Safety, Sustainability and Human Resources Panel

Date: 21 March 2017

Item: Climate Change and Planning for Unpredictable Weather Events

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This paper will be considered in public

1   Summary

1.1   In his vision for London, A City for All Londoners, the Mayor highlighted the imperative of improving London's resilience to impacts of severe weather and climate change. These impacts are already being felt in London and there have been a number of severe weather episodes in recent years that impacted on the transport network, which are very likely to have been exacerbated by climate change.

1.2   TfL works to improve short term resilience as well as respond to, and recover from, impacts of severe weather events. However, there is an opportunity to learn from others, notably Network Rail and the Environment Agency, to take a more strategic evidence based approach to long term management of risk, taking into account the wider objectives of the Mayor's Transport Strategy and financial pressures.

1.3   This paper summarises the following:

(a)   Climate change forecasts and the potential impacts on transport.

(b)   The current approach taken to managing the risks of severe weather and climate change and opportunities for improvements.

(c)   The arguments for better long term planning and investing in adaptation measures now in order to save money and protect the transport system in the future.

(d)   The approach taken by other organisations.

(e)   TfL's proposed approach to improving long term adaptation planning and risk management, based on an 'Adaptive Pathway Framework'.

1.4   Resilience to extreme weather and climate, particularly in the long term, has been identified as a TfL strategic risk (risk reference SR17) with a risk rating of 20 (1 being lowest and 25 being highest). Alex Williams (Acting Managing Director, Planning) is the risk owner. The risk assessment notes:

> *"The controls [that have been put in place] will continue, but are insufficient to ensure London's resilience. Without new action, TfL will have to spend large sums of money recovering from future events and there will be significant service reliability safety and reputational impacts. Additional resources are required in order to develop a comprehensive resilience plan."*

2   Recommendation

2.1   **The Panel is asked to note the paper.**

3   Extreme weather

3.1   Climate change is already happening:

(a) The 10 warmest years in the UK Annual Average Temperature Series have occurred since 1990 and eight since 2002.

(b) The period since 2000 accounts for two-thirds of hot-day records, and close to half of wet-day records, in monthly, seasonal and annual observations since 1910.

3.2   The most recent set of climate change forecasts (UKCP09) provide predictions of temperature (min, mean, max), precipitation (min, mean, max), heavy rainfall and severe weather (snow, ice, wind, storms, fog and heatwaves) for the 2020s, 2040s and 2080s.

3.3   The medium emission scenario has been used to quantify risk and it has identified that the risks in the 2050s are likely to be:

(a) Higher summer temperatures: 2.7°C to 6.5°C above the baseline.

(b) Warmer winters: 2.2°C to 3.5°C above the baseline.

(c) Wetter Winters: 15 per cent to 33 per cent wetter than the baseline average.

(d) Sea level rise: Sea levels are projected to rise by up to 96cms by the end of the century.

3.4   Although the UK will experience milder climate change than some other parts of the world, there is likely to be increased frequency and consequences in the short to medium term for flooding and high temperatures.

3.5   It is not possible to link specific events directly to climate change, however recent events, such as the closure of large sections of London's rail network in June 2016 due to flooding, highlight the potential disruption which can be caused. As well as a general warming of London's climate, severe weather events such as heatwaves, droughts and heavy rainfall are predicted to become more intense and frequent. The temperatures reached in the hot summer of 2003 (which research indicated resulted in 20,000 deaths Europewide, including 2,000 deaths in the UK[1]) are likely to feel average by the 2040s and cool by the 2080s.

3.6   Flooding and extreme heat are particularly critical issues to an urban area, such as London, because the high percentage of impermeable area leads to high rainfall runoff and the thermal mass of buildings causes an urban heat island effect, making cities hotter than surrounding countryside. Potential impacts on transport include flooding of key assets such as roads, railways and stations, overheating of buses and London Underground platforms and trains and damage to infrastructure, such as signals, due to extreme heat.

3.7   Without adequate mitigation, climate change presents a risk to London maintaining and increasing a high mode share for public transport, walking and cycling, will reduce comfort, safety and reliability of London's transport and will

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[1] http://www.metoffice.gov.uk/learning/learn-about-the-weather/weather-phenomena/case-studies/heatwave

ultimately have negative effects on London's economy and the health of Londoners.

