiency for all new developments and major refurbishment projects, as part of sustainable design and construction.	X												
LDF to **require** rainwater harvesting and greywater recycling, where appropriate, in all new developments.	X												
BAC3: Awareness-raising and organisational learning													
Undertake a co-ordinated and sustained awareness-raising campaign aimed at City businesses, property developers and residents regarding water use and water efficiency.	X		X										
Undertake awareness-raising campaign with residents on 'low water gardens'.	X		X										X
Initiate a 'Green Plumber Watersaver' training scheme to train plumbers in water conservation.	X		X								X	X	

Table A2.4: Description of measures to be considered for managing water resource risks	City of London	Other public sector	Water resources	Transport	Energy	Waste	Telecoms	Emergency services	Health care	Education	Property developers/owners	City businesses	City residents
BAC4: Working in partnership to co-ordinate activities													
City of London Corporation and Thames Water Utilities to discuss contingency planning for vital City functions in times of extreme drought.	X		X										
City of London Corporation and Thames Water Utilities to investigate possibility of jointly-funded rebates scheme for residents to purchase and install water-saving devices.	X		X										
DAA2: Reducing risks													
Review water cooling systems in City buildings and ensure most water-efficient systems are in place. Investigate new cooling systems that are not dependent on mains water such as ground source heat exchange and river water cooling.	X	X	X						X		X	X	
Investigate installing rainwater harvesting systems on roofs of mainline, DLR and tube stations. Use the harvested water for cleaning, toilet flushing etc. Target measures at flood 'hotspots' initially.				X									
Install rainwater harvesting systems on roofs of	X												

Table A2.4: Description of measures to be considered for managing water resource risks	City of London	Other public sector	Water resources	Transport	Energy	Waste	Telecoms	Emergency services	Health care	Education	Property developers/owners	City businesses	City residents
market buildings. Use the harvested water for cleaning, toilet flushing etc.													
Design and install drought-resistant landscaping schemes and 'low water gardens' in open spaces that require minimal irrigation. Adopt water-efficient irrigation practices, such as moisture-sensitive and drip systems.	X	X							X	X	X	X	X
Install rainwater harvesting in gardens and large open spaces and use the captured water for irrigation.	X	X							X	X	X	X	X
Use 'bio-bombs' or barley straw in water courses when needed to absorb nutrients and prevent algal blooms.	X										X	X	

Managing heat risks and air pollution

Table A2.5: Description of measures to be considered for managing heat risks and air pollution	City of London	Other public sector	Water resources	Transport	Energy	Waste	Telecoms	Emergency services	Health care	Education	Property developers/owners	City businesses	City residents
BAC1: Research, data collection and monitoring													
Undertake research to establish groundwater cooling potential in the City under current conditions and with climate change.	X										X		
Analyse the overall benefits in terms of energy savings of cool roofs on low-rise city buildings: Investigate their effectiveness at reducing summer cooling loads and whether they lead to more heating being required in winter.	X	X		X	X	X	X		X	X	X		
Investigate risks of heat stress to residents of City of London Corporation-owned housing. Evaluate the effectiveness of low-carbon adaptation measures including improving natural ventilation, green roofs, green walls and cool roofs.	X								X				
Identify residents of City-owned buildings across London and other City of London residents who are most vulnerable to heat stress (elderly, young and those with existing health problems) and ensure that they are regularly visited during heatwaves.	X								X				X

Table A2.5: Description of measures to be considered for managing heat risks and air pollution	City of London	Other public sector	Water resources	Transport	Energy	Waste	Telecoms	Emergency services	Health care	Education	Property developers/owners	City businesses	City residents
Undertake an assessment of the risk of overheating in St Bartholomew's hospital, taking account of climate change over the hospital's design life.									X				
Identify outside spaces that do not provide sufficient shade and investigate possibilities to increase shade in deficient areas.	X	X									X		
Undertake an analysis of the relationship between weather conditions and fire risk in open spaces and parks and investigate the prevalence of these conditions now and in the future.	X							X					
Undertake an analysis of the relationship between increasing temperatures and air pollution to identify 'hotspot' areas in the City and critical levels whereby action is required. Identify what actions should be put in place to manage this risk.	X								X				
Monitor populations of disease-bearing vermin and pests in the face of rising temperatures and review resource requirements to manage them.	X								X				
BAC2: Changing or developing policies, standards etc													

Table A2.5: Description of measures to be considered for managing heat risks and air pollution	City of London	Other public sector	Water resources	Transport	Energy	Waste	Telecoms	Emergency services	Health care	Education	Property developers/owners	City businesses	City residents
Establish appropriate overheating criteria for different building types (offices, homes, schools, hospitals etc).	X	X							X	X	X		
LDF policy to **require** that sustainable designs are implemented in development.	X												
As part of 'sustainable design', developments should be designed to have the optimum thermal mass to provide a comfortable internal environment with the least use of energy over their lifetimes, taking account of rising temperatures due to climate change. Cooling systems should maximise use of natural ventilation and low carbon cooling techniques.	X	X		X	X	X	X		X	X	X		
Develop policies in LDF to ensure that new development reduces the impacts of the Urban Heat Island effect through appropriate design and construction.	X												
Ensure that the City of London's Civil Risk Register correctly assesses and ranks the risk of heatwaves and air pollution episodes.	X							X					
Develop guidelines for appropriate care of	X								X				

