London Climate Change Partnership / Environment Agency

Heat Thresholds Project

Final report

8 June 2012

This report takes into account the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Job number 218984-00

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1 Executive summary

Over the last 30 years, London has experienced extreme high temperatures that have affected the health, comfort of Londoners and the economic vitality of the city. These include the heat waves of 1976, 2003 and 2006 and the unseasonal hot weather of April, September and October 2011. Due to the exacerbating factors of London's existing Urban Heat Island and climate change projections for increased average temperatures and more extreme hot weather events in the South East of England, decision makers across all of London's interdependent urban systems need to start thinking about evidence based, risk management approaches to planning, designing and managing for the impacts of hot weather.

This report summarises the findings of a small qualitative research project which has identified some key hot weather related thresholds relevant to London and its urban systems. It focuses on some of the specific issues for the social housing and care home sectors. Based on the findings of the desk based literature review and a series of semi-structured interviews with experts in the two sectors selected for more detailed study, this report then attempts to set out the beginnings of a generic flexible pathway, threshold based decision making approach relevant to decision makers across all of London's urban systems and sectors.

A series of recommendations for improving policy and practice relating to hot weather planning and heat risk management are set out at the end of the report. These are aimed at three target audiences: decisions makers in the social housing and care home sectors in London; decision makers within London's urban systems, including the London Climate Change Partnership and the Environment Agency, and national level decision makers who are responsible for policy, legislation and guidance relevant to heat risk management in the UK. Key recommendations are summarised in **Table 1** below and set out in full in **Section 3.5.**

Table 1. Key recommendations for improving policy and practice relating to hot weather planning and heat risk management

Target audience	Key recommendations
Decisions makers in London's social housing and care home sectors.	**Clarification and revision of policy** • Greater London Authority (GLA) to revise and/or clarify policies on hot weather planning, overheating and heat risk for Registered Social Landlords (RSLs) in London (and nationally). • Care Quality Commission (CQC) to revise and/or clarify policy on hot weather planning, overheating and heat risk for care home providers (whether LBs, RSLs or private sector) in London (and nationally). **Better linkages and training** • London Boroughs (LBs) and RSLs to continue to build upon linkages between Health, Social Care and Buildings teams and explore the new public health role for LBs as an opportunity to better join up services to address heat risk. • LBs, RSLs and care home providers to continue to ensure levels of training and awareness about hot weather planning, overheating and heat risk are adequate amongst staff and residents. **Risk registers, asset mapping and mapping of hot and cool spots** • LBs, RSLs and care home providers to incorporate heat risk on strategic risk registers where not incorporated already. • LBs, RSLs and care home providers to develop heat risk vulnerability registers

	which defines a set of key characteristics for vulnerable residents, buildings assets or infrastructure. • LCCP to work with partners, such as the AWESOME project team at Bartlett School of Graduate Studies, University College London (UCL) to identify 'multiple factor hot spots' (i.e. building within urban heat island zone, prone to overheating and with vulnerable inhabitants). • LCCP to encourage asset mapping and characterisation of all LB and RSL property, buildings, land and green space using GIS and searchable databases. • LBs and RSLs to develop and integrate 'cool spots/cool buildings' mapping work into their heat risk plans. **Information hubs and dissemination** • LCCP working with the G15 groups of housing associations and the Good Homes Alliance/SHIFT (Sustainable Homes Alliance) to: – create a repository of information about assessing and managing heat risk in London's social housing and RSL sectors, with examples of good practice – disseminate and communicate existing research, plans and guidance relating to assessing and managing heat risk more widely and effectively. **Joining up with other initiatives** • Integrate adaptation measures into criteria for Green Deal, Green Investment Bank and Decent Homes funding for residential building retrofit projects. • Use new housing development and regeneration projects (both RSL and private developer led) as case studies or live research project for value of green infrastructure in contributing to keeping inner city housing and surrounding areas cool and comfortable. • Integrate 'heat sensitive urban design' considerations into existing work on 'water sensitive urban design'.
Decision makers within and across all of London's urban systems	• LCCP to lead on incorporating heat risk on London Community Risk Register in a way consistent with Met Office, NHS and Health Protection Agency thresholds. • LCCP to lead on clarifying terminology around heat risk and coordinate responsibility for planning and preparing for hot weather related risks in London. • LCCP to lead on the research, development and implementation of low cost public awareness campaigns and guidance on how individuals can prepare and respond to hot weather events.
National level decision makers responsible for policy, legislation and guidance relevant to heat risk management in the UK	• Government to commission a review of and establish temperature thresholds for communal areas of social housing and care homes in addition to those for residential areas and bedrooms. • Government to commission a review of the acceptable comfort ranges and threshold temperatures for all building types in addition to those for hospitals and school buildings. Guidance on 'heat sensitive building design' criteria for each building type to be developed in partnership with relevant professional institutions and government departments. • Government to continue to give heat risk in UK cities and urban systems high priority in the 'Climate Ready' National Adaptation Programme, particularly across the Built Environment and Infrastructure themes. • Key professional institutions and employers to develop targeted interdisciplinary training and CPD for relevant design and construction industry professionals

	around planning, designing and management to avoid overheating risk in cities. • Further collaborative research work to be commissioned by the Research Councils, Technology Strategy Board, Climate UK and Environment Agency regarding projections and return periods for extreme hot weather events in UK cities.

In summary, extreme hot weather is considered by various experts and decision makers as a significant risk for London and the South-East of England, and the evidence base suggests it will become an increasing risk.

However, whilst some key organisations working within the urban systems which comprise London are responding to this risk (e.g. Transport for London, National Grid, the Health Protection Agency and Crossrail amongst others), many individuals working within the social housing and care home sectors do not currently perceive hot weather related risks as serious enough to make major changes to their strategic and operational decision making processes. Therefore, the development of clear and credible information and case study examples is required to facilitate: wider and deeper engagement with the issues around heat risk management; co-production and co-generation of messages to be communicated; and relevant and logical decision making approaches within these two sectors, and across all of London's urban systems.

It is hoped that this report contributes to the growing body of knowledge and guidance around understanding and communicating heat risk and heat risk related decision making in London, as well as providing some recommendations for further work to be commissioned.

2 Project objectives and approach to tasks

The objective of this LCCP project was to explore and begin to develop a generic methodology for a flexible pathway, threshold based analysis for heat risk management in London. In order to achieve this objective, the necessary work and the structure of this report have been organised around five key tasks summarised in **Table 2** below.

Table 2. Description of five key tasks for this project

Task	Description of task
1	Review and summarise existing research on heat risk thresholds and management relevant to London
2	Identify key vulnerabilities, thresholds and possible policy and practice responses relevant to heat risk management in London
3	Produce a high level case study and worked example for a methodology to map and respond to heat risk related thresholds in London
4	Identify next steps for producing a flexible pathway threshold analysis methodology for heat risk management in London
5	Produce a final report summarising the outcomes and outputs of Tasks 1-4, setting out a series of SMART recommendations (Specific, Measurable, Achievable, Realistic and Timebound) for heat risk management policy and practice

The aspiration is that this generic approach and methodology could potentially be used, or developed further, by any sector, service or organisation operating within the wide range of closely inter-dependent urban systems which comprise London. **Figure 1** represents the key interdependent systems that enable a city to function. It should be noted that these are largely physical and organisational categories and that there are complex social and cultural systems within and across each category which affect perceptions of risk and approaches to decision making.

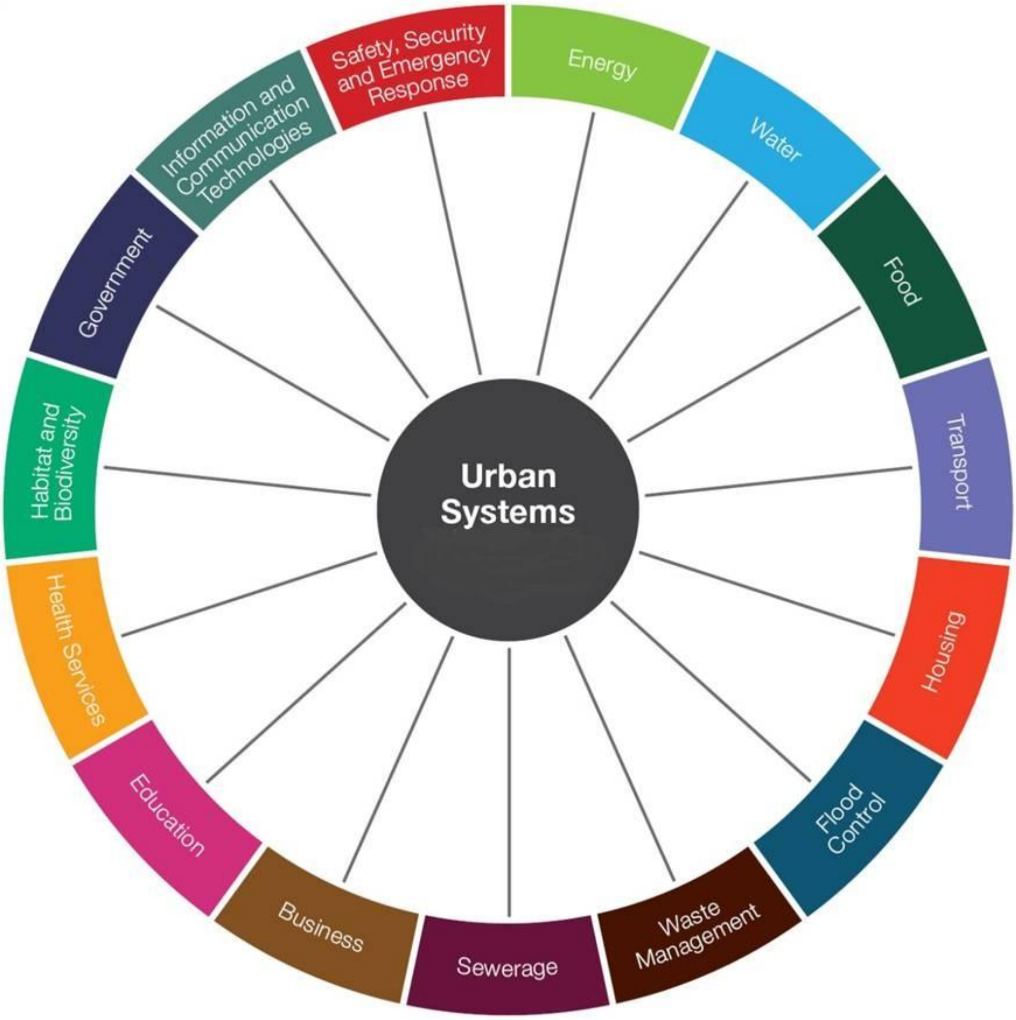


Figure 1 London as a system of fifteen urban systems

The approach to the five tasks was to start with a review of the UK and international literature on heat related risks and thresholds relevant to all of the urban systems illustrated in **Figure 1**. There was then a focus on a worked example of the heat related risks, thresholds and decision making processes most relevant to the social housing and care homes sectors within London. Lastly key findings from this worked example were drawn out which could be generalised and developed across all urban systems as illustrated in **Figure 1** above. This approach is illustrated in **Figure 2** below.

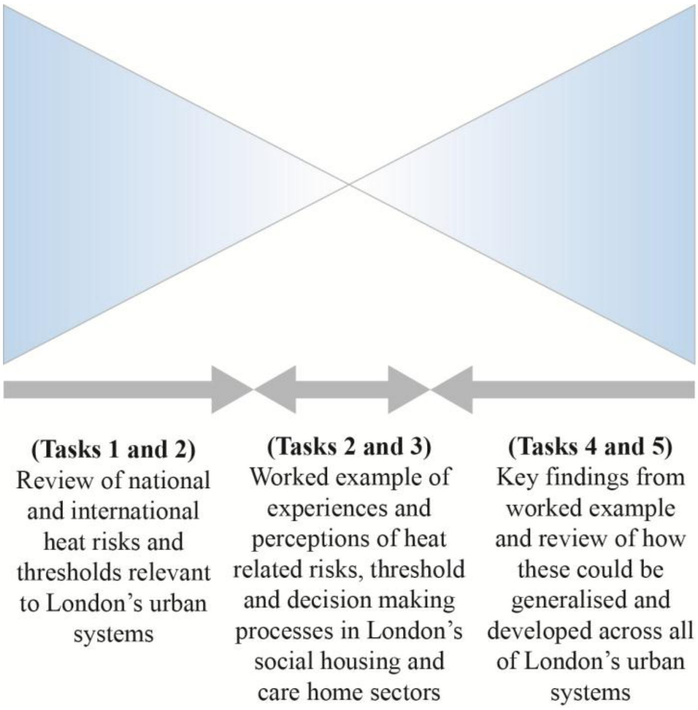


Figure 2 Approach to the five tasks for this project.