4   Current approach and opportunities for improvement

4.1   The 2008 Climate Change Act set out a requirement for key infrastructure owners to report on what actions they were taking to ensure resilience of their assets. TfL has published two reports (in 2011 and 2015[2]) which include risk assessments for key asset types. It is no longer mandatory to report to government on adaptation, but the GLA and TfL do this on a voluntary basis.

4.2   TfL's has a legal duty to manage risks to 'as low as reasonably practicable'. Our operations and assets are diverse and there are many systems that have been put in place by operational, asset and continuity managers to manage the risks of, recover and learn from, severe weather events. Colleagues from across TfL work together, and with other organisations, such as the Met Police and the Environment Agency, to ensure there is a coordinated response to severe weather events, as they do with other non-weather related unplanned events, such as traffic collisions or protests.

4.3   TfL is a member of the London Resilience Forum and has systems in place for improving resilience in the short term and responding to the impacts of severe weather events (for example most services were operational again within 24 hours of the 23 June 2016 heavy rainfall and flooding).

4.4   Infrastructure providers, including TfL, are required to consider climate change forecasts and include appropriate resilience measures when planning and designing new infrastructure. However, there have been a number of instances where adaptation measures have been designed into a major infrastructure project, but then been 'value engineered' out at a later stage due to budget pressures. For example, green roofs on operational buildings.

4.5   The biggest challenges associated with this work area include the complexity and uncertainty of climate change generally and the lack of specific research about how climate change might impact on London and its transport system, which assets are most vulnerable, the thresholds at which they fail and the required mitigation.

4.6   There is also an opportunity to create an improved and unified understanding of risks and weather resilience programmes across TfL. This includes better reporting (for example "signal failure due to extreme heat", rather than just "signal failure") and quantification (including financial costs) of the impacts of events when they occur. This will enable more robust evidence-based investment decisions.

4.7   Effective mitigation might simply involve maintenance and inspection. For example, the flooding at Surrey Quays Station during heavy rain and a high tide on 23 June 2016 was due to a Thames Water valve (to prevent water flowing back up from their main sewer) not being in place. This was discovered following an investigation after the flood.
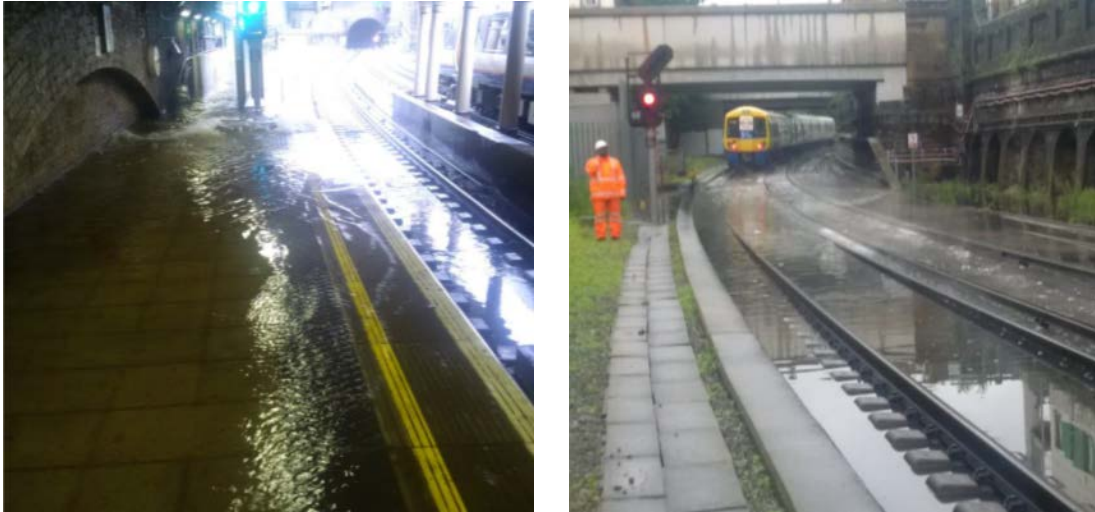
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[2] http://content.tfl.gov.uk/tfl-adaptation-report-may-2015.pdf

Figure 1: Flooding at Surrey Quays Station on 23 June 2016

4.8   There are some examples of the kind of research that is required to better understand risks, such as the London Underground Flood Risk Review, but more is needed. A summary of the key measures currently in place is included in Appendix 1.