Table A2.5: Description of measures to be considered for managing heat risks and air pollution	City of London	Other public sector	Water resources	Transport	Energy	Waste	Telecoms	Emergency services	Health care	Education	Property developers/owners	City businesses	City residents
vulnerable individuals during heatwaves in health and social care institutions, and enforce the guidelines as part of homes registration.													
Review and revise Codes of Practice and enforcement to ensure proper storage of waste to take account of rising temperatures and increased vermin.	X					X							
Enhancements to biodiversity, including increased planting for shade in open spaces, as well as green roofs and vertical habitats, should be made a *requirement* in the LDF. The measures must be designed to take account of climate change. Importantly, these are win-win measures – they provide multiple benefits, in terms of managing flooding and overheating risks that will intensify with climate change, as well as benefits for biodiversity. The species planted should be adaptable to climate change.	X												
Review and revise maintenance regimes for transport systems to take account rising temperatures, e.g. ensure that seasonal pre-stressing of tracks is undertaken in good time.				X									

Table A2.5: Description of measures to be considered for managing heat risks and air pollution	City of London	Other public sector	Water resources	Transport	Energy	Waste	Telecoms	Emergency services	Health care	Education	Property developers/owners	City businesses	City residents
BAC3: Awareness-raising and organisational learning													
Train Social Services staff to identify, manage and advise on heat stress risks for the elderly, young, those with physical and mental health problems, and the homeless.	X												
Produce and distribute guidance on how to avoid heat stress to those City residents and other residents in City-owned property across London who are most vulnerable to heat stress.	X								X				
Undertake a public communications campaign on risks of fire in open spaces (e.g. Hampstead Heath).	X							X					
Environmental Health Officers to educate owners of food premises of the increased risk of food poisoning in the face of rising temperatures.	X												
BAC4: Working in partnership to co-ordinate activities													
The City of London Corporation to liaise with electricity providers to the City to ensure security of supply for City buildings and infrastructure, taking account of climate impacts on seasonal	X			X	X							X	

Table A2.5: Description of measures to be considered for managing heat risks and air pollution	City of London	Other public sector	Water resources	Transport	Energy	Waste	Telecoms	Emergency services	Health care	Education	Property developers/owners	City businesses	City residents
demands													
DAA1: Avoiding risks													
Emergency planners and Emergency Services need to be prepared for heatwaves and to integrate heat risk management measures into their plans, in the same way that they currently address flood risk management.	X							X					
Implement the local heatwave plan in the City and include actions to manage air pollution health risks, as high air pollution episodes often coincide with heatwaves	X							X	X				
Create 3 day travel cards to support home-working during heatwaves.				X									
DAA2: Reducing risks													
Install electronic displays outside tube stations, showing temperatures on platforms.				X									
Investigate feasibility of making drinking water freely available on platforms at underground stations.				X									

Table A2.5: Description of measures to be considered for managing heat risks and air pollution	City of London	Other public sector	Water resources	Transport	Energy	Waste	Telecoms	Emergency services	Health care	Education	Property developers/owners	City businesses	City residents
Install natural ventilation and green roofs on City of London Corporation-owned housing, targeted at vulnerable residents.	X												
If analysis shows they reduce overall annual energy demand, install cool roofs on low-rise buildings that do not have the structural integrity to support green roofs.	X	X		X	X	X	X		X	X	X	X	
Based on the outcomes of the heat risk study of City-owned housing, target low-carbon cooling measures at vulnerable groups most susceptible to heat stress (elderly, young and those with existing health problems).	X												
Provide 'cool' centres (cooled public buildings) during heatwaves, with extended opening hours for vulnerable people and include them in emergency plans. Suitable buildings could include Guildhall Library and Guildhall Art Gallery.	X								X				
Provide shade on construction sites to reduce heat stress to construction workers.	X	X	X	X	X	X	X		X	X	X		
Continue to promote measures that reduce air	X												

Table A2.5: Description of measures to be considered for managing heat risks and air pollution	City of London	Other public sector	Water resources	Transport	Energy	Waste	Telecoms	Emergency services	Health care	Education	Property developers/owners	City businesses	City residents
pollution, e.g. encouraging zero-emission vehicles, cycling and walking.													
DAA5: Exploiting opportunities													
Exploit groundwater cooling capacity under City as far as possible, to cool City buildings.	X	X							X	X	X	X	

Managing risks to ground conditions

Table A2.6: Description of measures to be considered for managing risks to ground conditions	City of London	Other public sector	Water resources	Transport	Energy	Waste	Telecoms	Emergency services	Health care	Education	Property developers/owners	City businesses	City residents
BAC1: Research, data collection and monitoring													
Review incidence of subsidence in City buildings and infrastructure in recent hot, dry summers to establish whether these types of summers are causing significant increases in subsidence.	X	X	X	X	X	X	X		X	X	X	X	
Undertake research to evaluate the impacts of climate change on subsidence and heave risk across the City of London, to determine appropriate foundation depths on development sites.	X										X		
Undertake a review of City of London Corporation assets to determine which are most at risk from subsidence and heave in the face of climate change.	X												
Ensure geo-physical site investigations takes account of climate change impacts on subsidence and heave over the lifetime of the development.	X	X		X	X	X	X		X	X	X		
DAA2: Reducing risks													
Ensure the layout and massing of development takes account of the increased risks of subsidence	X	X	X	X	X	X	X		X	X	X		

