2019 – 2024

NW&C

Region CP6 Weather Resilience and Climate Change Adaptation Plan

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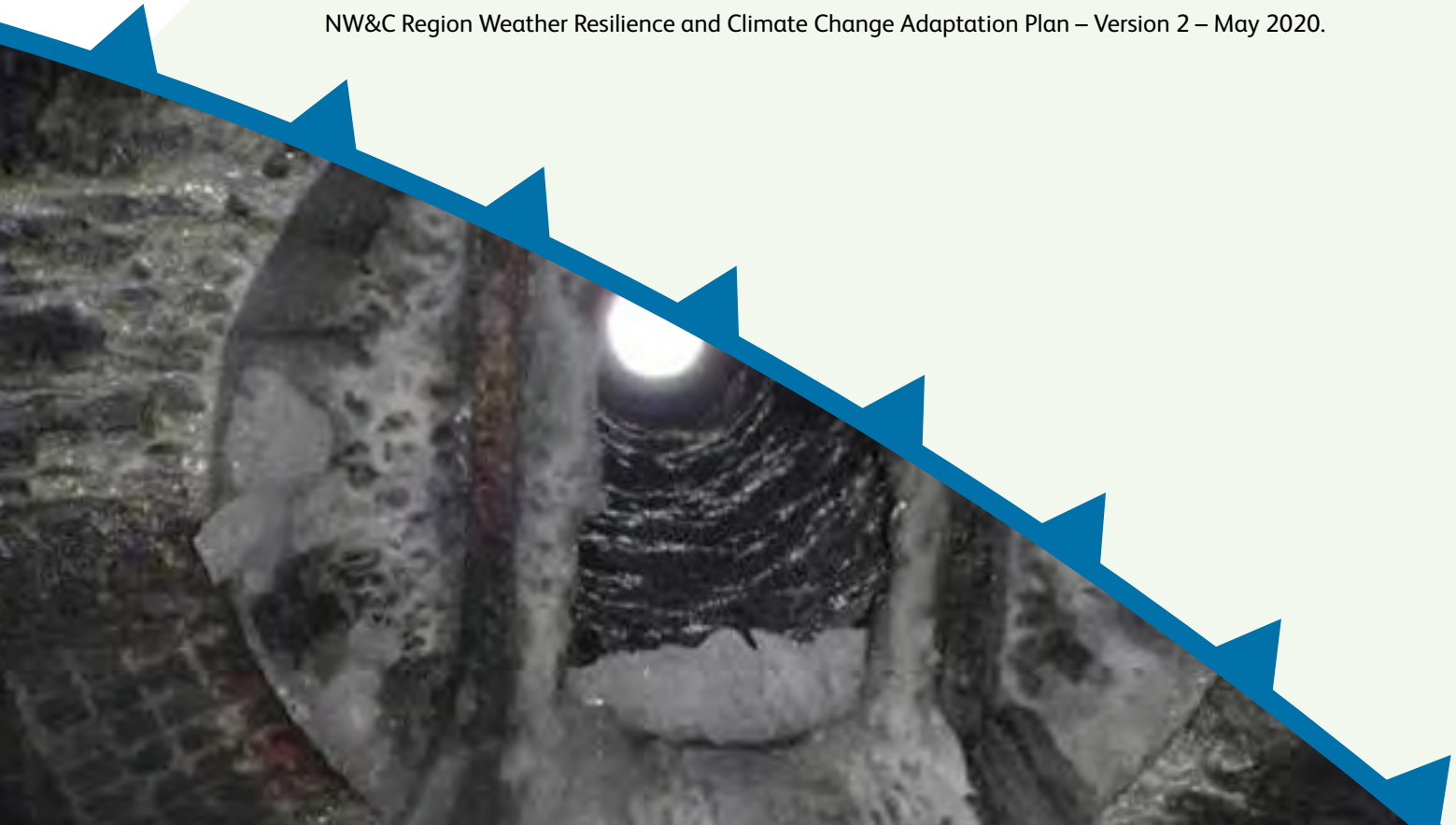
Purpose of this document

This document; defines the NW&C Region Weather Resilience and Climate Change Adaptation (WRCCA) Plan for CP6 and reviews progress against the WRCCA Plan published for CP5. This is supported by an evaluation of the resilience of rail infrastructure to historical weather events and an awareness of potential impacts from regional climate change projections. The resilience of the rolling stock operating within the Region is not specifically assessed.