5   Why plan for climate change?

5.1   The 2006 Stern Review estimated that the costs of uncontrolled climate change to the global economy could be 5-20 per cent of GDP, but acting now would cost 1-2 per cent of GDP.

5.2   As well as early action to mitigate climate change, incorporating resilience into the design of new infrastructure, maintenance and upgrade programmes, could be more cost effective than retrofitting once impacts have reached unacceptable levels. It might also reduce disruption to passengers and inequality (because climate change will disproportionately affect the most vulnerable in society). In order to better understand where this is the case, we need to plan now.

5.3   Climate change adaptation measures can also be designed to achieve multiple benefits. For example, the use of green infrastructure, to reduce water run-off and heat, can also improve air quality, biodiversity, encourage walking and cycling and improve mental health.

6   The approach taken by other organisations

Environment Agency tidal flood risk in the Thames estuary

6.1   The Environment Agency developed the Thames Estuary 2100 Plan (TE2100) in order to manage long term tidal flood risk. TE2100 sets out the actions required in the short, medium and long term. The plan has been developed using the 'adaptive pathways framework' and identified different measures for different levels of sea level rise (see Figure 2 below). The report concluded that the Thames Barrier could continue to protect London and the Thames estuary throughout this century but that it may be more cost-effective to build a new barrier further downstream by 2070.

6.2   The benefit of the adaptive pathways approach is that it manages the uncertainty of climate change by linking infrastructure requirements to thresholds (e.g. sea

level rise). Investment in mitigation measures can then more readily be adjusted in response to new information, including climate change forecasts.
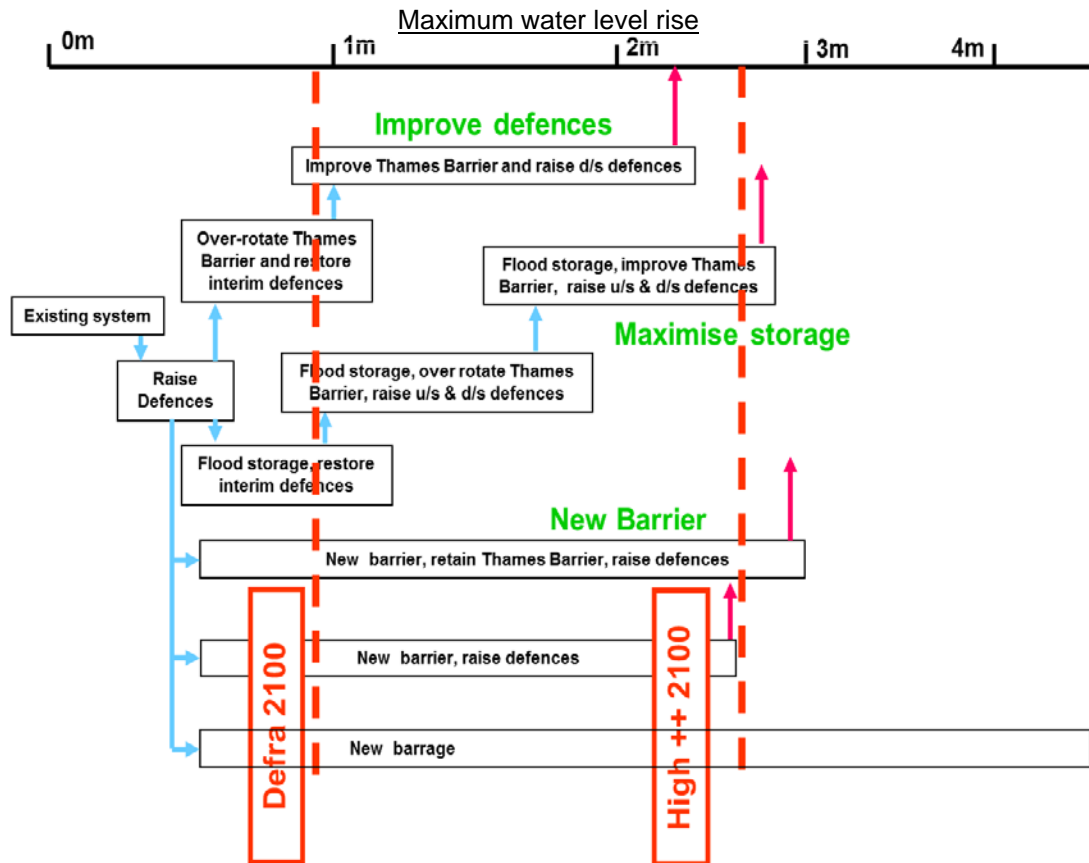