The sectors selected for the worked example for this project are the social housing and care home sectors within London. The aim of the worked example was to: understand the generic decision making and communication processes and channels within these sectors; establish a snapshot of existing levels of organisational and institutional awareness, perception and experience of heat related risks specifically, and explore the associated capacity to respond to these risks. It is important to note that there is a close relationship between the quality and management of social housing and care homes and the health services. For example, if social housing is of poor quality it may either result in more people than necessary having to move into care homes, or more people requiring medical care.

Attention was paid to ascertaining what kinds of further information and guidance on heat risk management would be useful for decision makers in these sectors given projections for hotter weather and more frequent and intense heat waves in London resulting from natural climate variability, the exacerbating influence of the Urban Heat Island effect and projected climate change.

This approach has led to a number of recommendations for more effective policy and practice related to heat risk awareness and management for consideration by three key audiences; decision makers in London's social housing and care home sectors; the London Climate Change Partnership working with other stakeholders in London, and national government and organisations. See **Section 3.5** for the full set of recommendations**.**

3 Summary of outcomes and outputs from Tasks 1-4

3.1 Task 1: Review and summary of existing research relevant to heat risk management and thresholds in London

The main aim of the literature review in **Task 1** was to establish and reference the key sources of national and international information about heat risk and heat risk related thresholds relevant to all of the urban systems which comprise London as illustrated in **Figure 1**. Literature was reviewed with a general focus on information of most relevance for the built environment, critical infrastructure and health and social care sectors as well as cross-cutting issues, such as physiological and psychological acclimatisation and heat stress indices, prioritised by the LCCP 'Overheating Thresholds for London Experts' Roundtable' meeting in September 2011. There was a specific focus on the social housing and care home sectors to inform the worked example in **Task 3**. Key findings from the literature review are summarised in **Appendix 1** which consists of a number of Excel tabs, and a full list of corresponding references is included as one of the tabs and in **Section 5** of this report.

In summary, there is a considerable amount of literature including; scientific and academic research; design and engineering guidance; and government and industry standards on the topics of heat risk and temperature thresholds. Some of this is specific to individual urban systems (e.g. CIBSE Guide A which sets out internal temperature thresholds for living areas and bedrooms within housing) and some is relevant to multiple systems (e.g. the NHS Heatwave Plan for England which sets out what constitutes a heat wave in terms of diurnal temperature range and duration for London and other regions). Much of this literature is the result of a number of research projects aimed at better understanding and assessing current and future patterns of hot weather and heat risk in the UK and London specifically. A selection of these research projects are listed in **Table 3** below.

Table 3. Selection of research projects aimed at better understanding and assessing current and future patterns of hot weather and heat risk in the UK

Research project	Weblink
ARCADIA (Adaptation and resilience in cities: analysis and decision making using integrated assessment)	http://www.ukcip-arcc.org.uk/index.php?option=com_content&task=view&id=628/542
CREW (Community resilience to extreme weather)	http://www.ukcip-arcc.org.uk/content/view/586/9/
Low Carbon Futures: decision support for building adaptation in a low carbon climate change future	http://www.ukcip-arcc.org.uk/content/view/589/517/
LUCID (Local urban climate and intelligent design)	http://www.ukcip-arcc.org.uk/content/view/594/9/
SCORCHIO (Sustainable cities: options for responding to climate change impacts and outcomes)	http://www.ukcip-arcc.org.uk/content/view/588/9/
SNACC (Suburban neighbourhood adaptation for a changing climate)	http://www.ukcip-arcc.org.uk/content/view/630/9/
Climate change, justice and vulnerability (Socio-spatial vulnerability approach to assessing heat risk)	http://www.jrf.org.uk/publications/climate-change-justice-and-vulnerability

However, this is a developing area of research and the identification of specific temperature thresholds to inform decision making merits further exploration. Whilst thresholds are useful, as they provide a benchmark to design to or to trigger responses, they are problematic in that they are difficult to generalise across all risk receptors, systems or geographical regions. Heatwaves by their definition don't occur very often, therefore experiences and studies of actual examples of different temperature thresholds being exceeded are limited. Even when thresholds are exceeded during hot weather events, it is difficult to pin down exact reasons and causes. Furthermore, many suggested or recommended thresholds are not definitive or fixed and the subject of ongoing research and debate. For example, there is no definitive threshold for what constitutes 'heat stress' in sources of guidance which people might look to for clarity and certainty, and there is no general agreement as to what constitutes 'overheating' in buildings. Designers, engineers, managers and decision makers use a number of suggested or recommended metrics to assess the predicted and actual impact of hot weather on people, buildings, infrastructure and other assets, and some of these are threshold based.

Table 4 below highlights extracts from the literature review of existing research relevant to heat thresholds in London organised by the urban systems illustrated in **Figure 1.** These systems incorporate the three sectors prioritised by the LCCP Expert Roundtable group (i.e. the built environment, critical infrastructure health and social care, as well as cross cutting issues). Those systems highlighted in bold are considered by Arup to be most relevant to decision makers in the social housing and care home sectors. This was backed up by the responses of the interviewees. A selection of these temperature thresholds are illustrated in **Figure 3** below.

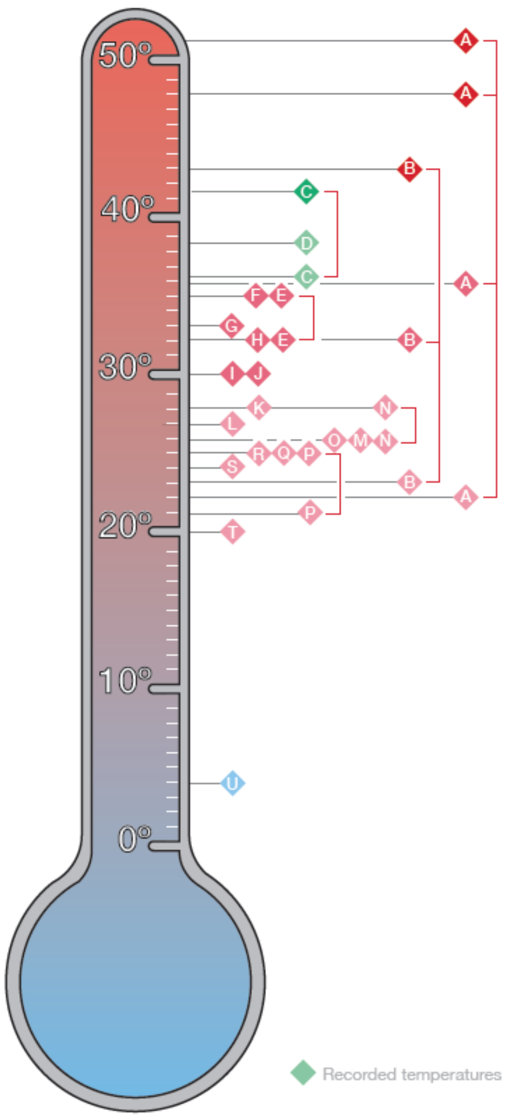
Table 4. Extracts from the literature review of existing research relevant to heat thresholds in London categorised by urban system.

Urban systems (as per Figure 1)	Relevant thresholds
Energy	Overhead power lines have reduced rating factors at air temperatures of more than 30°C (IET, 2008). Vulnerability of buildings to power outages increases when external air temperatures exceed 30°C due to increased demand for air conditioning (Walsh, 2011). Power and refrigeration networks lose capacity per one degree rise in temperature (IET, 2008).
Water	Legionella bacteria begins to develop in potable cold water supplies (both stored and piped) if water temperature exceeds 20°C. However, stored and piped water temperatures of 25°C are acceptable in hot weather (HSE ACoP L8, 2000). Fresh water temperatures of around 25°C create optimal growth for certain types of algae which can lead to algal bloom and eutrophication (IPCC, 2007).
Food	Temperatures of between 4ºC and 60°C encourage bacterial growth on food (Food Standards Agency, 2006). Likelihood of food borne diseases increase by 4.5% for every 1°C increase in air temperature (Scotland, 2011).
Transport	External air temperature of 36°C results in rail track temperatures of 48°C-52°C. Extreme precautions, such as temporary speed restrictions, taken by Network Rail at this air temperature to avoid buckling of non-pre-stressed rails and overheating of power sources. At air temperatures of 22°C Network Rail begin to implement staged

	preventative measures (Benzie, 2011. NHS, 2010). London Underground begin to implement overheating plans at external air temperature of 24°C. This includes public health communications and measures to prevent existing tracks from buckling. There may be other ‘Cooling the Tube’ related thresholds of relevance which have not been accessed (TfL, 2010). Softening of tarmac, asphalt and bitumen road surfaces generally begins to occur at surface temperatures of 33°C but this dependant on direct solar exposure as well as just air temperature (NHS, 2010).
Housing (buildings)	Threshold temperatures for internal spaces in housing stated as 28°C for living areas and 26°C for bedrooms. ‘Warm’ temperature threshold for offices, schools and living areas is considered to be 25°C. ‘Hot’ temperature threshold for offices, schools and living areas is considered to be 28°C (CIBSE, 2005). *N.B. CIBSE is reviewing these criteria and may replace them with the adaptive thermal comfort approach and potential discomfort index. Suggestion is that discomfort be measured on a basis of difference between comfort temperature and operative temperature (CIBSE, 2011).* Heat stress risk for healthy adults is an internal air temperature of 35°C at a relative humidity level of 50% (ASHRAE, 2009). This danger line temperature decreases by several degrees for higher humidity levels and for more vulnerable groups such as the elderly. *N.B. The majority of thresholds suggested or recommended by both CIBSE and ASHRAE are based upon conditions for fit and healthy individuals.* Threshold temperature for ‘overheating’ in well insulated housing is 27°C and measured by the number of degree hours by which this is exceeded (Energy Savings Trust, 2005).
Flood control	No specific temperature thresholds identified in the literature reviewed, but in the UK heavy rain events can often follow an extended period of hot weather during summer due to slow moving low pressure weather systems (which cause rain) moving into areas previously occupied by high pressure weather systems (which cause hot weather). Victorian drainage systems in London are unable to deal with the flash flooding that can be caused by heavy rain run-off from impermeable ground. Summer convective storms are usually set off by hot weather periods.
Waste management	No specific temperature thresholds identified in the literature reviewed, but potential issues arising from warmer temperatures include increased methane production from landfill and accelerated growth of maggots and flies in stored waste bins (see AEA, 2012 for further information).
Sewerage	No specific temperature thresholds identified in the literature reviewed but potential issues arising from warmer temperatures include biogas production in sewers and accelerated eutrophication in freshwater when treated effluent is released.
Business	Internal air temperatures for mechanically cooled spaces in UK commercial office space should not exceed 24°C +/- 2°C (British Council of Offices, 2009).
Education	Internal air temperatures in school buildings should not be greater than 5°C above external air temperatures and internal air temperatures should not exceed 32°C when occupied (Department for Education, 2011).

Health services	Hospitals should provide internal cool areas at temperatures of 26°C or below if internal air temperatures rise above 26°C (NHS, 2011) as this is when people begin to find it difficult to keep cool. External air temperature of 24.7°C over 2 day average leads to greater incidences of mortality along with morbidity and hospital admissions (Armstrong, 2010). Mortality in housing increases when external air temperatures reach 25°C (CLG, 2006). Core body temperature is 37.5°C (linked to air temperature, movement and humidity levels). Human skin temperature is 33°C (linked to air temperature, movement and humidity levels). At temperatures of 35°C combined with 50% relative humidity levels most fit and healthy adults begin to feel 'heat stressed' (ASHRAE, 2009).
Habitat and biodiversity	Different types of vegetation thrive in different temperatures and moisture levels. Have not found any specific literature for key species in London, but rye grass and London Plane trees would be worth researching further due to their prevalence in London. In a city with less than 10% urban green cover, air temperatures in that city are projected to increase by approximately 4°C - 8.2°C by 2080. However, if urban green cover is greater than 10%, temperatures are projected to increase by only 1% above current city temperatures (Gill et al, 2007; CABE, 2009; NHS, 2011).
Information and communications technology (ICT)	Maximum internal air temperature of 23°C advised for IT equipment rooms (CIBSE, 2006). Absolute maximum internal air temperature limits set at 32°C for computer rooms and 43°C for server rooms (IBM, 2011).
Safety, security and emergency response	NHS Heatwave Plan for England considers the threshold for a heat wave in London as when temperatures are at least 32°C during the day and do not drop below 18°C at night for 2 consecutive days. The London Community Risk Register considers heat wave to be a risk for London when temperatures are at least 32°C during the day and do not drop below 15°C at night for at least 5 consecutive days.

Source: Various sources from the literature review undertaken for **Task 1.** See **Appendices 1** and **2** for further information.