NW&C Region Weather Resilience and Climate Change Adaptation Plan – Version 2 – May 2020.



Director of Engineering and Asset Management Statement

The railway network has been significantly affected by severe weather conditions including wind, snow, rainfall, lightning, heat and cold.

Climate change projections suggest we will be entering a period with increasing average and maximum daily temperatures, drier Summers, wetter Winters, sea level rises and increased storminess.

Figure 1
Wellington flooding

Increased storminess and Winter rainfall will increase the risk of flooding, subsidence and coastal storm surges. Hotter and drier Summers will increase track buckles and the risk of desiccation respectively. High winds result in debris falling on to the track, and snow and cold weather result in frozen points and blocked Routes.

The past 5 years have seen dramatic examples of the impacts of adverse and extreme weather in NW&C Region. In December 2015 Storm Desmond brought widespread damage across Cumbria. The rising flood waters in Carlisle submerged a section of the West Coast mainline damaging track, electrification and signalling assets. This left the Route team with a £5m restoration programme to re-open the line. The next year a combination of high ground water and river scour triggered movements in the natural and man-made slope at Eden Brows on the Settle and Carlisle railway leading to closure of the line for some 13 months and a £23m bill to restore the line. The derailment at Watford cutting in September 2016 was a stark reminder of just how serious the impact of extreme weather can be.

As we progress in a new control period our focus is on learning from these significant incidents and building a more reliable network. We need to find ways to minimise the delays to our train services and the occurrence of incidents such as those highlighted. We need to understand the vulnerabilities of the Region so that we can consider what reasonable interventions can be put in place and to plan for delivery over the next 5 years.

Over the past two years we have taken steps across the Region to introduce operational changes to address the areas of highest performance impact; for example, raising the sustained wind speed that can be tolerated before Emergency Speed Restrictions (ESRs) have to be imposed on electrified lines. We have also enhanced operational processes for managing events through Extreme Weather Action Teleconference (EWAT) and moved to an agreed process for the imposition of blanket speed restrictions to minimise the safety risk to trains.

Director of Engineering and Asset Management Statement continued

We now have a planned programme for management of vegetation across the Route which is already delivering benefits. It is reducing the risk of tree fall and improving the performance figures during the Autumn leaf-fall season as well as reducing the likelihood of embankment shrinkage during extended periods of hot dry weather. Lessons learned during the very hot Summer of 2018 are that a programme of interventions is required on our Overhead Line Equipment (OLE) if we are to prevent the imposition of speed restrictions to reduce the risk of de-wirement. This is a core element of the CP6 plan for improved weather resilience.

However, continued weather event impacts serve to highlight the need for improved resilience in our assets if we are to deliver the service that our customers demand. We will address weather resilience and climate change by working more effectively through continuing to improve how we engage with all stakeholders involved in this challenge, including the Environment Agency (EA) and lineside neighbours.

NW&C Region is experiencing significant investment over CP6; we will spend over £6.48 billion enhancing, renewing, maintaining and operating the infrastructure. This level of investment reflects the growth in the demand for rail travel and the economic significance of the railway in the NW&C Region connecting the Midlands and North West regions to the capital. It is therefore important for the network as a whole that we make these improvements – and in this document we outline how we will go about that challenge.

Kamini Edgley
Director of Engineering and Asset Management – NW&C Region

Executive summary

Current weather events can cause significant disruption to the operation of train services and damage to rail infrastructure.

The UK Climate Projections 2018 (UKCP18) indicate that there will be a shift to a warmer climate with significant changes in sea level and the pattern and intensity of precipitation across the year.

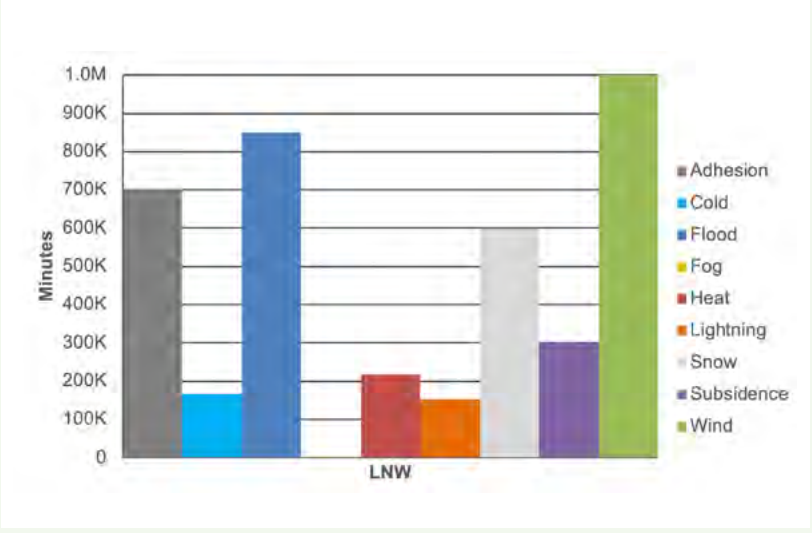
Changes in the frequency and intensity of extreme weather events and seasonal patterns as a result of this could alter the likelihood and severity of weather event impacts.