Table A2.6: Description of measures to be considered for managing risks to ground conditions	City of London	Other public sector	Water resources	Transport	Energy	Waste	Telecoms	Emergency services	Health care	Education	Property developers/owners	City businesses	City residents
and heave due to climate change, over the lifetime of the development.													
When designing landscaping, choose the types and locations of trees carefully, considering how subsidence and root penetration will be affected by climate change.	X	X		X	X	X	X		X	X	X	X	
Where necessary, use enhanced or piled foundations capable of withstanding increased risks of subsidence and heave due to climate change, over the lifetime of the development.	X										X		
When underpinning existing buildings already affected by subsidence and heave, ensure the underpinning is sufficient to cope with climate change.	X										X		

Cross-cutting adaptation measures

Table A2.7: Description of adaptation measures to be considered for cross-cutting issues	City of London	Other public sector	Water resources	Transport	Energy	Waste	Telecoms	Emergency services	Health care	Education	Property developers/owners	City businesses	City residents
BAC1: Research, data collection and monitoring													
Analyse the effects of recent weather events on the performance of assets, infrastructure and services, to better understand vulnerabilities, thresholds and sensitivities to climate risks.	X	X	X	X	X	X	X	X	X	X	X	X	
Undertake risk analysis or vulnerability assessments to improve understanding of how these risks will change due to climate change.	X	X	X	X	X	X	X	X	X	X	X	X	
Undertake additional appraisal of the adaptation measures proposed in this report – for instance cost benefit analysis or multi criteria analysis.	X	X	X	X	X	X	X	X	X	X	X	X	
Undertake research on the possibility of equity markets falling due to climate risks globally and evaluate adaptation strategies. As part of this research, evaluate the exposure of the City of London Corporation's own portfolio to climate risks.	X											X	
Review research on climate risks to species and habitats (e.g. the MONARCH project) to establish whether the London Biodiversity Action Plan, the	X	X										X	

Table A2.7: Description of adaptation measures to be considered for cross-cutting issues	City of London	Other public sector	Water resources	Transport	Energy	Waste	Telecoms	Emergency services	Health care	Education	Property developers/owners	City businesses	City residents
City's Biodiversity Action Plan and the various Habitat Action Plans measures are appropriate in the face of climate change.													
BAC2: Changing or developing policies, standards etc													
Thoroughly address climate adaptation in the Sustainability Appraisal of the LDF.	X												
Request that developers address climate change risks and adaptation measures as part of Environmental Impacts Assessments (EIA), explaining that if the EIA does not take account of climate change, the development will not perform as intended over its lifetime. In particular, the risk management measures proposed may not deliver their intended benefits, and damage to the environment could occur as a result.	X										X		
Review existing measures in place to manage existing climate or weather risks to see whether they provide sufficient protection against changing climate risks. In many cases, additional allowances may need to be made to build in 'headroom' for climate change.	X	X	X	X	X	X	X	X	X	X	X	X	

Table A2.7: Description of adaptation measures to be considered for cross-cutting issues	City of London	Other public sector	Water resources	Transport	Energy	Waste	Telecoms	Emergency services	Health care	Education	Property developers/owners	City businesses	City residents
Review design standards and codes of practice for assets, infrastructure and services, to identify those that include climatic factors.	X	X	X	X	X	X	X	X	X	X	X	X	
Based on the outcome of the review (see above) upgrade design standards and codes of practice where required to take account of predicted climate changes.	X	X	X	X	X	X	X	X	X	X	X	X	
Ensure that contracts specifying new assets or infrastructure require them to be adaptable to the climates that they will experience over their lifetime.	X	X	X	X	X	X	X	X	X	X	X	X	X
LDF policies should **require** sustainable design and construction measures for new developments and major refurbishments. The requirement should state that these measures should be designed to take account of climate changes over the lifetime of the development.	X												
Prepare a Supplementary Planning Document on sustainable building design that fully integrates mitigation and adaptation measures. For instance, this will need to investigate the climate conditions	X												

Table A2.7: Description of adaptation measures to be considered for cross-cutting issues	City of London	Other public sector	Water resources	Transport	Energy	Waste	Telecoms	Emergency services	Health care	Education	Property developers/owners	City businesses	City residents
under which natural ventilation alone will be insufficient to keep buildings cool and recommend other low-carbon cooling mechanisms.													
Revise the Supplementary Planning Guidance for open spaces in the City to take account of climate change, e.g. emphasising further the need to provide shade in summer and to minimise water use.	X												
Ensure that any major hospital refurbishment programmes design in adaptability to climate change.									X				
Review resources available to Emergency Services and Social Services in the face of increasing demands on their services to address climate risks.	X	X						X					
Incorporate climate adaptation principles into the 'London Principles' (which aim to promote sustainable finance).	X												
BAC3: Awareness-raising and organisational learning													
Ensure that the City of London Corporation's own assets, infrastructure and services set the exemplar	X												