Temp.	
A	**36°C** External air temperature which results in rail track temperatures of **48°C-52°C**. Extreme precautions, such as temporary speed restrictions, taken by Network Rail at this air temperature to avoid buckling of non-pre-stressed rails and overheating of power sources. **22°C** Network Rail begin to implement staged preventative measures at this air temperature.
B	**43°C** Maximum internal air temperature advised for server rooms. **32°C** Maximum internal air temperature advised for computer rooms. **23°C** Maximum internal air temperature advised for IT equipment rooms.
C	**41.5°C** and **36.2°C** Air temperatures recorded on the tube and on platforms respectively during the 2003 heatwave in London.
D	**38.5°C** Highest daytime temperature recorded in the UK (at Gravesend, Kent).
E	**32°C** and **35°C** Internal air temperature thresholds to which Crossrail rolling stock and stations respectively are designed not to exceed.
F	**35°C** Heat stress risk for healthy adults begins at this internal air temperature combined with a relative humidity level of 50%.
G	**33°C** Softening of tarmac, asphalt and bitumen road surfaces generally begins to occur but is also dependant on direct solar exposure.
H	**32°C** The highest estimate for summer mean daily maximum temperatures by the 2080s.
I	**30°C** Vulnerability of commercial buildings to power outages increases when external air temperatures exceed this.
J	**30°C** Overhead power lines begin to experience a reduced rating factor above this air temperature.
K	**28.1°C** The highest estimate for summer mean daily maximum temperatures by the 2050s.
L	**27°C** Threshold temperature specified for overheating in well insulated housing.
M	**26.2°C** The central estimate for summer mean daily maximum temperatures by the 2080s.

Temp.	
N	**28°C** Current CIBSE temperature threshold for living areas. If 1% of annual occupied hours exceed this temperature, internal spaces in a building have technically overheated. **26°C** Current CIBSE temperature threshold for bedrooms
O	**26°C** Threshold for air temperatures of internal cool areas required to be provided by hospitals.
P	**25°C** Suggested 'hot' temperature threshold for bedrooms. **21°C** Suggested 'warm' temperature threshold for bedrooms.
Q	**24.8°C** The central estimate for summer mean daily maximum temperatures by the 2050s.
R	**24.7°C** over 2 days leads to greater incidences of morbidity, mortality and hospital admissions in London.
S	**24°C** London Underground implement overheating plans including public health communications and measures to prevent non-pre-stressed railtracks from buckling.
T	**20°C** Legionella bacteria begin to develop in potable water supplies (both stored and piped) if water temperature exceeds this.
U	**4°C** to **60°C** Bacterial growth on food encouraged between these temperature. Likelihood of food borne diseases increase by 4.5% for every 1oC increase in air temperature.

Figure 3. Selected temperature thresholds relevant to London's urban systems.

3.1.1 Definitions of thresholds

There are different kinds of thresholds in addition to temperature thresholds to consider when approaching the management of heat risk in London. These thresholds are summarised below and expanded upon in **Table 5** below.

- **Other climate thresholds** e.g. humidity, wind speed
- **Temporal** thresholds e.g. season/duration of hot weather, time since last event
- **Spatial** thresholds e.g. proximity to central London, green space ratio
- **Organisational** thresholds e.g. levels of awareness of heat risk, training
- **Individual** thresholds e.g. physiology, physical and mental health/ability, culture, access to services, and willingness to take action

Table 5. Key thresholds related to heat risk management across all of London's urban systems

Category of thresholds	Summary of threshold variable
Climate thresholds	• Air temperature (external and internal; min, average and max; daytime and night time, diurnal range, extremes, critical) • Wind speed / air movement (external and internal; min, average and max; daytime and night time, diurnal range) • Humidity (absolute and relative, external and internal; min, average and max; daytime and night time, diurnal range). • System / organisation specifications or requirements for internal temperatures (min, average and max).
Temporal thresholds	• Extent of warm spell / heat wave e.g. 2 days, 5 days or 2 weeks • Time of year warm spell / heat wave occurs e.g. during June, July and August ('expected' summer months), June and September (NHS Heatwave Plan period), or between April and October (earliest and latest recent hot spells). • Time since last hot and/or cold weather event. • Return period of a warm spell or heat wave e.g. how likely and how hot will it be? • Amount of advanced warning from Met Office of a warm spell / heat wave. • Design life and replacement schedule for infrastructure / buildings / system elements.
Spatial thresholds / location within urban systems	• Proximity of a building / asset to Urban Heat Island 'hot spots' / 'cool spots'. • Proximity of a building / asset to a green space or water body • Green space / blue space ratio of area • Building density • Population density • Occupancy density
Organisational	• Levels of awareness and previous experience of heat risk linked to the existence or absence of a heat risk management plan • Health and safety training • Risk management training • Business continuity training • 'Technical literacy' • Numbers of complaints from key customers/stakeholders received • Numbers of staff required for effective service/system delivery • Number of emergency phone lines/staff at the end of phone lines • Ability of websites/intranet sites to be updated and accessed • Length of staff service / extent of familiarity with service / system • Investment and upgrade cycles • Strategic business plans

	• Operational service plans • Political / legislative cycles (e.g. Parliamentary, GLA, LB) • Building Regulations review cycles
Individual / physiological thresholds	• Age • Health • Physical and mental ability • Socio-economic status • Level of education and awareness about health and heat risk • Level of English understood • Experience and memories of previous hot (and cold) weather events • Length of tenancy/occupation/use of/familiarity with service or system • Perception of own vulnerability and sense of connection with neighbours, friends, family and service providers.

3.1.2 Definitions of vulnerability to heat risk

There are different ways of defining vulnerability in relation to heat risk, and assessments of who is ‘vulnerable’ to a hot weather event are highly complex. Recent work commissioned by the Joseph Rowntree Foundation has generated two interesting and relevant reports (see Benzie et al., 2011 and Lindley et al., 2011).

Vulnerability is generally understood as a combination of someone’s exposure and sensitivity to hazards (e.g. heat waves) as well as their ability to adapt. There are likely to be strong links between some existing forms of social disadvantage and vulnerability to climate change. Heat vulnerability appears to have a very strong social dimension. Many of the factors relating to heat risk and vulnerability in cities overlap with those which already occur within disadvantaged communities.

While temperature can be mapped and modelled within urban environments, the extent to which people are vulnerable to heat stress is difficult to assess without detailed local knowledge. Research is underway to better assess vulnerability to climate change impacts (including extreme heat), but methods are complex and are not yet being used by local decision-makers (Benzie et al, 2011).

People’s vulnerability to extreme heat is considered to be an outcome of the following contextual factors and social processes:

- **Exposure to high temperatures** at home, at work or in local communities because of the design and fabric of their housing or urban environment, or type of employment;
- **Sensitivity to heat stress**, influenced by their respiratory, physical or mental health, age or relative acclimatisation to heat;
- **Capacity to adapt** to circumstances in order to anticipate, escape or treat heat stress – e.g. ability to pay for air-conditioning, physical access to local cool outdoor spaces, water bodies, type of housing tenure (e.g. council tenants, some private tenants and care home residents may not have options to adapt their accommodation), place of work (e.g. outdoor workers, manual labourers, people working in office buildings which easily overheat);
- **Self-perception of vulnerability to and awareness of heat stress** combined with willingness to act to avoid or prevent heat stress;
- **Social networks** and their ‘visibility’ or connection with the outside world (e.g. with social services);
- **Transience**, **lack of local knowledge or inflexibility**, which may reduce people’s chances of receiving support during heat waves

Five factors of socio-spatial vulnerability to climate risks, including heatwaves, have been identified by researchers. They are: sensitivity, enhanced exposure, ability to prepare, ability to respond and ability to recover which are summarised in **Table 6** and illustrated in **Figure 4** below.

Table 6. The five factors of socio-spatial vulnerability

1	**Sensitivity**	Personal biophysical characteristics such as age and health which affect the likelihood that a heatwave will have negative welfare impacts;
2	**Enhanced exposure**	Aspects of the physical environment, such as the availability of green space or housing characteristics, which tend to accentuate or mitigate the severity of a heatwave;
3	**Ability to prepare**	Personal and social factors that enable an individual or community to prepare for heatwaves or floods, such as insurance, income and knowledge;
4	**Ability to respond**	Personal, environmental and social factors that enable individuals and communities to immediately respond to a heatwave events, such as income, insurance, personal mobility, fear of crime, community networks, availability of public spaces, local knowledge and personal autonomy;
5	**Ability to recover**	Personal, environmental and social factors that enable individuals and communities to recover from heatwaves, such as income, insurance, housing mobility, social networks, knowledge, availability of hospital and GP services.

Source: Lindley et al., 2011.

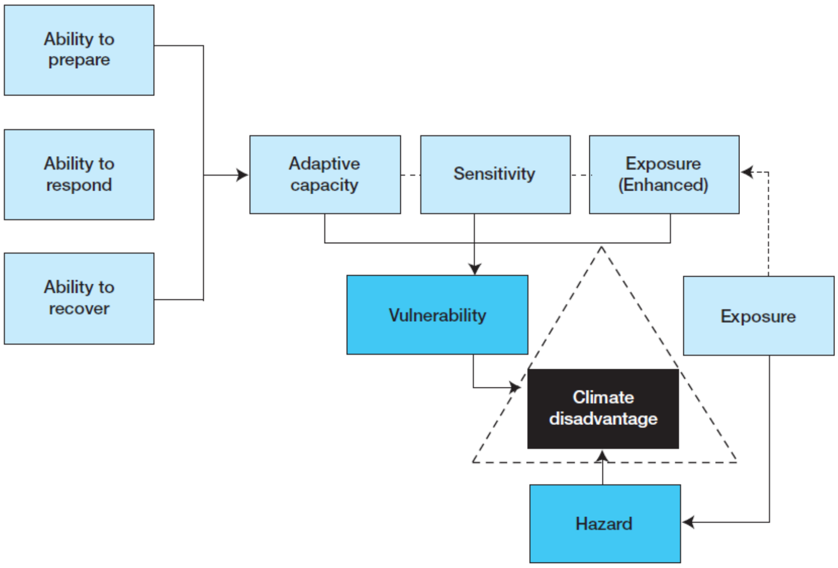


Figure 4. Conceptual framework for assessing socio-spatial vulnerability and climate disadvantage. **Source:** Lindley et al., 2011.

3.2 Task 2: Key risks, vulnerabilities and interdependencies related to heat risk management in London

Having identified some key heat risk related thresholds (not just temperature thresholds) and defined what we mean by vulnerability to heat risks, this section explores what the implications of reaching or exceeding these thresholds are for risks to and vulnerability of London's urban systems, and the people, organisations and assets within them.

3.2.1 Experience of hot weather in London

London has previous experience of hot weather. For example the summers of 1976, 1989, 1990, 1995, 2003 and 2006 and, most recently, the unusually warm April and October in 2011. The spells of hot weather during each of these years each have differing characteristics in terms of time of occurrence, duration and intensity as set out in **Table 7** below. Since 1976 there has also been a warming trend (see Figures 5 and 6 for how this trend can be seen in both annual maximum temperatures and April-September average temperatures), albeit accompanied by a considerable amount of month-to-month and year-to-year variability. Figure 5 shows a warming trend for annual maximum temperatures of approximately 0.5°C per decade historically and 1.5 to 2°C per decade since 1980. Figure 6 shows average temperatures for April to September with an increase of approximately 0.3-0.5°C per decade historically and 0.7°C per decade since 1980.

Table 7. Temperature and temporal characteristics of selected historic hot weather events in London.

					Mean temperatures during event*			Maximum temperatures during event**	
Year	**Start date**	**End date**	**Duration (days)**	**Temporal characteristics (duration)**	**Tmean**	**Tmin**	**Tmax**	**Tmin**	**Tmax**
1976	22/06	08/07	17	Warm spell of June – July characterised by a prolonged period of sustained warmth	24.8	17.9	31.6	20.9	34.0
1989	15/07	26/07	12	One major warm spell in July and then a number of more minor warm spells	22.5	16.6	28.7	20.2	33.6
1990	31/07	04/08	5	One particularly intense short lived warm spell in early August	25.4	17.6	32.4	19.9	35.6
1995	29/07	06/08	9	Characterised by a succession of relatively intense warm spells for a two month period from late June to late August, main one end of July-early August,	23.6	17.4	30.2	21.4	34.0
2003	02/08	13/08	12	A particularly intense and relatively prolonged warm spell in early-mid August, which is the most intense heat wave on record in London	22.0	15.7	25.2	19.0	32.7
2006	15/07	28/07	6	A long double-peaked warm spell in July and two additional warm spells earlier in the year.	23.1	17.5	29.6	20.3	35.0
2011	20/04	30/04	~10	An unusually warm April and September/ October.	Average maximum temperature during April 19.3°C Highest temperature in April 27.2°C				
2011	25/09	10/10	~15		Average maximum temperature during September 21.2°C Highest temperature in Sept 28.6°C Average maximum temperature during October 17.8°C Highest temperature recorded in October 29.2°C				

Source: CIBSE TM49, 2012. N.B. 2011 values obtained from http://www.london-weather.eu

N.B. The definition of a hot weather event used for this analysis was any continuous period when there is at least one hour of the day with a temperature above the adaptive thermal comfort temperature. Warm spells separated by less than 3 days have been counted as a single hot weather event. All temperatures were recorded at London Heathrow weather station to West of Central London, except for 2011 values which were recorded in South London.