Figure 2: Thames Estuary 2100 Plan 'adaptive pathways'

Network Rail's Climate Change Adaptation strategy

6.3   Following a series of high profile incidents where extreme weather caused significant disruption to rail services, notably the collapse of the sea wall at Dawlish in 2014, Network Rail have developed a Climate Change Adaptation strategy.

6.4   The strategy includes analysis of the thresholds at which failure rates of its assets increase[3]. For example, Figure 3 illustrates how, as temperatures exceed 25°C and dip below 3°C, the frequency of points-operating-equipment incidents doubles (orange line) and triples (red line). Inspired by Network Rail's work, London Underground is in the process of undertaking similar analysis.

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3 https://safety.networkrail.co.uk/home-2/environment-and-sustainable-development/wrcca/
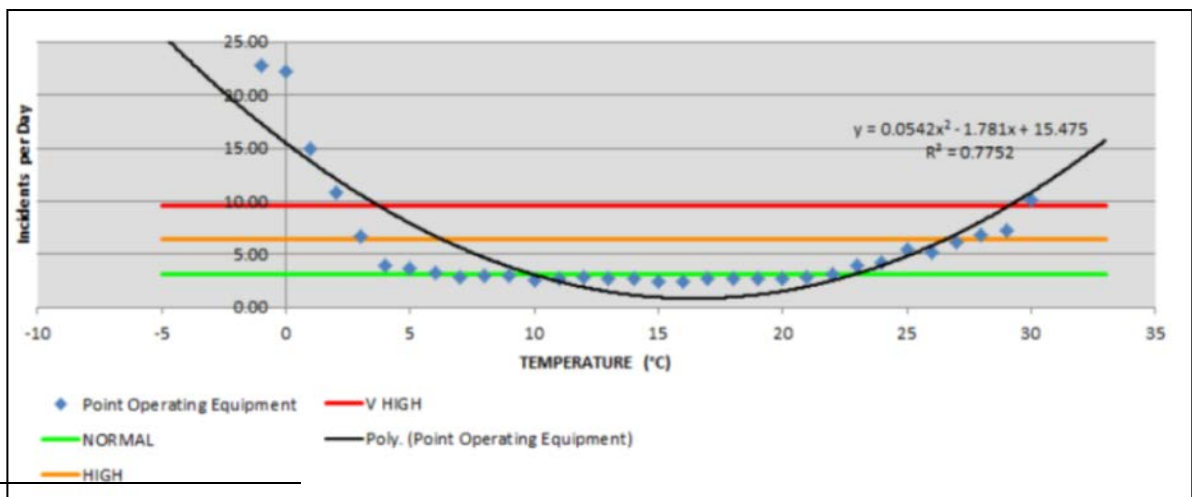
Figure 3: The relationship between temperature and point operating equipment failure (Source: Network Rail)