Table A2.7: Description of adaptation measures to be considered for cross-cutting issues	City of London	Other public sector	Water resources	Transport	Energy	Waste	Telecoms	Emergency services	Health care	Education	Property developers/owners	City businesses	City residents
standards in adaptation design and management.													
Widely publicise research on costs of recent extreme events (floods and hot summers).	X	X										X	
DAA1: Avoiding risks													
Ensure all organisations have tried and tested business continuity measures that fully address current and evolving climate risks (e.g. offline IT, records, back-up office facilities).	X	X	X	X	X	X	X	X	X	X	X	X	
Emergency planners, Emergency Services, TfL and tube companies to assess and prioritise extreme events risks (e.g. flood, heatwave) to the transport system taking account of climate change, and develop and implement contingency plans.	X			X				X					
DAA2: Reducing risks													
Ensure that the design of Crossrail is fully addressing the impacts of climate change over the lifetime of the scheme.	X			X									
Use planning gain supplement or planning conditions to secure long-term commitment to the management and maintenance of adaptation	X												

Table A2.7: Description of adaptation measures to be considered for cross-cutting issues	City of London	Other public sector	Water resources	Transport	Energy	Waste	Telecoms	Emergency services	Health care	Education	Property developers/owners	City businesses	City residents
measures.													
Routinely identify and assess risks and opportunities from climate change, and integrate adaptation measures to reduce risks into business planning.	X		X	X	X	X	X					X	
DAA3: Reducing vulnerability – diversify, share risk													
Encourage adaptation of habitats and natural colonisation by species suited to changing climatic conditions through the London Biodiversity Action Plan, the City Biodiversity Action Plan and the various Habitat Action Plans.	X	X										X	
DAA4: Bearing losses													
In the longer term, review and revise the London Biodiversity Action Plan, the City Biodiversity Action Plan and the various Habitat Action Plans based on increased understanding of the impacts of climate change and guidance from the England Biodiversity Strategy. This may include accepting loss of some habitats where this can not be avoided in the face of climate change (e.g. accept loss of some land to sea level rise) and providing alternative habitats elsewhere.	X	X										X	

Appendix 3: Checklist for 'climate-proofing' City of London Corporation policies and projects

This checklist summarises the main 'climate-proofing' principles that should be considered by City of London Corporation Departments when developing policies and projects.

	✓
Could climate risks affect your policy or project, directly or indirectly? ⇒ Refer to the risk tables in the climate adaptation strategy for information on the range of climate impacts that could occur. ⇒ Can you identify vulnerable receptors or populations at higher risk?	☐ ☐
Is the policy or project expected to provide benefits in the long-term (>10 years) or have other long-term consequences? ⇒ Decisions with long-term consequences are likely to be more sensitive to climate change.	☐
Could the policy or project possibly constrain other stakeholders' ability to manage climate risks? ⇒ If so, have they been involved in the decision-making process?	☐ ☐
Has climate change already been accounted for at a strategic level? ⇒ If so, was consideration of climate change adequate?	☐ ☐
Could your policy or project contribute to increasing climate risks? ⇒ For instance, does it contribute to the urban heat island effect, increase risks of flooding, subsidence or heave, or does it increase water consumption? ⇒ Refer to the risk tables in the climate adaptation strategy for a fuller list of climate risks.	☐ ☐
Could your policy or project be designed to contribute to reducing climate risks? ⇒ Refer to the adaptation tables in the climate adaptation strategy for information on risk management measures.	☐
Have opportunities arising from climate change been considered as part of the policy or project development process? ⇒ Refer to the risk tables in the climate adaptation strategy for information on opportunities.	☐
If climate risks are important to the policy or project, can options be identified that manage these risks to acceptable levels? ⇒ Can 'no regret', 'low regret' and 'win-win' options be identified? ⇒ Can options be defined in a flexible manner to take account of changes in climate over time? ⇒ Would it be feasible or advisable to delay making a decision until further information about climate risks is available? ⇒ Refer to the adaptation tables in the climate adaptation strategy for	☐ ☐ ☐ ☐

information on risk management measures.	

Checklist for 'climate-proofing' developments and infrastructure

This checklist summarises the main 'climate-proofing' principles that should be considered by developers and infrastructure managers[51].

	✓
• Have you addressed climate change risks and risk management measures as part of the Environmental Impact Assessment (EIA) for your development?	☐
Managing flood risks	
• Have drainage systems been designed with sufficient capacity to cope with heavier rainfall events expected over their lifetimes, taking account of climate change?	☐
• Have you considered sustainable drainage systems (SuDS) and floodwater storage areas to manage flash flood risks more sustainably?	☐
• Have you designed your development for flood resilience, ensuring that flood-sensitive assets and equipment are located away from high-risk areas, such as basements?	☐
Managing water resources	
• Does your development provide best practice in water efficiency?	☐
• Have you considered installing rainwater harvesting and greywater recycling facilities?	☐
• Have you ensured that your landscaping schemes are drought-resistant and require minimal irrigation?	☐
Managing heat risks	
• Have your buildings been designed to provide a comfortable internal environment with the least use of energy over their lifetimes, taking account of rising temperatures due to climate change?	☐
• Has your development been designed to incorporate green spaces to provide cooling and shade in the face of rising temperatures?	☐
Managing ground conditions	
• Does the design of your development and its foundations take account of climate change impacts on subsidence and heave over its lifetime?	☐
• In landscaping schemes, have you considered how subsidence and root penetration will be affected by climate change, when choosing and siting trees?	☐

[51] A more detailed checklist is provided in "Adapting to climate change: a checklist for development. Guidance on designing developments in a changing climate." Greater London Authority. November 2005.