* ‘Mean temperatures during the event’ refers to the mean averages of the daily minimum, mean and maximum temperatures over the duration of the warm spell, denoted by Tmin, Tmean and Tmax respectively.

** ‘Maximum temperatures during the event’ refers to the highest daily minimum and maximum temperatures over the duration of the warm spell, denoted by Tmin and Tmax respectively.

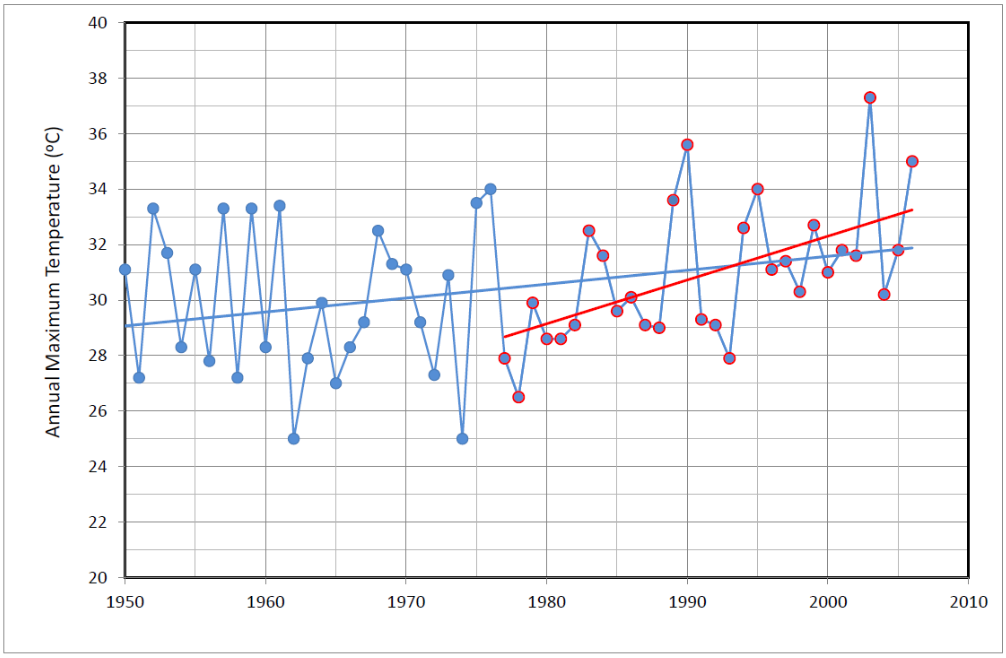


Figure 5 Annual maximum temperatures 1950-2010. **Source:** CIBSE TM49.

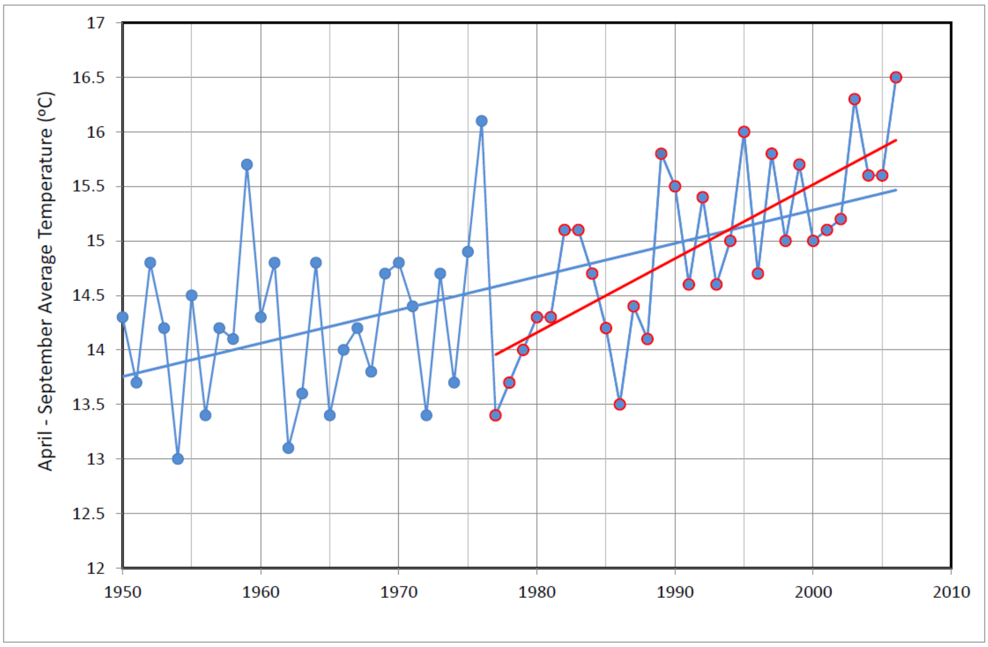


Figure 6 April-September average temperatures 1950-2010. **Source:** CIBSE TM49.

What this observed data highlights is that the use of temperature thresholds for decision making about heat risk in London is insufficient in isolation from consideration of other types of thresholds, such as the spatial and temporal nature, the time of year of occurrence and duration of the hot weather event. It also highlights that predicting heat waves and characterising them in a statistically robust way, in order to better prepare for them, is challenging. However the overarching trend, both observed and projected forward, is for warmer weather on average and for more frequent extreme hot weather events (see UKCP09; GLA, 2011; Hacker et al, 2012).

3.2.2 Overheating risks for London's urban systems

Based on some of the heat related thresholds identified in **Table 4**, key risks for four of the fifteen urban systems and examples of the heat risk related interdependencies between them are illustrated in **Figure 7** below. The area of greatest overlap between systems is where multiple systems failure, or cascade failures, can occur. This simple visual depiction could be used for any combination of urban systems.

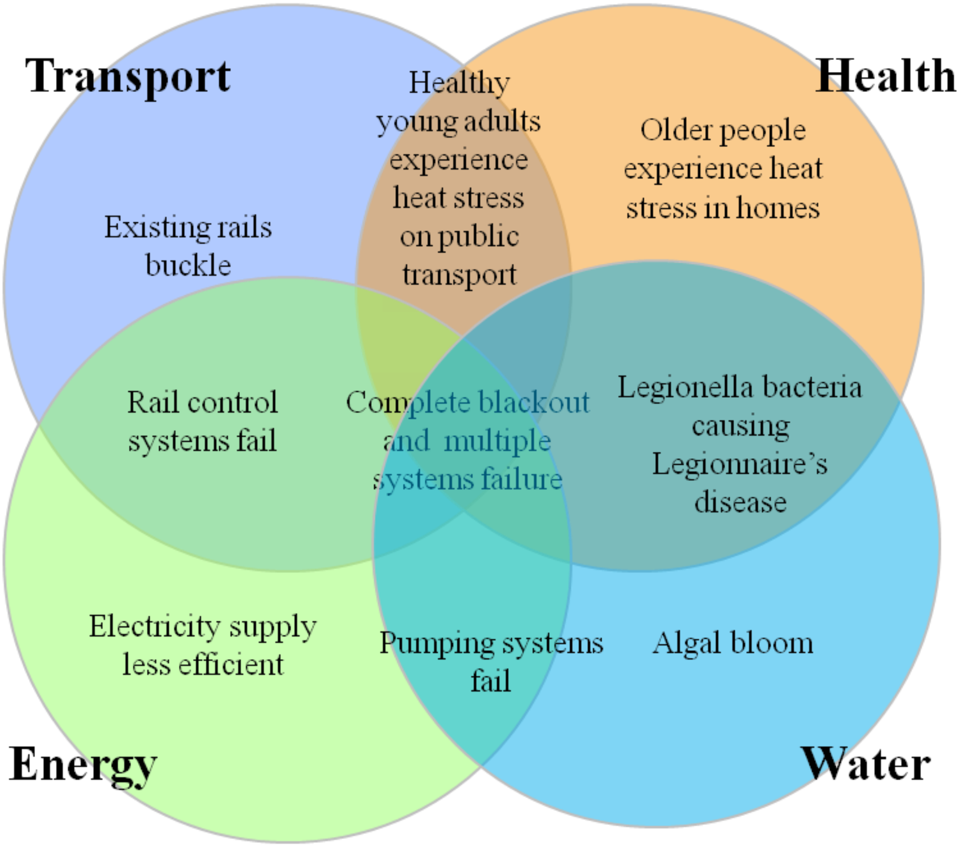


Figure 6 Venn diagram of heat risk related interdependencies between four selected urban systems, Health, Water, Energy and Transport.

3.2.3 Factors which exacerbate heat risk vulnerability: London's Urban Heat Island

London experiences an urban heat island (UHI) effect which means the city tends to stay warmer on average than the surrounding rural areas. The UHI is most noticeable at night, and the 'urban heat island intensity' is typically taken to be the difference in the night time minimum temperature between the city and a rural reference location. The UHI is primarily associated with the different rates at which solar heat is stored in and released from urban and rural land surfaces, due to their differing characteristics. It tends to be most intense under conditions of warm weather, light-winds and clear skies and is generally focussed on the centre of the city, sometimes extending to the west to Hammersmith and to the east over the City of London and Docklands. The UHI is not homogenous across the city and cooler spots are associated with major parks, such as Regent's Park and Richmond Park in **Figure 8**, open green spaces and water bodies such as rivers and canals. The waste heat emitted from buildings and transport also is also a contributing factor to the UHI, but is thought to be less important in London than the climatological drivers (GLA, 2006; Hacker, White and Belcher, 2012).

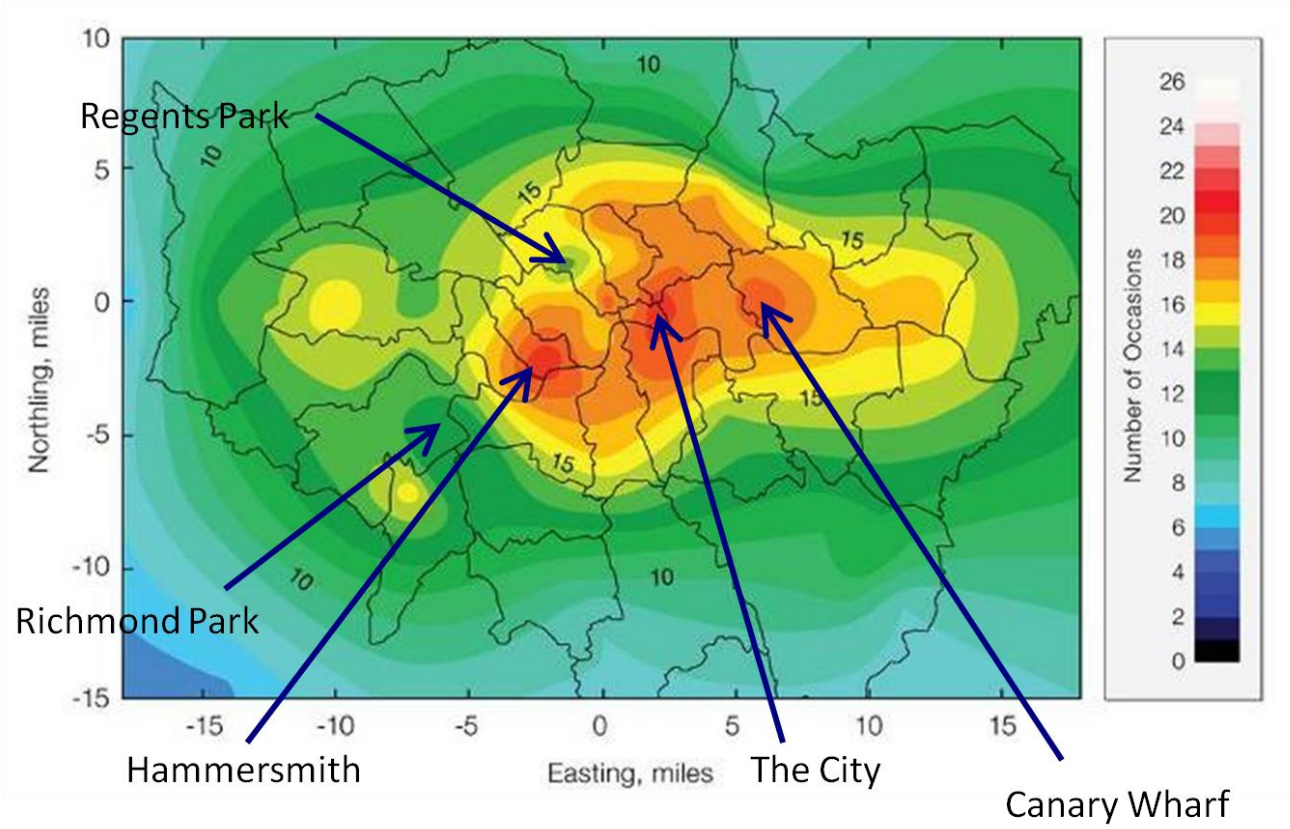


Figure 8 Local 'hot spots' and 'cool spots' within London's Urban Heat Island as illustrated by the number of occasions that daily average temperatures across London exceeded 19°C for 48 hours during summer 2010. **Source:** GLA, 2006.