6.5 The strategy sets out Network Rail's aspiration to reduce the gap between its Public Performance Measure[4] (PPM) on adverse weather days as compared with normal weather days by one per cent by the end of Control Period 6. Figure 4 shows current levels of impact.
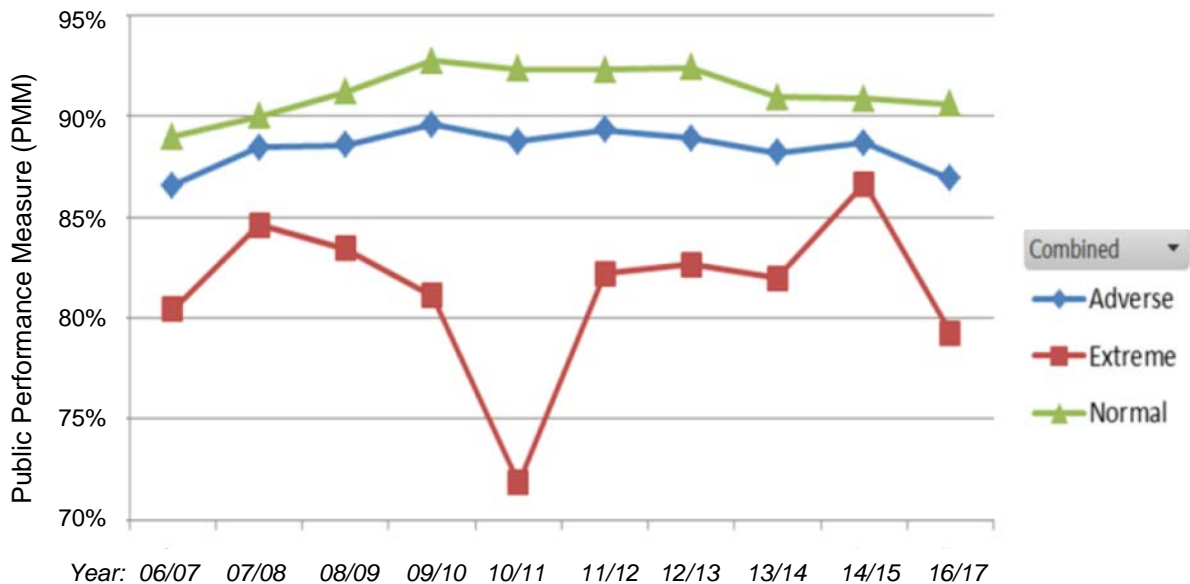

Figure 4: levels of punctuality and reliability (public performance measure) of National rail services during adverse, extreme and normal weather events (Source: Network Rail)

7 Proposed improvements for London's transport risk management

7.1 In line with the Mayor's call for London to become more resilient to climate change, TfL is improving its current approach. We commissioned two independent studies last year, looking at the direct and indirect impacts of climate change. In November 2016, TfL held a workshop with stakeholders and TfL/GLA colleagues to review the outcome of these studies and draw on the experience of others. Informed by this, and ongoing engagement with stakeholders including GLA, London Climate Change Partnership, Network Rail, HS2 and the Environment Agency, TfL has developed the following plan to improve our approach (see Figure 5).

> 1. Improve measurement of current impacts of today's severe weather events.
>
> 2. Work with stakeholders and other infrastructure providers to undertake a dedicated programme of research to understand the thresholds at which assets fail.
>
> 3. Work with stakeholders to develop adaptive pathways (described below), including interdependencies with different sectors (eg energy).
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> 4. Develop a metric(s) to measure improvement in the resilience of the

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[4] PPM is a combined figure for punctuality and reliability on the National Rail network

transport network in London.

5. Improve business case development processes in order to better capture resilience benefits to inform business planning decisions.

6. Maintain existing transport assets based on risk in order to maximise their resilience.

7. Include adaptation measures in asset construction and renewal, informed by the costs and benefits.

8. Ensure major projects are designed for future weather conditions over their entire design life.

9. Develop a pro-active programme for implementing measures, based on prioritisation of risk.

Figure 5: TfL's plan for improving weather and climate change resilience.

Adaptive Pathways Framework

7.2   Inspired by the approach taken by the Environment Agency in the Thames Estuary 2100 Plan, TfL will organise management of long term severe weather and climate change resilience around an 'Adaptive Pathways Framework' (APF).

7.3   The APF approach, illustrated by Figure 6 below, establishes thresholds at which different infrastructure would fail for increasing levels of weather impacts. Once thresholds for infrastructure failure have been identified, appropriate mitigation is identified, some to reinforce previous mitigation, others would be 'either / or' (i.e. could not be implemented together).

7.4   When identifying mitigation, an understanding of the implementation lead in times would be required. In some cases, it may also be possible to identify opportunities to switch to a stronger mitigation measures (if necessary) during implementation, whilst minimising additional cost.