Appendix 4: Methodology for developing the City of London climate change adaptation strategy

A risk management approach

In line with best practice in policy-making and decision-making more generally, this adaptation strategy has been developed using a risk management approach. Its development has drawn on the UKCIP risk-based climate adaptation decision-making framework[52] (see figure overleaf), following stages 1 to 5 as follows:

- **Stage 1: Identify objectives**: This stage involves establishing the reasons for the development of the adaptation strategy, what it aims to achieve and who needs to be involved in its development.

- **Stage 2: Establish decision-making criteria**: Criteria for evaluating the range of possible adaptation options are determined at this stage.

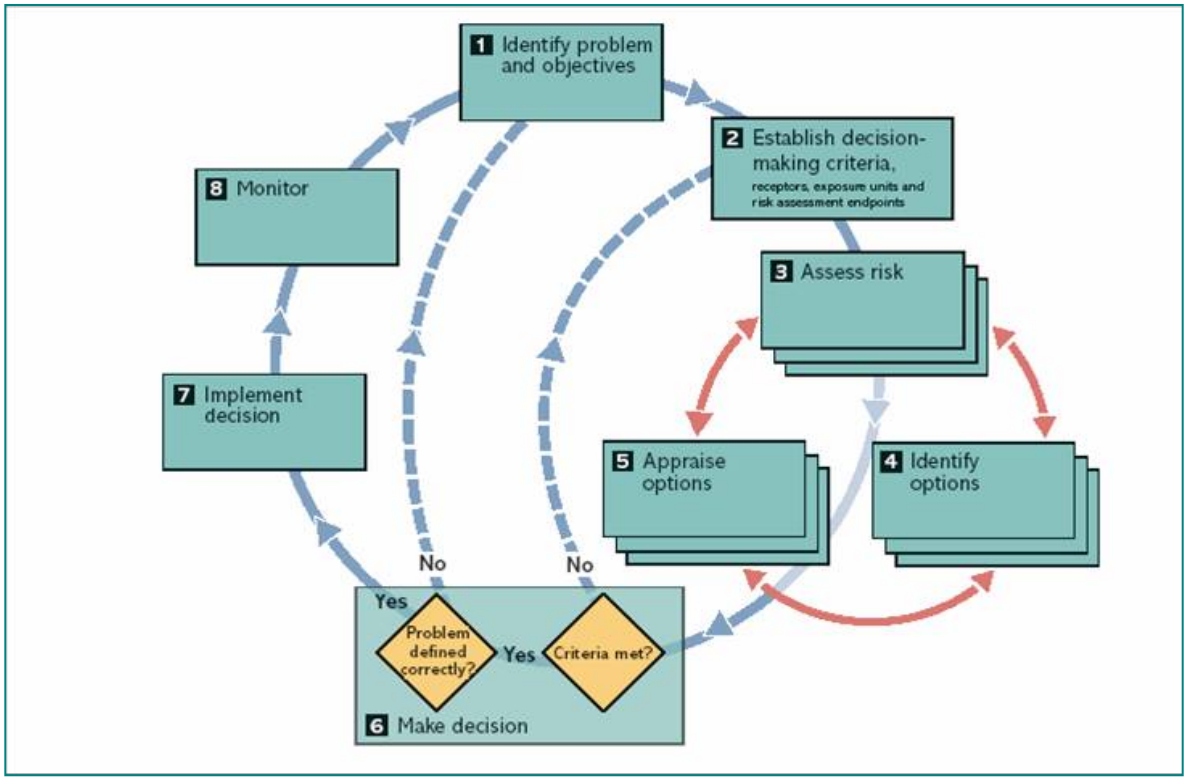
- **Stage 3: Assess risks**: Climate risks are assessed. The development of this adaptation strategy drew existing information about climate risks to London, including the London Climate Change Partnership report, 'London's warming'[53]. Additional risks were identified through a stakeholder workshop (see below).

- **Stage 4: Identify risk management options**: Options to manage the risks from Stage 3 are identified. Options were identified through reviews of existing literature and through a series of working meetings (see below).

- **Stage 5: Appraise options**: The adaptation options are appraised qualitatively against the decision-making criteria established at Stage 2. Where it is not possible to evaluate the suitability of an adaptation option, further research or investigation will be required.

[52] UKCIP. Climate adaptation: Risk, uncertainty and decision-making. UKCIP Technical Report. UKCIP, Oxford. 2003.
[53] London Climate Change Partnership. London's warming: The impacts of climate change on London. Technical Report. 2002.