3.2.4 Factors which exacerbate heat risk vulnerability: climate change projections for hot weather in London

The Mayor of London's climate change adaptation strategy (GLA, 2011) highlights overheating of buildings, infrastructure, urban environments and people as one of three key climate change risks facing London and points towards the importance of finding low-energy and passive measures to manage these risks. This report does not explore in any detail what the implications of future climate change are for the likelihood of warmer summers, but other studies have done so (see Hacker et al., 2012). However it is interesting and relevant for this project to note the indicative return periods for the types of hot weather events London has previously experienced for the 2020s (the time period from now until 2040), the 2050s and the 2080s. See **Table 8** below.

The UKCP09 Medium emission scenario and the 50% probability levels were selected for this analysis as they represent the 'central estimate' for future climate change projections. If the High emissions scenario and 90% probability level were used for this analysis, the return period values would be even lower. However, whichever emission scenario or probability level is used, there will always be a degree of uncertainty involved, therefore any responses to these projected return periods need to be aware of and address those uncertainties.

Table 8. Projected future return periods for historical hot weather events in London under the Medium emissions scenario and for the 50% probability level.

Hot weather event	Historical return period (~1970-2000)	Current/2020s return period (~2010-2040)	2050s return period (~2030-2060)	2080s return period (~2050-2080)
1976	**1 in 27** chance of occurring each year during this period	**1 in 11** chance	**1 in 5** chance	**1 in 2** chance
1989	**1 in 9** chance of occurring each year during this period	**1 in 3** chance	**1 in 2** chance	**1 in 1** chance
1990	**1 in 16** chance of occurring each year during this period	**1 in 6** chance	**1 in 3** chance	**1 in 1** chance
1995	**1 in 18** chance of occurring each year during this period	**1 in 7** chance	**1 in 3** chance	**1 in 2** chance
2003	**1 in 19** chance of occurring each year during this period	**1 in 7** chance	**1 in 3** chance	**1 in 2** chance
2006	**1 in 20** chance of occurring each year during this period	**1 in 8** chance	**1 in 4** chance	**1 in 2** chance

Source: Hacker et al., CIBSE TM49, 2012.

3.2.5 Summary of exacerbating factors

Future climate change projections for high temperatures in London, as well as early work on estimating return periods for hot weather events, suggest that planning for and managing hot weather and heat risk requires consideration of the variability and likelihood of extreme events, not averages. For example, overheating in buildings is not typically associated with average conditions experienced during an average summer but with shorter periods of extreme weather or heat waves which are exacerbated by the UHI effect. However, some surveys have indicated a relationship between 'acceptable internal temperatures' in buildings (offices) and the 'weighted average external temperature' over the preceding month, known as the running mean temperature (see CIBSE, 2006 and CIBSE 2012 forthcoming).

There is limited information about the variability and likelihood of extreme hot weather events within the existing sources of data and guidance, for example the UKCP09 climate projections and CIBSE Future Weather Years. However, work is ongoing to better understand and integrate the variability and likelihood of extreme hot weather into these sources of data and guidance (see Hacker et al, 2012).

Heat risk is also exacerbated by the different levels of capacity to adapt and acclimatise to more frequent hot weather events amongst people, industry, businesses and organisations within London's urban systems, about which there is limited information available in the literature reviewed for this report. Acclimatisation includes the physiological and behavioural change that takes place in humans in adjusting to historic and future climates, over longer periods of time.

It is important to note that climate conditions and characteristics of hot weather events themselves are not necessarily indicative of heat risk thresholds for different receptors (i.e. people, buildings, infrastructure and other assets). Better understanding is required about the sensitivity or vulnerability of different receptors in order to better define these thresholds. Other research projects (for example LUCID) consider that the epidemiological community have traditionally related external climate conditions to morbidity and mortality rates, but should consider instead the temperatures in the buildings occupied by those affected to morbidity and mortality. It's an incorrect assumption that the same relationship exists between the internal and external climate and air temperatures for all building types in all locations within a city.

3.3 Task 3: Worked case study example for a methodology to map and respond to heat related thresholds in London

The two key reasons for selecting the social housing and care home sectors, which are distinct yet inter-related, for the worked case study example are listed below. Other researchers (such as Oven et al., 2012, Porritt et al., 2010, and Brown and Walker, 2008) have also looked at these two sectors.

1. Amongst the people considered to be most vulnerable to heat risk in London according to the available literature are the elderly, those with physical or mental disabilities, those within lower socio-economic groups, and those living in the more densely populated and typically less green inner London Boroughs. Many of these people live in social housing or care homes. For example most of the mortalities associated with the 2003 heat wave in London were amongst older and more vulnerable people (Porritt et al, 2010) many of whom live in care homes, and the highest day and night time temperatures were recorded in Central London (GLA, 2006) where there is a significant amount of social housing. However, many of the 12 interviewees for this project did not view their organisation or residents as particularly vulnerable to hot weather (see **Section 3.3.2**) and a recent London wide survey (London Councils Omnibus, 2011) highlights that people older than 60 were generally more concerned about hot weather than younger people, but that there was no notable difference in levels of concern about hot weather across the social class, tenure or ethnic origin categories of respondents, and only a minor difference in concern between people living in inner and outer London Boroughs.

2. London Boroughs and Registered Social Landlords operating within London are directly or indirectly responsible for a considerable number of people (both staff and residents), buildings (both offices and homes), assets and land which may either be at risk during hot weather, or may play a role in reducing heat risk at the building, block, street, estate and local community scales. It is widely considered that heat risk needs to be tackled at a range of spatial scales and within an urban systems based approach, but that typically heat risk tends to be experienced by individuals at the local community to building scale, which is also the scale of the decision making sphere of London Boroughs, RSLs and the people they are responsible for.

N.B. It should be noted and reiterated that the focus of this worked example is on the people, buildings, assets and land for which London Boroughs (LBs) and Registered Social Landlords (RSLs) are responsible for. Neither the responsibilities of the private care home sector, the private or owner occupied housing sector (specifically), nor the healthcare sector (more widely) are explored in any great depth. However, reference is made to these sectors where relevant and it is acknowledged that the boundaries between LBs, RSLs, the NHS and the private health and social care sectors are permeable due to private-public partnership arrangements between many organisations working in these sectors, and the fact that they could all be considered to come under the public health umbrella.

3.3.1 Methodology for interviews

A total of 12 experts and practitioners working within, or with knowledge about, London's social housing and care home sectors, were interviewed for the worked example for this project. They are listed anonymously in **Table 9** below. The three main aims of the interviews, which also semi-structured the interview questions, were to:

1. identify both the **strategic and day to day management challenges and decision making processes** within each organisation relating to the resources, people, properties and services they are responsible for (specifically), and those relevant to the social housing and care home sector in London (more widely);

2. establish the **general level of awareness about heat related risks in London and the approaches to heat risk management** within each organisation (specifically), and the social housing and care home sector in London (more widely).

3. establish what kind of **additional information about managing heat risk** in each organisation would be most **useable and useful**, and establish what **features of flexible pathway, threshold based approaches to decision making approaches would be most valued in the context of managing heat related risks** in each organisation (specifically), and the social housing and care home sector in London (more widely)

Table 9. Interviewees representing expertise within London's social housing and care home sectors

Interviewee reference	Role/position/area of expertise	Organisation represented
1	• Senior Healthcare Consultant – specialist in care environments for older people	Large multi-disciplinary design and engineering consultancy (MDC)
2 **3** **4** **5**	• Team Manager Residential Services • Sustainability Manager • Property Manager • Programme Procurement Manager, Housing and Adult Social Care	Large London Borough (LB)
6	• Director and Leader, Global Healthcare Business – specialises in procurement of health facilities, PFI process, therapeutic environments and sustainability	Large multi-disciplinary design and engineering consultancy (MDC)
7	• Chairman – Trained as a structural engineer	Large Registered Social Landlord (RSL)
8	Associate Director – Code for Sustainable Homes expert – Former CABE Design Review panel member	Large multi-disciplinary design and engineering consultancy (MDC)
9 **10**	• Director of Technical Resources • Head of Property Services	Small Registered Social Landlord (RSL)
11	• Head of Extreme Events and Health Protection	Public Health Agency
12	• Head of Sustainable Development	Large Registered Social Landlord (RSL)

3.3.2 Key findings from the interviews

Key findings, highlights and quotes from each of the interviews are summarised below under the three themes which structured the conversations.

1. Strategic and day to day management challenges and decision making processes (non-heat risk related) within organisations in the social housing and care home sector in London

- Many of the interviewees described innovative and effective examples of addressing and integrating policies (set at the national, city and local level) and guidance (developed by industry and regulators) into their strategies and operations.

- The starting point for changes in strategic investment priorities and day to day operations tended to be high level discussions as a result of financial, reputational, legal requirements. However, suggestions and complaints from staff and residents were also key drivers.

- There is a great diversity of responsibility within the social housing and care home sectors. For examples, some London Boroughs, but not all, are responsible for care homes. Some Registered Social Landlords, but not all, are responsible for sheltered accommodation for elderly people, or for people with physical or mental disabilities.

2. Level of awareness about and experience of heat related risks in London and the approaches to heat risk management within organisation

Awareness and experience

- There was some awareness and experience of heat risk amongst interviewees, but generally it not considered as high a priority as cold weather and fuel poverty.

- There were no serious problems reported or recalled by interviewees amongst staff or residents as a result of 2003 and 2006 heat waves. The recent hot weather in April, September and October 2011 did not appear to have caused any problems either. This seems surprising given the temperatures and durations of the 2003 and 2006 heatwaves in particular. It may be that the interviewees were unaware of problems which were perhaps dealt with by other teams or colleagues. This would be worth exploring further with other LBs and RSLs.

- Some of the interviewees had either not experienced extreme hot weather in their organisation, or if they had the impacts of hot weather were considered as being positive, short-lived, unpredictable, and not as serious as cold weather impacts.

- There was recognition from the large LB and both the small and large RSLs of the differences in the heat related issues and risks for existing buildings and new development. However, experiences of overheating as a result of hot weather in both older and newer buildings were limited. This was surprising.

- Where overheating was experienced by the large RSL, as reported by residents, it was due to the waste heat from hot water pipes and the boiler in a new building causing communal areas to overheat throughout the year, not necessarily due to high external air temperatures.

Perceptions and attitudes

- A common thread amongst interviewees was the credibility around future climate change scenarios and the requirements, or lack of, to use them. It was noted that contractors for new buildings are prepared to adhere to compulsory targets and mandatory standards but see no need to go beyond existing regulatory minimum standards.

- Staff in the LB were experienced and trained in day to day management of buildings and residents during hot weather. Measures such as drawing curtains, ensuring sufficient fluids for residents, providing electric fans and air-conditioning units, and the use of basic thermometers to monitor room temperatures were all mentioned.

- There was some ambiguity about whether the issue of overheating in homes was caused by poor design and control on heating systems (i.e. waste heat emitted during the winter heating period) or the relationship between internal air temperatures and external air temperatures. In some examples mentioned there was an overlap between the two causes.

Drivers and priorities

- The Sustainability Managers at the LB and the large RSL had heard of the UKCP09 projections but some of their colleagues and other interviewees (the care home managers at the LB and the small RSL) had not. However, there was uncertainty about how to integrate the UKCP09 projections into their decision making processes, and if they were robust enough to change strategic plans or day to day management plans.

- Building regulations and CIBSE guidance were seen as key drivers and sources of information for the procurement of new buildings by the LB and both the large and small RSLs.

- Window design and the amount of ‘openable areas’ (i.e. windows and other facade openings combined) in new buildings were considered key in keeping rooms and circulation areas comfortable and ventilated. Window restrictors for safety were seen as potential barriers to natural ventilation.

- The LB mentioned a duty of care to its staff and its clients (i.e. residents and tenants). Hot weather working procedures for staff, triggered by an internal air temperature being exceeded were also mentioned. Any manager with concerns about whether this threshold was being exceeded was able to contact the Health and Safety Advisor within the Human Resources team.

- National Indicator 188 (NI 188) was considered a good hook for engaging teams with the issue and importance of climate change across the LB in the past, but since it has been removed, it was there has been a decrease in interest and priority given to thinking seriously about future climate change. Project specific opportunities, such a new developments, were considered more fruitful territory for raising awareness of and responding to heat risk and future climate change projections.