7.5   The latest climate change forecasts are used to provide likely timings of when mitigation would be needed, informing investment decisions. As evidence and understanding improves and climate change forecasts are updated, the long-term mitigation plan is updated, either in terms of the mitigation required or timescales.
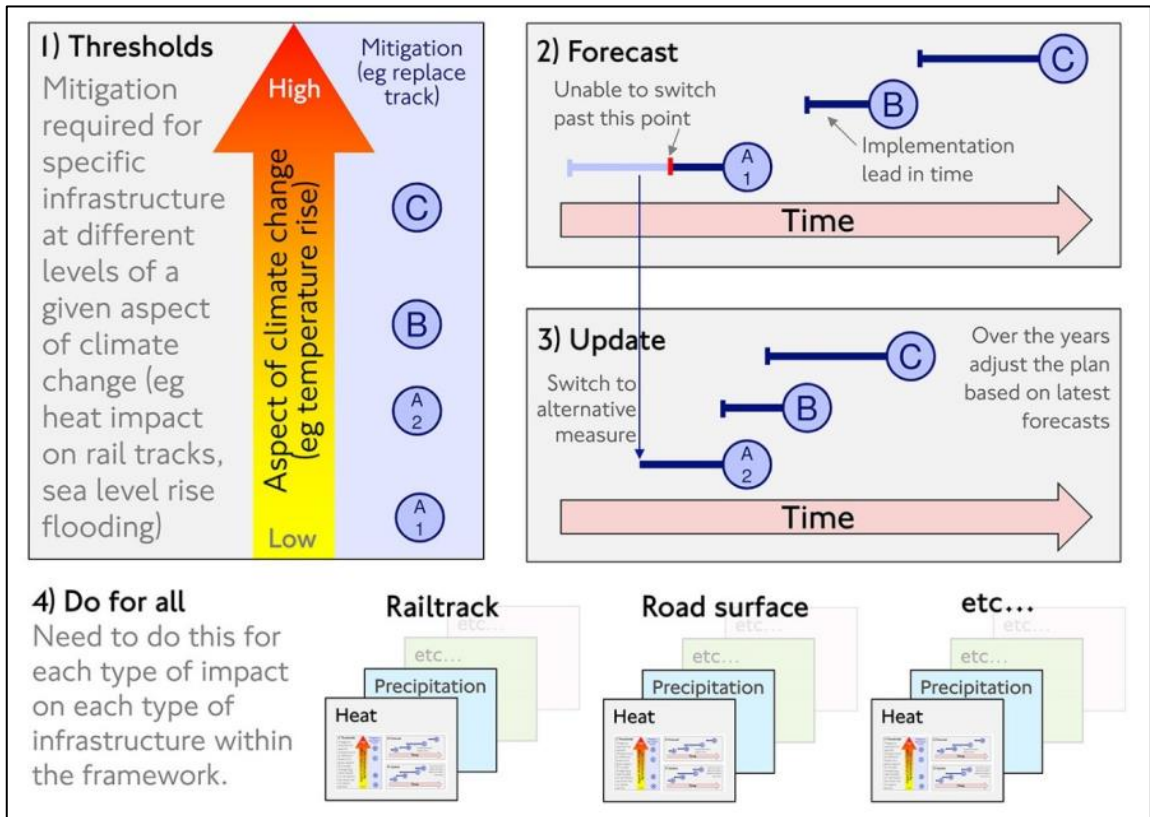
Figure 6: Adaptive Pathways Framework