The UKCIP risk-based climate adaptation decision-making framework



Stages 1 – 3: Decision-making criteria, risk assessment and prioritisation

Decision-making criteria for evaluating adaptation options

In discussion with City of London Corporation staff, the following criteria were identified as being important to evaluating adaptation options:

- Whether they are no-regrets, low-regrets or win-win measures,
- Acceptability to different stakeholder groups,
- How successful the measures are at reducing the climate risk,
- Value for money,
- Ease of implementation,
- Sustainability,
- Whether the measures are reliable and 'tried and tested',
- Adaptability of the measures in the face of changing climatic conditions.

Risk assessment and prioritisation

Climate risks and opportunities were identified from existing literature and through engagement with City of London Corporation staff and external stakeholders. Tables presenting the range of risk and opportunities identified for the City of London (see Appendix 1) were developed for the four main affected groups – the 'receptors':

- Assets and Infrastructure,
- Business,
- People,
- Open spaces and heritage.

For each climate risk, the tables detail the City of London Corporation departments likely to be most affected by the risk, and external stakeholders who are also affected.

There are some cases where detrimental risks will lessen as our climate changes – for instance the numbers of winter cold deaths are expected to decrease as temperatures rise. These have been identified as 'opportunities' in the risk tables, along with business opportunities arising from climate change, such as new financial products.

The risks identified have also been assigned a 'risk rating' so that they are prioritised according to their potential significance as 'Very High', 'High', 'Medium' or 'Low'. This rating process has been undertaken using the method outlined in the Community Risk Register[54] developed by the Central London Local Resilience Forum for contingency planning, since the Register is used by Contingency Planners in the City of London.

The risk rating method involves considering the two components of risk:

- Likelihood of hazard,
- Magnitude of consequence (impact).

The likelihood assessment relates to the probability of the hazard occurring over the lifetime of the particular asset or service in question. The magnitude is based on a qualitative assessment of the consequence of the hazard, by considering four categories of consequence:

- health,
- social,
- economic,
- environment.

The risk rating matrix from the Community Risk Register (see figure below), is then used to prioritise the risk as 'Very High', 'High', 'Medium' or 'Low'.

Usability of risk rating approach in the context of a changing climate

Adoption of the risk rating approach has been undertaken as far as reasonably possible. However, there are limitations, particularly concerning the fact that the likelihood of hazards is changing, as climate changes. This has been addressed by considering two factors:

- First, considering any hazard ratings for climate-related hazards given in the Community Risk Register (e.g. storms and gales, flood risks),
- Secondly, considering whether the probability of the climates hazard is expected to change, as the climate changes:
    - If the probability is expected to increase due to climate change, then the hazard rating is increased. In judging whether to make any increases to the hazard rating, consideration has been given to the relative confidence levels attached to the changes, as detailed in Appendix 5.

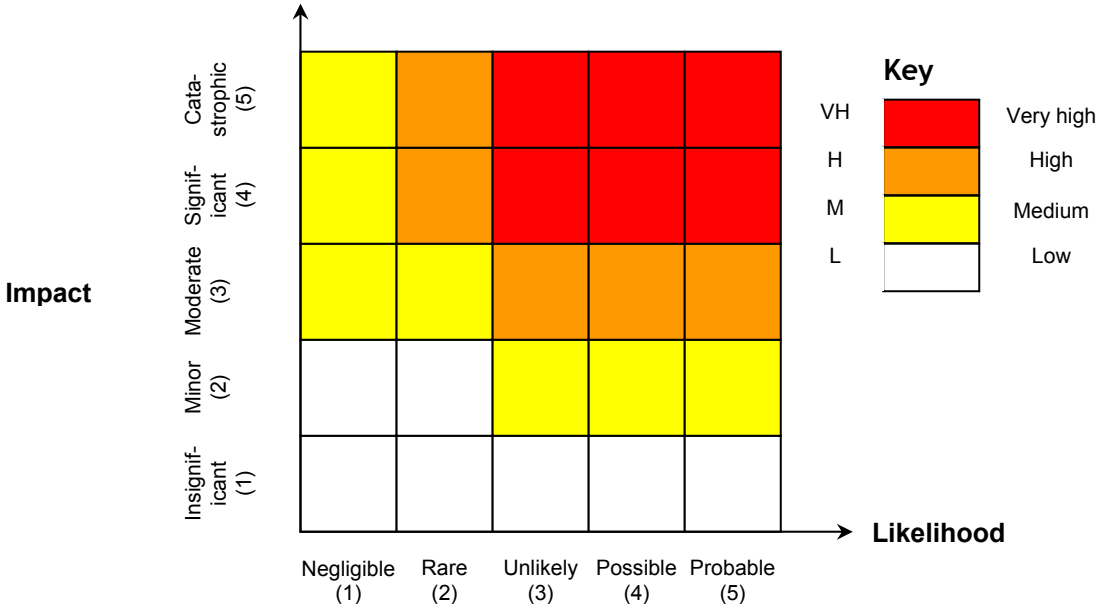
Therefore a risk is rated higher if:

- It is already a problem in the City of London, and/or
- The risk will become more significant over the lifetime of the asset or service in question.

[54] Central London Resilience Forum. Community Risk Register Version 1.1. July 2006.

Specific examples of how risk ratings have been developed using this approach are outlined below, for tidal/river flooding and for winds and storms.