- It was noted that new build leases are typically 30 years, therefore the contractor has responsibility for the building for 30 years and should in theory they should be interested in environmental conditions affecting the buildings in the 2040s. In the large LB, key performance indicators, incentives and financial penalties are built into contracts and leases to ensure buildings are maintained to a certain standard before being handed back to the LB. It was interesting to note that aspects of the NHS Heatwave Plan for England was being formalised into contracts.

- Attention to detail for those who are considered most vulnerable and frail, and being familiar with care home residents' individualised care plans was considered vital by the large LB.

- Short or near term weather forecasts for hot weather or heat waves were considered useful and effective in terms of operational responses to manage heat risk by the LB. Department for Health guidelines were (re-)circulated to staff whenever a hot weather event was forecast. Existing risk registers were reviewed to check if there was anyone particularly susceptible to negative impacts of hot weather.

Table 10. Key hot weather related impacts as perceived or experienced by representatives of London's social housing and care home sectors.

Receptor of impact	Impacts perceived or experienced by interviewees
People – both staff and residents	Discomfort Heat stress Health risk
Buildings / assets / land	Softening of asphalt on roofs and balconies Softening of tarmac in car parks Overheating of internal spaces – bedrooms, living areas and communal areas with implications for fabric of building, efficiency of operation of electrical or mechanical equipment (e.g. fridges and freezers, and ICT) and for the comfort and health of residents and workers Safe temperatures for storing water in tanks and transporting water through pipes
Critical infrastructure / interdependencies	Energy – essential for keeping internal spaces cool (if mechanically or electrically aided) and for keeping fridges and freezers working to keep vital medicines cool Water – if a local water main bursts many LBs and RSL residents may be without drinking water, or in extreme cases any water, for a short period (hours-days) Vulnerability of electrical and telecommunications to overheating - many LBs and RSLs rely on intranet systems and mobile phones for day to day management and communication between staff and residents Transport – staff need to get to work safely and on time

Source: Interviews with experts and practitioners working within, or with knowledge about, London's social housing and care home sectors.

The information in **Table 10,** gathered from the interviews, is used to inform the 'context first approach to climate change adaptation decision making' table described in **Section 3.3.3** and included as **Appendix 2.**

3. User needs for information and threshold based approaches to decision making in order to manage heat related risks

During the interviews, five illustrated examples of decision making approaches based on dealing with risk, uncertainty and thresholds were shown to interviewees as a way of introducing the concept to them and getting their feedback. The five examples are listed below and are included in **Appendix 3**.

1. Risk, uncertainty and decision making framework
2. Thames Estuary 2100 developed options
3. Thought piece on responses to heat risk in London
4. Indicator value versus time graph
5. Decision tree analysis

It was generally considered by interviewees that most of these visual depictions of approaches to threshold based or risk based decision making were too complicated for practical use by themselves or colleagues working within LBs or RSLs. The usefulness of these types of decision making approaches for professionals who might be more familiar with them, such as urban planners, environmental consultants and building services or civil engineers, was acknowledged. However, many of the interviewees felt that a simple risk register or risk matrix approach as set out in **Table 11** below would be more useful when prompted. All interviewees made requests for more robust evidence of heat risk in London along with clear and consistent guidance on options for addressing heat risk.

Table 11. Risk register / matrix approach to dealing with heat risk in the social housing and care home sectors

Criteria	Variables or thresholds to assess
1. Location within London	Urban Heat Island intensity (e.g. near a UHI 'hot spot' or 'cool spot' such as a major road junction or large park.
2. Typology of development / dwelling or building environment	Age of construction, materials, orientation, layout, height, storeys, deep plan, dual aspect, balcony, garden.
3. Characteristics / existing risk profile of occupant / adaptive capacity issues	Age, health, sex, socio-economic status, culture, languages spoken, awareness and perception of heat risk.

The information in **Table 11** is used to inform the 'context first approach to climate change adaptation decision making' table described in **Section 3.3.3** and included as **Appendix 2.**

Using this as a starting point for **Section 3.4** it seems that any decision making approach to dealing with heat risk in any given urban system within London, based around risk, uncertainty and thresholds, needs to be as simple and practical as possible. It also needs to be consistent with existing risk management and decision making frameworks, and the capacity of those using the approach.

A selection of existing research, plans and guidance considered important and useful for dealing with heat risk in London and the social housing and care home sectors was discussed with interviewees to ascertain whether they had heard of them or used them as reference documents in their working capacity. These are listed in **Table 12** below. Many of the interviewees were unfamiliar with this existing information which is considered by the LCCP as important and useful for dealing with heat risk in London, their sectors and their organisations. Other sources of guidance mentioned by interviewees when prompted are listed in **Table 13.**

Table 12. Selection of existing research, plans and guidance considered important and useful for dealing with heat risk in London's social housing and care home sectors with hyperlinks

- DH Heatwave Plan for England, 2011
- GLA Climate Change Adaptation Strategy 'Managing risks and increasing resilience', 2011
- UK Climate Projections 2009 (UKCP09)
- CIBSE Technical Manuals e.g. Guide A, TM36, TM37 and TM48
- EST Reducing overheating a designers guide
- HSE Heat stress in the workplace
- SAP: Appendix P **'**Assessment of internal temperature in summer**'**

Source: Suggested by Arup researchers.

Table 13. Selection of existing research, plans and guidance considered important and useful for dealing with heat risk in London's social housing and care home sectors with hyperlinks

- Care Quality Commission standards
- Social Care Institute of Excellence good practice guidance
- Institute of Healthcare Engineers and Estate Managers HTM55 Windows
- Various British Standards (BS) and International Standards (ISO)
- Health and Safety Executive (HSE) requirements e.g. HSE ACoPL8
- Department for Education School Buildings Design Guidance
- GLA Housing Design Guide
- BSRIA guidance
- Housing Health and Safety Rating System: guidance for landlords and property related professionals, CLG (2006)

Source: Mentioned by interviewees.

3.3.3 Issues and risks of most concern to the social housing and care home sectors

Through the desk based literature review undertaken in **Tasks 1 and 2**, and the interviews carried out for **Task 2 and 3**, it appears that the main heat related issues and risks for organisations in the social housing and care home sectors in London relate to the urban systems of housing, health services, habitat and biodiversity, information and communication technologies, safety security and emergency responses, energy, water and transport. These urban systems are highlighted below in **Figure 9.** It should be noted that the lack of impacts in other systems is due to lack of perceived importance amongst interviewees, rather than lack of impact.

Figure 9 The main urban systems which heat related issues and risks for the social housing and care home sectors cut across.

We have also identified some of the specific heat related vulnerabilities, risks and thresholds for the social housing and care home sectors in London, and the existing or possible decision making and adaptation responses to them. This provides the context for a high level worked example of how a theoretical methodology for mapping heat related thresholds could be applied in practice. However, it is clear that there are no generic types of building, open space, asset, infrastructure nor resident. Therefore an approach which sets out a framework of questions to inform decision making, and defines a set of key characteristics for buildings, open space, assets, infrastructure or resident seems sensible. This should be generalised up from the social and care home sectors to other key sectors and systems.

We have chosen to use the 'context-first approach' to structure the problems faced by the social housing and care sectors (see **Figure 10** for what we mean by a context based approach) to appraise the possible adaptation solutions and to evaluate effective implementation of these solutions. Please see **Appendix 2** for a worked example of this approach for these two sectors. Some of the information used to populate the table in **Appendix 2** is specific to the sectors, others are generic to other sectors and systems. The idea is that this approach could be used for any sector or urban system within London. It is important to note that people's perception and experience of heat risk is not always the same as the actual risk, therefore there are limitations to Stage 1b of the 'context-first approach' with regard to evidence based, heat risk management and adaptation decision making.

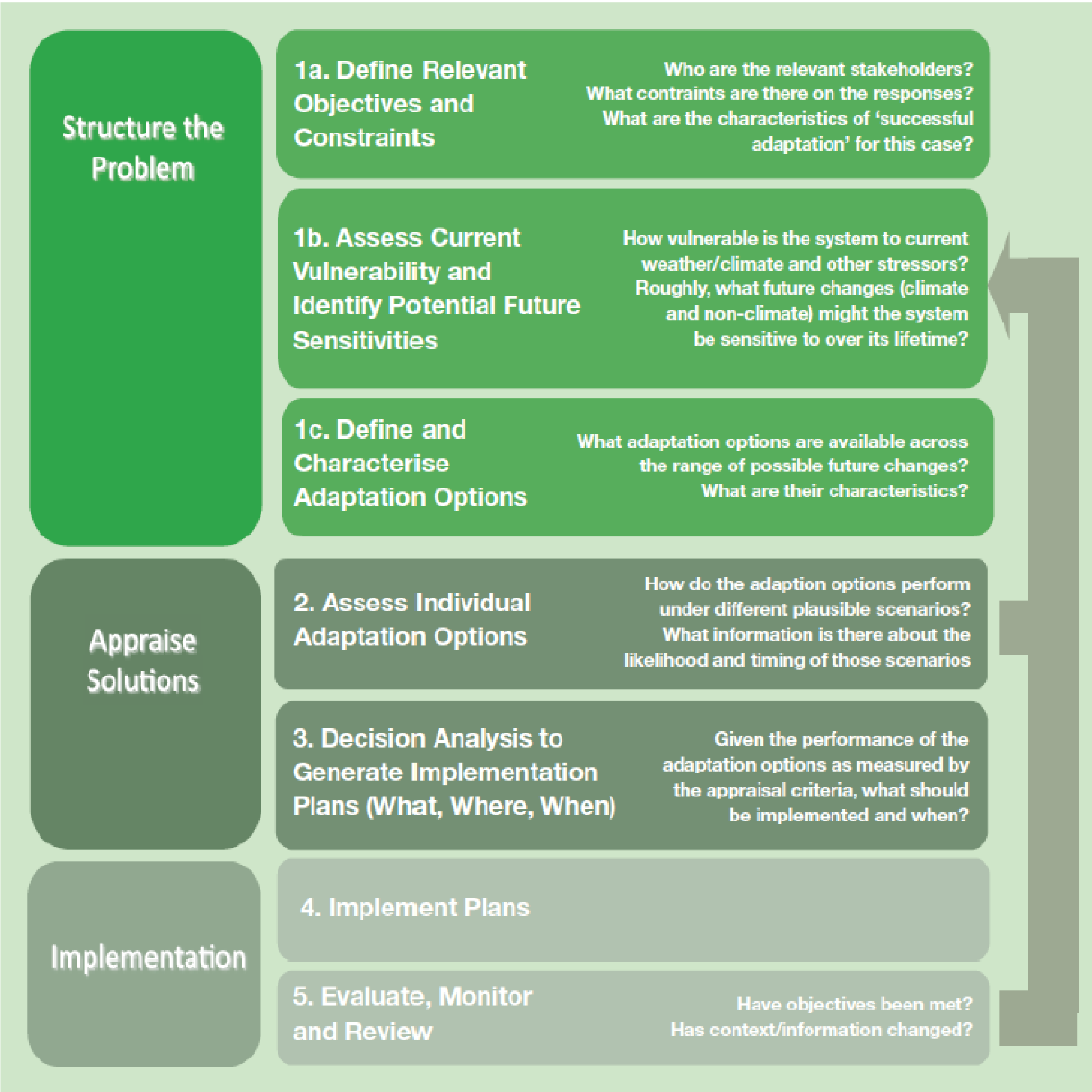


Figure 10 'Context-first' approach to climate change adaptation decision making. **Source:** Reeder and Ranger (2010).

3.4 Task 4: Next steps for producing a flexible pathways, threshold based methodology for heat risk management in London

Based on the outputs and outcomes of **Tasks 1-3** and content of previous sections, suggested steps for producing a full flexible pathway threshold analysis methodology for heat risk management across all of London's urban systems are identified below.

As discussed briefly in the previous section, a number of generic risk based, pathways based and threshold based decision making approaches already exist for the assessment and management of a range of climate risks. These approaches each have strengths and weaknesses in the context of managing heat risk within and across London's urban systems.

There is potential to build upon aspects of these approaches and avoid reinventing the wheel. There is also a need to better understand the risk management and decision making approaches across and within all of London's urban systems, not just the social housing and care home sectors in order to add value to existing approaches to non-climate risk related management and decision making.

Whilst tidal flood risk management is extremely challenging and complex, the Thames Estuary 2100 project and associated threshold based decision making approach is refreshingly simple. However, developing a similar threshold based approach to managing heat risk in London as the Thames Estuary 2100 project is in some ways not as straightforward as it is for tidal flood risk management.

As a starting point, or first step in supporting the LCCP and the EA to develop such an approach for heat risk management, we have used two sources of currently available scientific temperature data for London. Namely the UKCP09 projections and CIBSE TM49 have been used and overlaid with projected extreme temperature scenarios generated using UKCIP09 . These have highlighted current temperature thresholds for London. See **Figure 11** below.