A detailed understanding of the vulnerability of rail assets to weather events, and potential impacts from climate change, are therefore needed to maintain a resilient railway.

NW&C Region is committed to supporting the improvement of weather and climate change resilience through the delivery of the Region-specific objectives. We have developed an understanding of our risks by; assessing our weather-related vulnerabilities (for example Figure 2), identifying root causes of historical performance impacts and using UKCP18 regional climate change projections.

Our 2014 Route WRCCA Plan set out our WRCCA Strategy, summarised the findings of our vulnerability and impact assessments and detailed the CP5 investments and actions that we would take to mitigate these and highlighted future considerations.

Figure 2
NW&C Route weather attributed delay minutes – 2006/07 to 2018/19



This updated plan reports our CP5 progress, sets out our plan for CP6 and beyond. It also updates our vulnerability and impact assessments to account for changes in the Network Rail WRCCA Strategy and guidance. Key highlights include:

- In 2017 the Network Rail guidance on the climate change projections to be used for impact assessment and planning was reviewed. This recommended using the UKCP09 Medium scenario, 90th percentile probability. With the release of the UKCP18 data this has been updated to the UKCP18 Representative Concentration Pathway (RCP) 6.0 scenario, 90th percentile[1],
- Specification for weather forecasting and trigger levels,
- Risk mitigation process for earthworks in adverse and extreme rainfall,
- Flood management plan and database,
- Critical drainage asset management,
- Coastal strategy,
- Signalling SMS A13 reinstating flooded or water affected equipment,
- Scour (including requirements at scour risk sites with bridges having spans >10m),
- Seasonal working arrangements,
- Key Route strategies for adverse weather working including hot weather preparedness: OLE tensions, lineside building cooling and ventilation and integration of Critical Rail Temperature (CRT) planning into track renewals,
- List of 'At Risk' assets for each discipline,
- Further research into management of Ice in Tunnel Shafts,
- Developing our EWAT process including the strategy for proving trains, and
- Building a variety of Remote monitoring options including weather stations.

During CP6 NW&C Region will continue to work to understand vulnerability to a changing climate and to develop investment plans to address the risks in future control periods.

Although the actions taken in CP5 improved aspects of our resilience, weather events continue to impact our operations. NW&C Region is committed to addressing the risks through the timely, cost efficient and safe delivery of this Region WRCCA Plan.

[1]Previous recommendation used in the 2014 Route WRCCA Plans was UKCP09 High scenario, 50th percentile probability.

Introduction

The railway routinely operates in a wide range of weather conditions; however adverse and extreme weather can still cause significant disruption to our network.

Current weather events such as extreme rainfall, snow and high temperatures can cause delays, raise operating costs and increase safety risks.

In the NW&C Region, storm Desmond (December 2015) caused flooding in Carlisle and led to closure of the West Coast mainline into Scotland. More than £5m was spent to restore services. In February 2016 high rainfall and consequent high river levels at Eden Brows on the Settle and Carlisle line triggered movement in the railway earthworks closing the line for 13 months and costing £23m in repairs alone.

Adverse and extreme weather events continue to cause multiple minor earthworks failures and flooding events. In the Summer the weather has the ability to impact train performance, with peak temperatures in 2018 leading to issues with maintaining the OLE which supplies traction power to trains. These temperatures led to speed restrictions with consequent delays to services and inconvenience to passengers.