Risk rating matrix[55]



Tidal/ river flooding

The risk of tidal/ river (fluvial) flooding has been rated 'High', as it has been assumed that:

- The very high standard of protection against flooding offered by the Thames Barrier – currently 1 in 2,000 years – will continue to be provided over the longer term; this standard sits on the boundary between 'negligible' and 'rare' likelihood according to the Community Risk Register,
- If the Barrier were overtopped, the consequences would be catastrophic.

Wind and storms

The Community Risk Register assigns wind and storm risks a 'Medium' rating. The climate change models do not indicate a significant change in average wind speeds, and there is a low confidence that the number of winter storms will increase somewhat by 2080s, as shown in Appendix 5. Therefore evidence for changes in storm hazards due to climate change, is poor, and hence the rating attached to winds and storms is considered to remain as 'Medium'.

Stage 4 and 5: Identifying and appraising climate adaptation measures

The risks were ranked into five categories, ranging from 'Very high' to 'Low', and also covering 'beneficial' risks, i.e. opportunities.

Adaptation measures to manage the 'Very high' and 'High' priority climate risks have been identified through:

- Reviews of good practice emerging elsewhere in the UK and internationally,

[55] Central London Resilience Forum. Community Risk Register Version 1.1. July 2006.

- Workshops hosted by the City of London Corporation (for attendees please see below),
- Acclimatise's knowledge and expertise.

The adaptation measures identified can be found in Appendix 2.

City of London Corporation departments covered in this adaptation strategy

While climate change will affect the City of London in many ways, the strategy has focused on those parts of the City of London Corporation that are expected to be most affected. These include:

- City Surveyor's Department,
- Planning and Transportation Department,
- Economic Development Office,
- Environmental Services Department,
- Department of Community and Children's Services,
- Open Spaces Department,
- Town Clerk's Department,
- Markets.

Stakeholder engagement

There has been an emphasis on developing the adaptation strategy in consultation with stakeholders – including staff from within the City of London Corporation departments listed above as well as external stakeholders from City businesses and other infrastructure providers. This engagement has included the following:

- A large workshop to identify and discuss climate risks to the City of London, held in July 2006,
- Four smaller working meetings to identify and appraise adaptation actions to address the climate risks, held in August 2006.

Details of the attendees at these workshops are provided below.

Workshop 1: Identifying and assessing climate risks to the City of London, 10 July 2006, City Marketing Suite

Department/Organisation	Officer	Workshop
Planning	Janet Laban	Infrastructure / assets
Planning	Simon Phillips	Infrastructure / assets
Planning	Kerstin Kane	Living environment
Planning	Joost Bergers	Living environment
Planning	Paul Beckett	Business
Surveyors	Alan Gartrell	Infrastructure / assets
Surveyors	Andrew Wild	Infrastructure / assets
Rememberancers	Bruce Hunt	People
Markets	Nigel Shepherd	Infrastructure / assets
Environmental Health	Philip Thompson	People
Port Health	Steve Blake	Living environment
Cleansing Service	David Lee	People
Cleansing Service	Colin Russell	Infrastructure / assets
Open Space	Martin Rodman	Living environment
Economic Development	Liz Skelcher	Infrastructure / assets
Economic Development	Jeremy Fern	Business
DOTS	Paul Kennedy	Infrastructure / assets
DOTS	James Clare	Living environment

Freeman's school	Anthony (Tony) Riley	People
Children and Adult Services	Len Packman	People
Children and Adult Services	Ann Saunders	People
Children and Adult Services	Richard Dunn	Infrastructure / assets
Police	Ray Sykes	People
Emergency Planning	Paul Eskritt	People
Emergency Planning	Dermot McCarthy	People
Occupational Health	Ginny Giles	People
Health and Safety	Tony Holmes	People
Thames Water	Dr Keith Colquhoun	Business
Environment Agency	Tim Reeder	Living environment
ABI	Katy Cornish	Business
CHPCT	Jose Figueroa	People
TFL	Andree Blake	Infrastructure / assets
London Chamber of Commerce	Christiane Bruening	Business
Government Office for London	Penny Bramwell	Business
Government Office for London	Nigel Barker	Living environment
RBS	David Graham	Business
KPMG	Sam Pilcher	Business
Clifford Chance	Pat Berry	Business
Hackney BC	Ian McConnel	Infrastructure / assets
Tower Hamlets	Rachel Carless	Infrastructure / assets
Tower Hamlets	Lesley Muggeridge	People
Islington	Eric Manners	Infrastructure / assets
Westminster	Bridie Gunn	Infrastructure / assets
London Metropolitan University	Simon Goldsmith	Business
Mouchel Parkman	Amanda Aukett	Infrastructure / assets

Workshop 2: Identifying and appraising adaptation measures, August 2006, City Marketing Suite