This diagram could be informed by further studies which establish more robust and scientifically grounded projections for extreme hot weather events in comparison to UKCP09 projections for increases in average maximum temperatures for London.

To this diagram could be added illustrations of current 'coping capacity' for dealing with heat risk and points at which strategic intervention or investment might be required for various urban systems. This diagram alone is unlikely to be particularly useful for more operational responses to hot weather events in London, but if developed and simplified could be a helpful visual tool for decision makers at all levels to get a sense of the likelihood and magnitude of increased hot weather related risks.

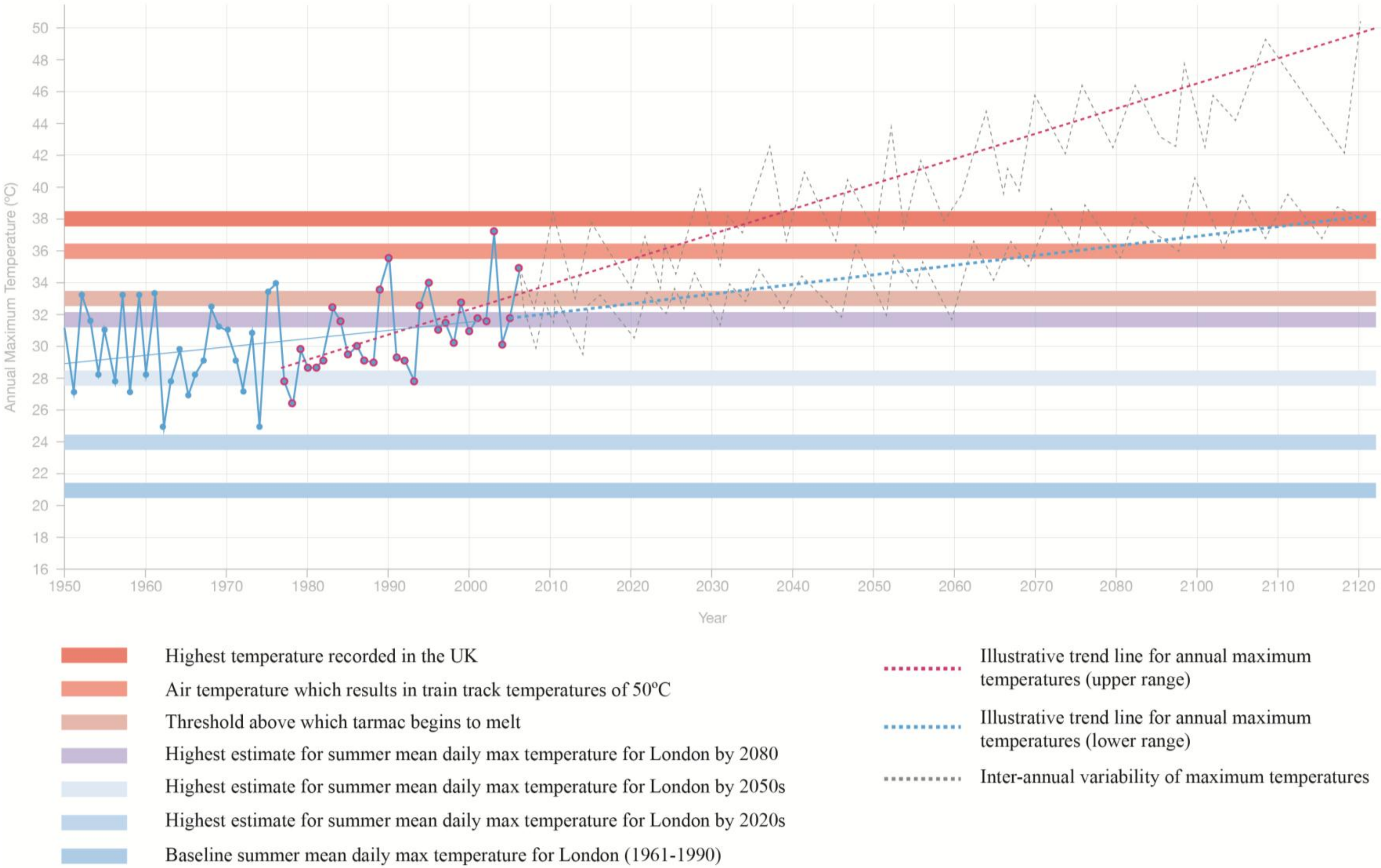


Figure 11 Future external air temperature projections and heat thresholds for London. **N.B.** This For illustrative purposes only. **Source:** Adapted from TM49 and UKCP09.

3.4.1 Note on approach used to create Figure 11

In order to create **Figure 11**, observed climate data obtained and analysed for the forthcoming CIBSE TM49 document has been combined with UKCP09 projections for the highest estimate of summer mean daily maximum temperature in London for the 2020s, 2050s and 2080s, along with three high temperature thresholds identified in the literature for this project.

By extrapolating the trend lines evident from the observed Annual Maximum Temperatures, represented by the dots along the solid blue lines to the left of the graph, an idea of when and how often certain temperature thresholds might be exceeded in the future is conveyed.

Whilst the underlying climate data behind the illustrative temperature thresholds and dotted trend lines indicated on **Figure 11** are considered to be robust and scientific, this diagram is only meant to provide a suggested way forward for how to analyse and visualise recorded and projected temperature data in a way that makes possible the identification of when and how often certain temperature thresholds might be exceeded in the future.

It is not intended to be a precise scientific diagram or decision making tool in its current form, and it is suggested that any further work on heat risk and heat thresholds in London includes a more detailed and scientific analysis and visualisation exercise for similar data.

Based on the specific worked example developed for this project **Table 14** sets out a suggested generic framework for assessing and managing heat risk in London.

Table 14. Generalising the approach: a framework for assessing and managing heat risk in London

Step	Method if applicable
Identify the key **current temperature thresholds** of each urban system (and sectors within each system).	• We recommend undertaking a basic literature review however the one completed for this report shows available information about temperature thresholds to at best be partial and inconsistent, and at worst inadequate. • Interviews and conversations with relevant stakeholders within each urban system
Record these temperature thresholds in table form and visually.	• Create thermometer diagram for each system
Identify the key **current risks and vulnerabilities** of each urban system (and sectors within each system) posed by hot weather and high temperatures.	• Complete context first approach table
Identify and map the key **interdependencies** between each urban system (and the sectors within each system) therefore identifying crucial systemic weak points	• Create a Venn diagram of urban systems of interest.
Identify **the potential future risks and vulnerabilities** of each urban system (and sectors within each system) posed by hot weather and high temperatures	• Complete context first approach table • Refer to future projections graph/tables for increased average temperatures and extreme hot weather events
Check if key interdependencies between each urban system (and the sectors within each system) and crucial systemic weak points have changed. If required **map changed interdependencies** visually.	• Create a Venn diagram of urban systems of interest.
Identify for each urban system (and sectors within each system) the possible strategic and operational responses to addressing those heat risk related vulnerabilities and dependencies.	• Interviews and conversations with relevant stakeholders within each urban system • Undertake a basic literature review
Identify for each urban system the stakeholders and responsible organisations for each response.	• Interviews and conversations with relevant stakeholders within each urban system • Undertake a basic literature review
Divide SMART recommendations for addressing vulnerabilities, dependencies and interdependencies for each system and sectors within systems into Strategic and Operational recommendations.	• Desk based exercise based on outcomes and outputs from previous steps above

3.5 Task 5: Recommendations for heat risk management policy and practice in London

This section is divided into three sub-sections:

1. **Strategic and operational recommendations for heat risk management specific to social housing and care home sectors (i.e. London Boroughs and Registered Social Landlords).**

2. **Top 5 recommendations for LCCP and EA to consider within their heat risk management and decision making remit across all of London's urban systems**

3. **Recommendations for action beyond London's direct remit for heat risk management and decision making which LCCP and EA should try to influence**

The basis for the selection of these recommendations are:

- They address priority issues raised during the interviews
- They address priority issues identified in the literature
- They have the potential to build upon and add value to existing work underway

It is clear that in order to address and manage heat risk, there is a need to look at both strategic and operational responses as two sides of the same coin. **Strategic responses** involve longer term, larger investments with slower immediate results. **Operational responses** involve reactive shorter term efforts but may have long term implications. For example the purchase of an air conditioning unit during a heatwave, or the development of policies for action following a heatwave which can be utilised during the next heatwave with relatively low additional investment. However, if operational responses are undertaken in a strategy vacuum, they may have limited effectiveness over the long term which may cause unexpected additional short term operational cost and disruption.

3.5.1 Decisions makers in London's social housing and care home sectors.

These recommendations are not exhaustive but indicative of where efforts would be well spent in order to begin to build the adaptive capacity of the social housing and care home community.

1. Clarification and revision of policy

- Greater London Authority (GLA) to revise and/or clarify policies on hot weather planning, overheating and heat risk for Registered Social Landlords (RSLs) in London (and nationally).
- Care Quality Commission (CQC) to revise and/or clarify policy on hot weather planning, overheating and heat risk for care home providers (whether LBs, RSLs or private sector) in London (and nationally).

2. Better linkages and training

- London Boroughs (LBs) and RSLs to continue to build upon linkages between Health, Social Care and Buildings teams and explore the new public health role for LBs as an opportunity to better join up services to address heat risk.
- LBs, RSLs and care home providers to continue to ensure levels of training and awareness about hot weather planning, overheating and heat risk are adequate amongst staff and residents.

3. Risk registers, asset mapping, and mapping of hot and cool spots

- LBs, RSLs and care home providers to incorporate heat risk on strategic risk registers where not incorporated already.
- LBs, RSLs and care home providers to develop heat risk vulnerability registers which defines a set of key characteristics for vulnerable residents, buildings assets or infrastructure.
- LCCP to work with partners, such as the AWESOME project team at Bartlett School of Graduate Studies, University College London (UCL), to identify 'multiple factor hot spots' (i.e. building within urban heat island zone, prone to overheating and with vulnerable inhabitants).
- LCCP to encourage asset mapping and characterisation of all LB and RSL property, buildings, land and green space using GIS and searchable databases including data about:
  - building age, condition, height, construction, fabric, orientation, typology etc and;
  - external space quality, condition, soil type, presence of trees, climbing plants, grass, paving, water features, shading.
- All LBs and RSLs to be made aware of the City of London 'cool spots/cool buildings' mapping work and develop and integrate into their heat risk plans.

4. Information hubs and dissemination

- LCCP working with the G15 groups of housing associations and the Good Homes Alliance/SHIFT (Sustainable Homes Alliance) to:
  - create a repository of information about assessing and managing heat risk in London's social housing and RSL sectors, with examples of good practice and;
  - disseminate and communicate existing research, plans and guidance relating to assessing and managing heat risk more widely and effectively to the relevant professional bodies, Chief Executives, Directors of Services and Heads of Team in the social housing and care home sectors.

5. Joining up with other initiative

- Integrate adaptation measures into criteria for Green Deal, Green Investment Bank, Decent Homes funding residential building retrofit projects.
- Use new housing development and regeneration projects (both RSL and private developer led) as case studies or live research project for value of green infrastructure in contributing to keeping inner city housing and surrounding areas cool and comfortable (e.g. mature trees in the Elephant and Castle regeneration area or role of Jubilee Park in keeping East Village cool and comfortable (i.e. Olympic Park site).

3.5.2 Decision makers within and across all of London's urban systems

Recommendations for heat risk management policy and practice across all urban systems for decision makers within and across all of London's urban systems, including the LCCP and the EA to consider are set out below.

1. Incorporate heat risk on London Community Risk Register in a way consistent with Met Office, NHS and Health Protection Agency thresholds.

A heat wave is considered to pose a risk to London by the London Community Risk Register if maximum temperatures are above 32°C and minimum temperatures are above 15°C for at least 5 consecutive days. These are different *temperature* and *temporal* thresholds than the definition of a heat wave as defined by the Met Office and Department of Health (2011) (maximum temperature of 32°C and minimum temperature of 18°C over two consecutive days). In addition heat risk is given a Medium Risk Rating within both the main risk register and the summary matrix (see **Figures 12** and **13** below) based on a Medium Likelihood rating (4) to occur within the next 5 years and Minor Impact rating (2) should the event occur.

H4 8	Heat Wave.	**Outcome Description** Daily maximum temperatures in excess of 32°C and minimum temperatures in excess of 15°C over most of a region for at least 5 consecutive days. Up to 1000 fatalities and 5000 casualties mainly amongst the elderly. There could be disruption to power supply and transport infrastructure. The heatwave event definition is based on and August 2003 type event, but more severe. There will be subsequent impact on electricity generation and cooling systems. Currently in the London area the summer peak demand is higher than winter due to building air conditioning systems.	Medium High (4)	Minor (2)	Medium	Health

Figure 12 Extract from the London Community Risk Register, GLA/London Resilience Forum, 2011.