We monitor the impact of these weather events on the performance of our network by using delay minutes and Schedule 8 delay compensation costs.[2] Incidents are recorded under 9 categories as follows:

- **Adhesion** – line contamination leading to traction loss, e.g. leaf fall, moisture, oils,
- **Cold** – e.g. ice accumulations on conductor rails, points and in tunnels,
- **Flooding** – standing or flowing water leading to asset damage or preventing trains from accessing the track,
- **Fog** – reduced visibility obscuring signals,
- **Heat** – high temperature impacts e.g. rail buckles, Temporary Speed Restrictions (TSRs), overheated electrical components,
- **Lightning strike** – e.g. track circuit and signalling damage or power system failure,
- **Snow** – e.g. blocked lines and points failures,
- **Subsidence** – the impacts of landslips, rockfalls and sinkholes, and
- **Wind** – e.g. trees and other items blown onto the track and into the overhead line equipment (OLE) or leading to TSRs.

As these data include the duration and location of each disruption, and attribute cause, they give a high degree of granularity for use in analysing weather impacts and trends.

In the past 13 years (2006/07 to 2018/19) the average annual number of delay minutes attributed to weather for the LNW network was 316K. This represents 11.3 % of the total number of delay minutes for all causes over that period and equates to an average annual cost of £11m.

The impacts of severe weather events on the NW&C Region can be clearly seen in Figure 3, for example:

- Rainfall during 2007/08, 2012/13 and 2015/16,
- Snowfalls of 2009 through to 2011, 2012/13 and 2017/18,
- Wind in most years, particularly 2006/07, 2013/14 and 2016/17, and
- Heat in 2018/19.

Weather related costs can also be captured in Schedule 4[3] payments and the capital expenditure required for reinstating damaged assets.

The costs of weather attributed Schedule 8 and 4 payments and the wider socio-economic impacts of rail disruption on the UK justify continued investments to increase current weather resilience. Network Rail's collaborative approach to understanding weather impacts in the increasingly interdependent infrastructure, societal and environmental systems is key to identifying appropriate resilience responses that support our role in developing regional and national resilience.

Trends in the UK climate, and the UKCP18 data, indicate that there has, and will continue to be, a shift to a warmer climate. Figure 4 illustrates the changes in frequency and severity of Atlantic Winter storms and Figure 5 shows observed increases in the Central England Temperature record.

[2]The compensation payments to passenger and freight train operators for network disruption.

[3]Compensation payments to passenger and freight train operators for Network Rail's possession of the network.

Figure 3
NW&C Route weather attributed delay minutes by year – 2006/07 to 2018/19