Department/Organisation	Officer	Workshop
Planning	Janet Laban	Infrastructure / Open Spaces
Planning	Simon Phillips	Infrastructure
Planning	Paul Beckett	Business
Planning	Joost Bergers	Open Spaces
Planning	Kathryn Stubbs	Open Spaces
Planning	Kerstin Kane	Open Spaces
GLA	Alex Nickson	Infrastructure / Business
GLA	Andrew Tucker	Infrastructure / Business / People / Open Spaces
Government Office for London	Will Lochhead	Business
British Land	Claudine Blamey	Infrastructure
RSSB	Joanna Gilligan	Infrastructure
Energy team	Karen Shaw	Infrastructure / People
Thames Water	Keith Colquhoun	Infrastructure / Business
Charles Russell Associates	Malcolm Dowden	Infrastructure / Business / Open Spaces
Markets	Nigel Shepherd	Infrastructure

		/Business
Cleansing	Peter Ager	Infrastructure
Surveyors	Peter Snowden	Infrastructure
Surveyors	Andrew Wild	Business
Environmental Health	Steve Blake	Infrastructure / People
London Chamber of Commerce	Christiane Bruening	Business
Economic Development	Clive Pearson	Business
ABI	Katie Cornish	Business
Security and contingency	Nicole Adams	Business
Environmental services	Philip Thompson	Business / People
London Met University	Simon Goldsmith	Business
Police	Ray Sykes	Business
Adult Services	Ann Saunders	People
Town Clerks	Claire Weeks	People
Cleansing Services	David Lee	People
Housing	Len Packman	People
Open spaces	Andy Barnard	Open Spaces
Open spaces	Susan Sparkes	Open Spaces
Open spaces	Cindy Blaney	Open Spaces
Open spaces	Lucy Stowell-Smith	Open Spaces

Appendix 5: Summary of expected climate changes in London for the UKCIP02 low and high emissions scenarios

Changes in climate hazards	Relative confidence level	Changes in London	
		Low emissions scenario	High emissions scenario
Increasing summer temperatures	High	2020s: 1 to 1.5°C 2050s: 2 to 2.5 °C 2080s: 2.5 to 3 °C	2020s: 1 to1.5°C 2050s: 3 to 3.5°C 2080s: >4.5°C
Increasing winter temperatures	High	2020s: 0.5 to 1°C 2050s: 1 to 1.5°C 2080s: 1.5 to 2°C	2020s: 0.5 to 1°C 2050s: 1.5 to2°C 2080s: 3 to 3.5°C
More frequent extreme high temperatures In central London. The urban heat island effect currently adds up to a further 5 to 6°C to summer night temperatures and is expected to intensify in the future	High	Increase of up to 14 'extremely'[(a)] warm days in summer by the 2080s[(b)]	Increase of up to 30 'extremely'[(a)] warm days in summer by the 2080s[(b)] Daily maximum temperatures of 33°C, which currently occur about 1 day per summer could occur 10 days per summer by 2080s[(b)(c)]
Less extreme low temperatures	High	Fewer frosts, long runs of snow less winters	
Increasing winter rainfall	High	2020s: 0 to 10% 2050s: 0 to 15% 2080s: 10 to 20%	2020s: 0 to 10% 2050s: 15 to 25% 2080s: 25 to 30%
Reducing summer rainfall	Medium	2020s: 10 to 20% 2050s: 10 to 30% 2080s: 20 to 30%	2020s: 10 to 20% 2050s: 30 to 40% 2080s: 50+%
Increases in winter precipitation intensity	High	By the 2080s, 10 to 20% increase in the daily precipitation amount which can be expected, on average, once every 2 years[(b)]	By the 2080s, 20%+ increase in the daily precipitation amount which can be expected, on average, once every 2 years[(b)] Heavy winter rainfall could occur twice as often by the 2080s[(b)(c)]
Potentially an increase in frequency of winter storms	Low	Increase in the number of winter deep depressions crossing the UK from 5 (1961-90) to 8 by the 2080s Mean winter wind speeds could increase by as much as 10% by the 2080s[(b)]	
Reduction in soil moisture content	High for summer changes	In summer, reduction of 20-30% by the 2080s[(b)]	In summer, reduction of 40% to 50% by the 2080s[(b)]
Sea level rise	Medium	Net sea level rise of approximately 26cm by the 2080s[(b)]	Net sea level rise of approximately 86cm by the 2080s[(b)]
Extreme sea levels (storm surges)	Low	Coast around the South East could experience an increase in 50-year return surge height of up to 0.9m by the 2080s[(b)]	Coast around the South East could experience an increase in 50-year return surge height of up to 1.5m by the 2080s[(b)]

(a) 'Extremely' warm days are defined using the 90th percentile daily average temperature modelled for the baseline period 1961-1990, i.e. the daily average temperature which is exceeded, on average, on 10% of days
(b) Data only available for the 2080s in the UKCIP02 Climate Change Scenarios
(c) Data presented are for the medium-high emissions scenario

Enquiries and further information

Simon Mills, City of London Corporation

PO Box 270
Guildhall
London
EC2P 2EJ

T: +44 (0) 207 3323598
F: +44 (0) 207 7962621
E: simon.mills@cityoflondon.gov.uk
W: www.cityoflondon.gov.uk

Dr Richenda Connell, Acclimatise

6 Nursery End,
Southwell,
Nottinghamshire,
NG25 0BY

T: +44 (0) 1636 812868
F: +44 (0) 1636 812702
E: r.connell@acclimatise.uk.com
W: www.acclimatise.uk.com