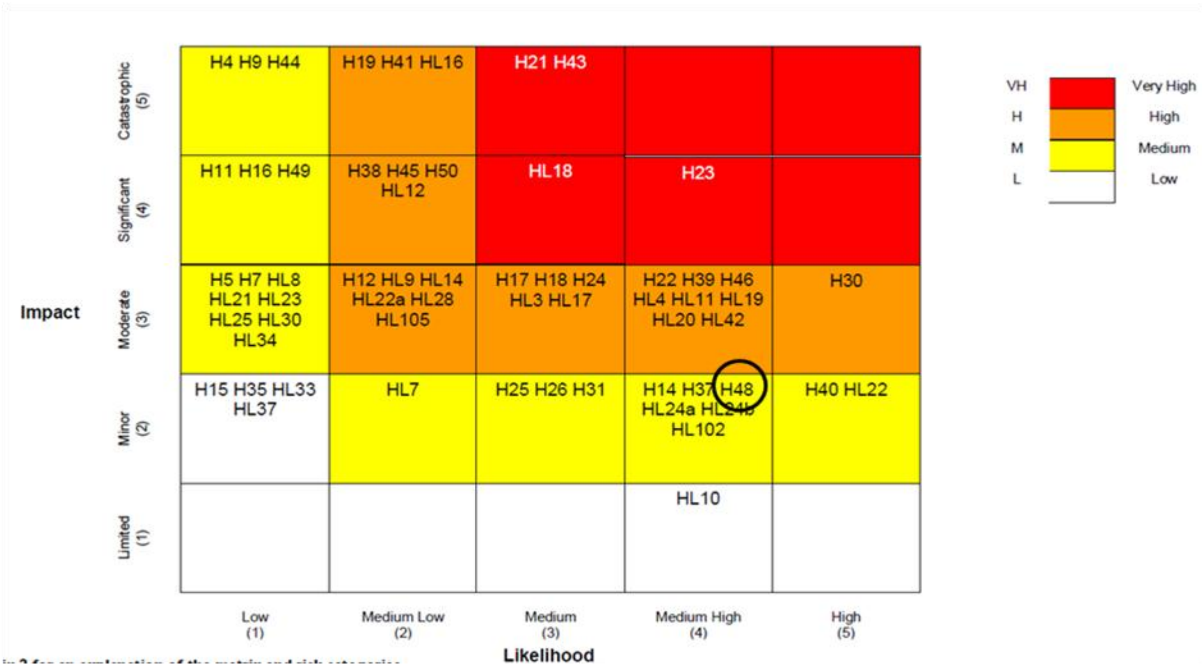


Figure 13 Extract from the London Community Risk Register, GLA/London Resilience Forum, 2011.

However, the High-Level Summary table in the same LCRR document categorises heat wave as a High Risk (see **Figure 14**). It is not clear whether this is an editing or graphic design error, or whether this is intended to reflect the fact that half of the six Local Resilience Fora in London (now subsumed into just one London Local Resilience Forum) assign Risk H48 Heat Wave a Medium Risk Rating (for West, South-West and South-East London) and the other half give it a High Risk Rating (for Central London, North-Central and North-East London). In addition, whilst North-Central rates H48 as High Risk in total it gives it a Minor Impact rating (2) which does not multiply up to a High Risk rating.

London Community Risk Register: High-Level Summary

Risk ID	Short Name	Pg
H21	Severe inland flooding	19
HL18	Fluvial or surface run-off	22
H23	Influenza Pandemic	26
H43	Telecommunication failure	34
HL16	Local coastal / tidal flooding	21
HL19	Local fluvial flooding.	23
HL28	Localised fire or explosion at a fuel distribution site	10
H45	Technical failure of regional electricity network	34
HL3	Industrial accident involving small toxic release	12
H12	Biological substance release	12
H46	Biological substance release during an unrelated work	13
HL4	Pollution of controlled waters	14
HL9	Aviation accident	15
HL11	Railway Accident	16
HL12	Accident involving transport of hazardous chemicals	16
HL14	Road accident involving transport of fuel/explosives	16
H17	Storms & Gales.	16
H18	Low temps and heavy snow.	17
H19	Major coastal and tidal flooding	17
HL17	Local coastal / tidal flooding (in one Region)	21
HL20	Flash flooding	24
H50	Drought	24
HL22a	Large Building Collapse	25
HL105	Complex Built Environments	26
H22	Influenza Epidemic	26
H24	Emerging infectious diseases	27
HL42	Industrial action by workers	30

Risk ID	Short Name	Pg
	providing a service critical to the preservation of life	
H30	Loss of emergency fire and rescue cover because of industrial action.	31
H38	Technical failure of a critical upstream oil/gas facility	32
H39	Failure of water infrastructure or contamination	32
H41	National electricity failure (Blackstart)	34
H48	Heat Wave.	17
H40	No notice loss of telecommunications	33
H31	Constraint on fuel supply at filling stations	31
H37	Influx of British Nationals not normally resident in the UK.	32
HL24a	Legionnaires Disease.	28
HL24b	Meningococcal Disease.	28
HL102	Oak Processionary Moth (OPM)	28
H26	Zoonotic animal diseases	30
HL23	Bridge Collapse.	25
H44	Reservoir dam failure/collapse	26
HL21	Land movement	25
HL22	Building Collapse.	25
H11	Accidental release of radioactive material	12
H14	Food Chain Contamination	13
H16	Aviation accident	15
H7	Explosion at a high pressure natural gas pipeline	11
HL30	Localised explosion at a natural gas main.	11

Risk ID	Short Name	Pg
H8	Very large toxic chemical release	
H9	Large toxic chemical release	11
H49	Loss of drinking water supplies due to failure of infrastructure	33
HL25	Fire or explosion at a flammable gas terminal	10
HL7	Industrial explosions and major fires	10
H4	Fire or explosion at a fuel distribution site or a site storing flammable and/or toxic liquids	10
HL34	Fire, flooding, stranding or collision involving a passenger vessel in or close to UK waters	15
HL8	Fire, flooding, stranding or collision involving a passenger vessel in or close to UK waters or on inland waterways	15
H25	Non-zoonotic animal diseases	29
H5	Fire at an onshore fuel pipeline	11
H15	Maritime pollution	14
HL33	Forest or moorland fire	14
H35	Industrial action by key rail or London Underground workers.	31
HL10	Local accident on motorways and major trunk roads	15
HL37	Release of hazardous chemicals as a result of shipping accident	15

Figure 14 Extract from the London Community Risk Register, GLA/London Resilience Forum, 2011.

Given this uncertainty, it is suggested that the London Community Risk Register (and the Local Resilience Foras' individual Risk Registers too if they still exist) is reviewed to ensure accuracy and consistency between them, or explain why the risk of 5 days of weather between 15°C and 32°C (or 2 days of weather between 18°Cand 32°), which would cause significant impacts for London as a whole, varies across the boroughs. The LCRR is reviewed every three years, and looks five years ahead at a time. It is recommended that a longer view is taken with regard to Risk H48 and indeed all other Severe Weather Risks at the next review of the LCCR in 2014 (i.e. at least to the 2020s, and ideally to the 2050s).

2. Clarify and coordinate responsibility for planning and preparing for hot weather related risks in London.

A recent London wide survey of 1,000 people to determine levels of concern and experience of weather related risks (London Councils Omnibus, 2011) showed that 43% of respondents said they were concerned about drought and heat waves (although 40% said they were not concerned and 17% were indifferent). 52% of respondents said they were concerned about hot still weather leading to higher levels of air pollution (although 33% said they were not concerned and 15% were indifferent).

Across every category (gender, age, social class, tenure, ethnic origin, inner or outer London Boroughs), over 90% of people felt that the public sector was responsible for planning and preparing for weather related risks in London and more specifically:

- 85% felt that London Boroughs were responsible.
- 83% felt that Central government bodies such as the Environment Agency or Defra were responsible.
- 79% felt that The Mayor of London and associated bodies like TfL were responsible.
- 63% felt that individual householders or families were responsible.
- 50% felt that private companies like insurance companies were responsible.
- 49% felt that community groups / organisations were responsible.

It is perhaps unsurprising that the majority of people look to the public sector to take responsibility for planning and preparing for weather related risks in London. It is perhaps more surprising that nearly two thirds of people felt that they themselves should take responsibility. However, they would only be able to plan for and respond to hot weather risks with good information and guidance which is likely to be provided in a clear and coordinated way by the Mayor, LBs, the EA, the NHS London and the HPA amongst others.

3. Clarify terminology around heat risk in London

There is a need to differentiate between building overheating as a result of badly designed systems with poor controls and building overheating as a result of warm or hot weather. Perhaps we need to find a new definition of overheating risk for London such as 'Excessive Summer Heat' or 'Extreme Hot Weather'. Even if Excessive Heat or Hot Weather is experienced in April or October (i.e. outside the typical summer period), people can still relate it to their experiences of hot summer conditions.

4. Research, develop and implement low cost public awareness campaigns and guidance on how individuals can prepare for and respond to hot weather.

Of the 1,000 people surveyed 60% were willing to sign up to a mobile phone text alert system to warm them if an extreme weather event was likely (including a heat wave), and 45% said they were willing to visit a vulnerable neighbour during a heat wave. Of the 60% who were willing to sign up to a mobile phone text alert system for an extreme weather event, fewer people over 65 were willing to do this than people under 64. However all social classes were equally willing to do so and there was no notable difference between men and women, people of different ethnic origins, or those living in inner or outer London Boroughs. Of the 45% who were willing to visit a vulnerable neighbour during a heat wave, approximately 80% of people across all categories would do so.

5. Hot and cold weather plans combined into one extreme weather plan, and linked to strategic and operational risk registers

The HPA, NHS London, TfL plans for hot and cold weather should be combined into one overarching extreme weather plan for London. Then all hot weather related risks identified for London as a whole should be explored in greater detail and incorporated into the risk registers of individual and interdependent systems, sectors and organisations, and reviewed regularly. Link to the Climate Change Risk Assessment reports and risk registers already submitted by the relevant Reporting Authorities (e.g. TfL, Crossrail, National Grid etc).

3.5.3 National level decision makers responsible for policy, legislation and guidance relevant to heat risk management in the UK

1. Government to commission a review and establish temperature thresholds for communal areas of social housing and care homes in addition to those for residential areas and bedrooms.

2. Government to review the acceptable comfort ranges and threshold temperatures for all building types in addition to those for hospitals and school buildings. Guidance for each building type to be developed in partnership with relevant professional institutions (e.g. HCA and CQC for social housing and care homes) and government departments (e.g. CLG and DH for social housing and care homes).

3. Government to continue to give heat risk in UK cities and urban systems high priority in the 'Climate Ready' National Adaptation Programme, particularly the Built Environment and Infrastructure themes.

4. Key professional institutions and employers to develop targeted interdisciplinary training and CPD for relevant design and construction industry professionals around planning, designing and management to avoid overheating risk in cities and keeping people, buildings and infrastructure cool and comfortable in low carbon ways.

5. Further collaborative research work to be commissioned by the Research Councils, Technology Strategy Board, Climate UK and Environment Agency regarding projections and return periods for extreme hot weather events in UK cities. This would be in addition to climate change projections for increases in average maximum temperatures. Clear and simple graphs and tables of information to be produced as a result, aimed at decision makers across all urban systems.

4 Conclusions

From the work undertaken for this project the following conclusions can be drawn.

- There is a sizeable and growing body of international, national and regional evidence, knowledge and guidance about current and future hot weather events and heat risks in cities which is relevant to London's decision makers. However, this existing information needs to be communicated more effectively and meaningfully, and new system and sector and specific guidance, with a focus on the interdependencies between them, needs to be developed further in order to make the case for action.

- There is also some experience of the risks and opportunities posed by hot weather risk in London. However, responses to these risks and opportunities are largely operational and reactive to short term warnings and guidance issued by the Met Office and the NHS. Whilst this appears to have been effective enough to date, there is a need for a more high level and strategic approach to assessing and managing heat risk over the short, medium and long term, in a way which embeds heat risk into strategic and operational decision making.

- The focus on the social housing and care home sector has been useful and enlightening in terms of gauging perceptions and experiences of historical and likely near future hot weather in London. It has also highlighted some opportunities for embedding heat risk management into existing decision making and risk management approaches. However, the scope and timescale of this project has meant the research is neither exhaustive nor completely representative of the two sectors. It would be valuable to explore these perceptions, experience and opportunities in more depth.

- The development of a flexible pathways, threshold based approach to assessing and managing heat risk in London has potential. However, a high degree of familiarity with the underlying evidence, terminology and principles of this approach is required by users in order to apply it in practice within an organisation, sector or system. Not everyone will find it helpful and there is no one size fits all. In order to avoid it being too generic and theoretical an approach, it needs to be further informed by the decision makers working within and across all of London's urban systems and sectors.

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6 Weblinks

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