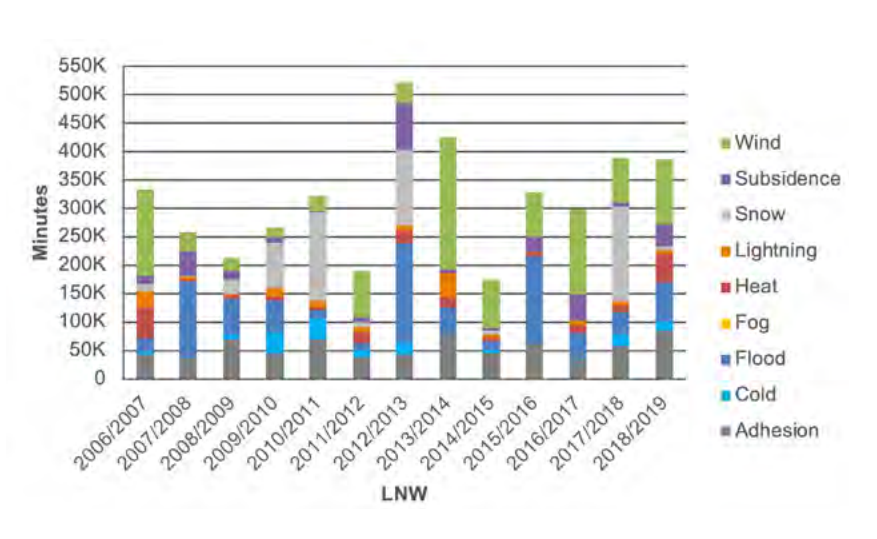


Figure 4
Intensity and frequency of high latitude Atlantic Winter storms

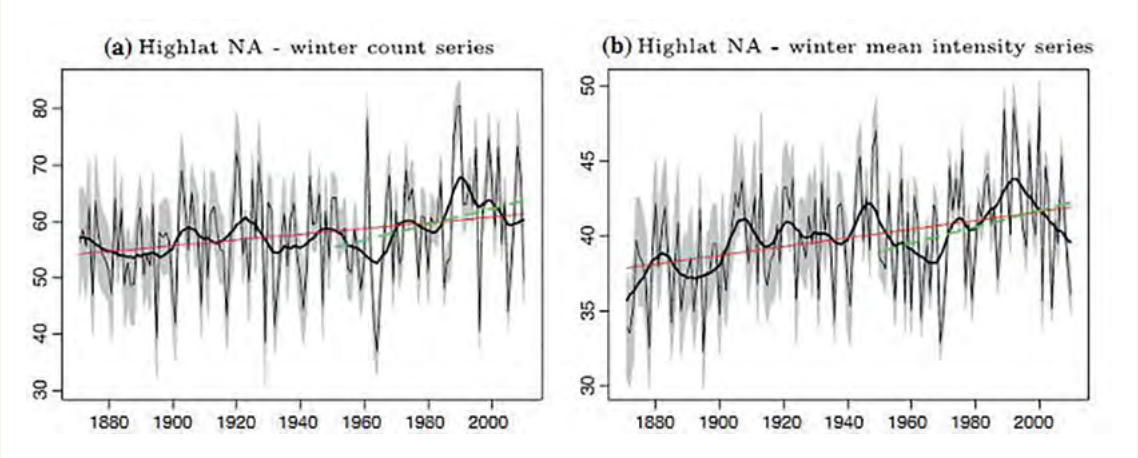
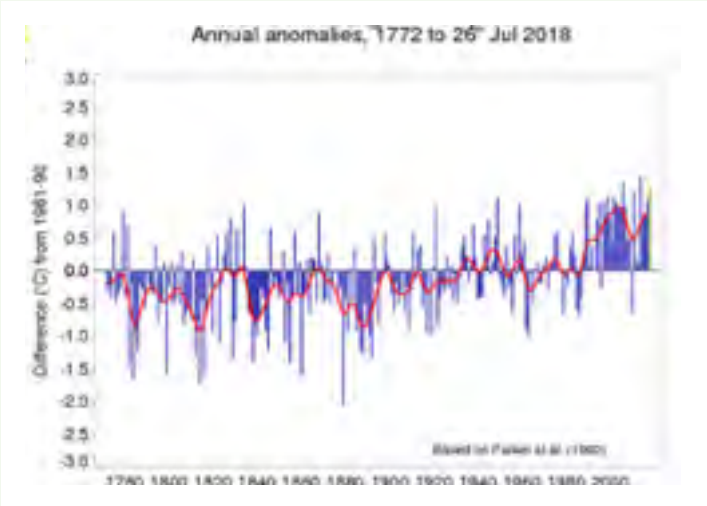


Figure 5
Mean Central England Temperature record[4]



[4]Parker, D.E., T.P. Legg and C.K. Folland. 1992. A new daily Central England Temperature Series, 1772-1992. Int. J. Clim., Vol12, pp 317-342.

Introduction continued

UKCP18 projects an overall shift towards warmer climates with drier Summers and wetter Winters for the whole of the UK, although the level of change will vary across the regions.

Examples of the changes are shown in Figure 6 for the mean maximum Summer temperature and Figure 7 for Winter precipitation.

Figure 6
Change in mean daily maximum Summer temperature (°C) (left to right; 2030s, 2050s and 2070s) based on a 1981-2000 baseline[5]