Pathway example – Heat on rail track

7.6　Rail tracks expand in high temperatures, which can cause them to deform. When working with rail, the track is mechanically or thermally altered. The process of stressing rail installs the proper Stress Free Temperature (SFT) so that there will be a reduced risk of fracturing or buckling at the temperature extremes. Higher SFT increases the brittleness of rail in cold temperature, so the best SFT must be chosen based on local atmospheric conditions. Temperature also impacts on electronic and mechanical rail track components.
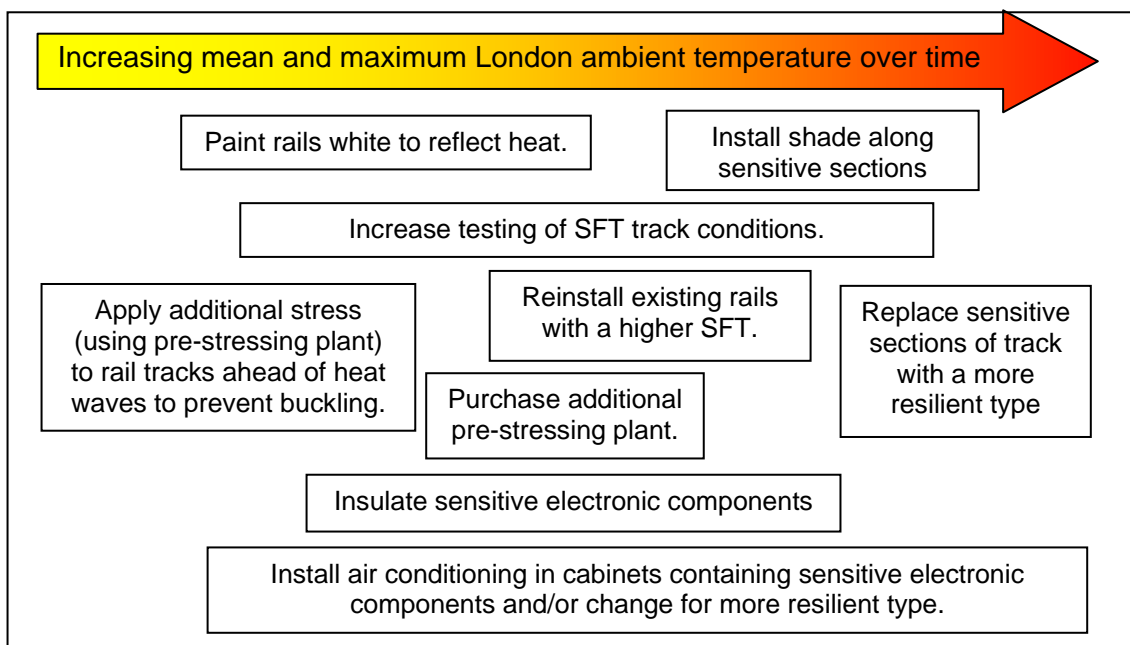

Figure 7: Illustrative pathway example – heat impact on rail track

7.7 Pathways, such as the above, would be spatially and temporally mapped. As well as informing investment decisions, it would provide evidence for the inclusion of mitigation in other projects, developments and planning policies.

8 Next steps

(a) Include supporting policies and proposals within new Mayoral strategies.

(b) Continue to investigate and review available data of current and historical impacts.

(c) Set up Transport sector working group with key colleagues from across TfL and other transport providers in London.

(d) Develop a dedicated programme of research, including the development of cost/benefit tools and metrics for measuring progress.

(e) Begin developing pathways, informed by initial prioritisation of risk, to populate the APF.

(f) Report progress annually.

List of appendices to this report:

Appendix 1: Key TfL controls in place for managed risk of severe weather and climate change

List of Background Papers:

None

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Appendix 1: Key TfL controls in place for managed risk of severe weather and climate change

Control Description	Frequency
1. Climate change forecasts built into project management processes so that adaptation measures are considered when designing new infrastructure	Ongoing
2. Cooling the tube programme – a series of measures to reduce temperatures in the London Underground (LU) network including improving train efficiency, natural ventilation and air conditioning	Ongoing
3. London Underground flood risk review – assessment of levels of risk of flooding on LU assets	One off
4. Defra Adaptation Reporting – a series of workshops and were held with asset managers in order to identify risks and mitigating measures required to improve resilience to climate change	Completed in 2011 and 2015
5. Asset management plans to manage the impacts of extreme weather on LU and Rail such as installing air conditioning	Ongoing
6. Asset management plans to manage the impacts of extreme weather on the Surface road network such as improving drainage in order to reduce flood risk	Ongoing
7. Short term resilience planning for Surface (response and recovery from extreme weather) such as gritting roads before snow and ice	Ongoing
8. Short term resilience planning for LU and Rail (response and recovery from extreme weather) such as the pre-stressing tracks to avoid buckling in extreme heat	Ongoing