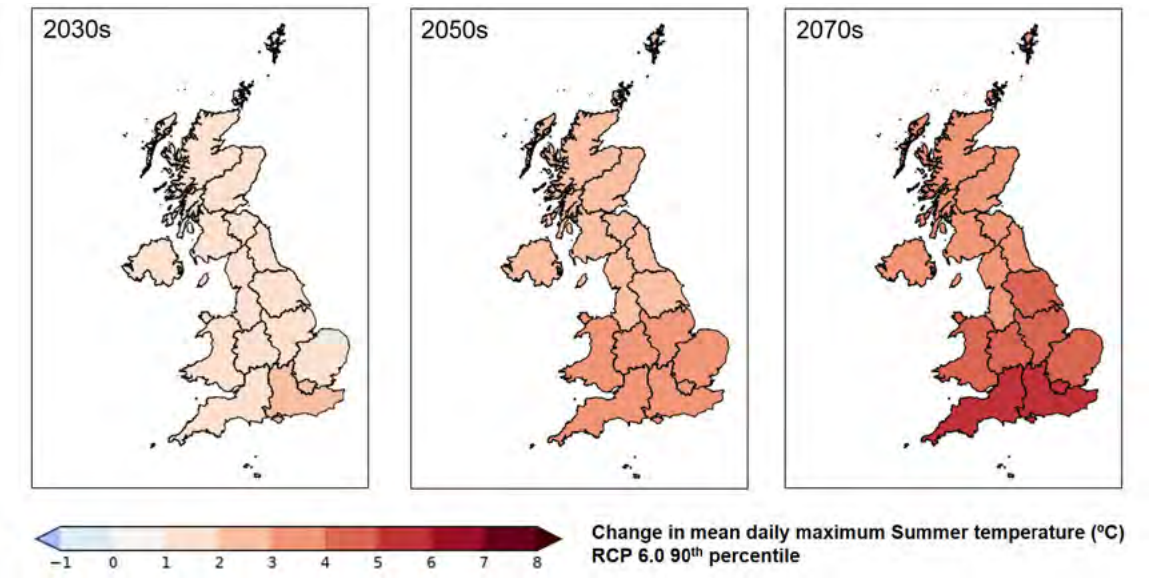
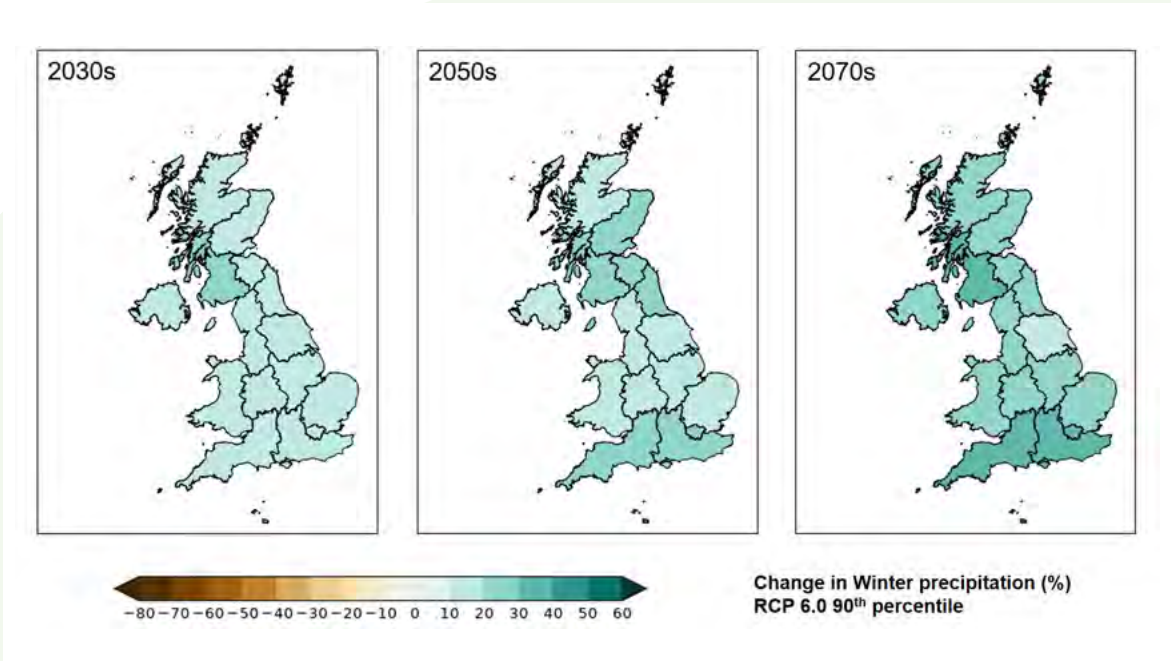


Figure 7
Change in Winter precipitation (%) (left to right; 2030s, 2050s and 2070s) based on a 1981-2000 baseline[6]



[5]UK Climate Projections, 2018.
[6]UK Climate Projections, 2018.

The potential increases in weather impacts due to climate change support the business case for enhancing weather resilience action and identifying actions that will deliver a railway that is safe and more resilient to the effects of weather, now and in the future.

The 2015 Paris Agreement unites nearly every nation in a common cause to undertake ambitious efforts to combat climate change and adapt to its effects. The central aim is for a strong global response to the threat that keeps the global temperature rise this century to well below 2°C above pre-industrial levels and to pursue efforts to limit it to 1.5°C.

The Department for the Environment, Food and Rural Affairs (Defra) provides national climate change guidance in a number of ways to enable the assessment of future climate risks and the planning of adaptation actions to maintain and improve resilience. Most important to Network Rail and the NW&C Region are:

- The UK Climate Projection data sets which are produced by the Met Office Hadley Centre, and
- The National Adaptation Programme (NAP).

The UK Climate Projection data sets are produced for use in assessing the future risk and impacts of the possible climate projections for the UK. They are used by government to conduct the 5 yearly UK Climate Change Risk Assessment (UKCCRA) and by individual organisations to understand and plan for their specific risks.

For the 2014 Route WRCCA Plans Network Rail's national guidance was to use the UKCP09 high scenario, 50th percentile probability projections as an appropriate benchmark on which to base evaluations and decisions. In 2017 Network rail commissioned a review of its guidance taking into account the Paris Agreement, advances in climate science, additional years of climate observations and the then pending release of the UKCP18 projections dataset.

The conclusions of the review[7] were that as a safety critical focused organisation and major UK infrastructure manager the most appropriate UKCP projections to use are:

- UKCP18 – RCP 6.0 90th percentile probability as the baseline scenario for evaluations and decisions, and
- RCP 8.5 90th percentile as the sensitivity test on assets with a lifespan beyond 2050.

Analysis in this report has been updated using the UKCP18 projections where available. It should be noted that some UKCP09 parameters have not been updated in UKCP18. Where this is the case, the UKCP09 data has been used and this is clearly indicated in the report.

[7]Identifying a climate change planning scenario, JBA Consulting 22/02/18.

Introduction continued

The NAP is based upon the UKCCRA and is published by Defra every 5 years. It contains a summary of the impacts expected for each sector of the UK economy and tables detailing adaptation actions that the UK Government requires those sectors to undertake to ensure the continuing resilience of the UK economy.

The sectorial actions are apportioned to key stakeholders such as regulators and national infrastructure operators. Details of the Transport Sector actions in the NAP 2018 that are apportioned to Network Rail and hence the NW&C Region are included in Table 6 in the NW&C Region WRCCA Actions section of this Plan.

Although climate change projections include uncertainties, associated with natural climate variability, climate modelling and future emissions, they and the actions from the NAP can be used to provide guidance on the direction that the UK climate may take. NW&C Region has therefore used the projections in the creation of this WRCCA Plan.

To ensure a consistent approach to WRCCA consideration and action across Network Rail an iterative framework of key management stages is used (see Figure 8). The same framework has been applied to develop this Region WRCCA plan.

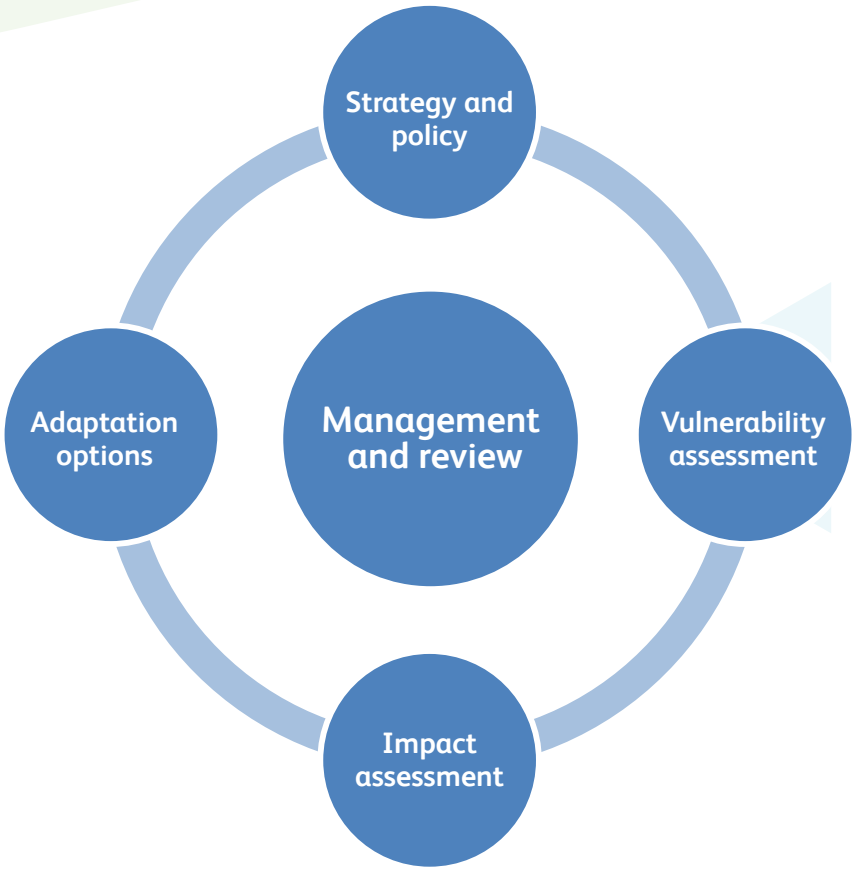


Figure 8
Weather resilience and climate change adaptation framework

Network Rail will take a range of soft (changes to processes, standards, specifications and knowledge and skill base) and hard (engineered solutions to increase resilience) WRCCA actions tailored to the level of risk and the strength of evidence for it. Examples include;

- **Do nothing/minimum** – the option to do nothing/minimum and the risks should be evaluated,
- **No regrets** – increasing current and future resilience without compromising future flexibility,
- **Precautionary** – investment in adaptation now in anticipation of future risk, and
- **Adaptation pathways** – staged adaptation balancing future risk and current investment funds through phased investment enabling assets to be retrofitted cost-effectively in the future.

The following sections provide findings from the updated NW&C Region vulnerability and impact assessments, and detail; progress on the CP5 resilience actions, actions planned for CP6 and additional actions for future consideration.

Figure 9
Flooding at Crick on the West Coast Mainline

NW&C Region WRCCA Plan

Network Rail's WRCCA Policy sets out the approach to achieving our company's vision of 'A better railway for a better Britain' by creating a railway that is safer and more resilient weather impacts now and in the future.

It commits the business to seeking to apply the following key principles:

- Including current and future weather impacts in our risk analysis and investment decision making and embedding climate change specifications into policies, procedures and standards,
- Adapting at construction and at asset renewal, designing schemes to be resilient in the most cost-effective manner to and/or with passive provision for future weather conditions,
- In the event of catastrophic asset failure replacing on a like for better basis rather than like for like, considering the whole life cost and the best strategy for managing the railway,
- Identifying high priority locations for proactive resilience interventions and working to identify funding sources for projects not included within agreed Control Period funding, and
- Working with stakeholders to identify opportunities to enhance our preparation for, response to and recovery from adverse/extreme weather events.

NW&C Region Plan

Weather has had a significant impact on asset condition and performance in our Region over the past 5 years. In CP6 we will continue to improve the weather resilience and sustainability of our assets. We will seek to improve our ability to predict the impacts of weather-related events through enhanced risk assessments, remote condition monitoring and improved weather forecasting combined with a better understanding of the condition of our assets.

Modern standards for design in all engineering disciplines require consideration of the impacts of weather. The renewals programme in CP6 will consequently build more resilience into the network as these standards are applied. In addition to design the lessons learned in recent adverse and extreme weather events will be applied to renewals in elements such as equipment specification and positioning. However, our base plan does not include an allowance for actively planned programmes of work to specifically address the impacts of extreme weather events. Rather we have adopted a programme to address those assets which present the greatest safety and performance risk in adverse weather balancing them against the continued need for condition-led renewals.

Our increased focus on drainage and the risk from third party land will start to have a positive effect on both asset sustainability and reliability. We expect to see a reduction in the likelihood of safety critical incidents and the impact of weather-related delays in CP6 arising from our improving drainage asset knowledge and a continuing focus on vegetation management. We have included additional earthworks renewals in our plans specifically to address known adverse weather sites and have included scour and flood protection works in our structures work-banks for those locations at greatest risk.

We plan to develop an NW&C Region Extreme Weather Strategy in CP6 which will encompass the following elements:

- Specification for weather forecasting and trigger levels,
- Risk mitigation process for earthworks in adverse and extreme rainfall,
- Flood management plan and database,
- Critical drainage asset management,
- Coastal strategy,
- Signalling SMS A13 reinstating flooded or water affected equipment,
- Scour (inc requirements at scour risk sites with bridges having spans >10m),
- Seasonal working arrangements,
- Key Route strategies for adverse weather working including hot weather preparedness: OLE tensions, lineside building cooling and ventilation and integration of CRT planning into track renewals,
- List of 'At risk' assets for each discipline,
- Further research into management of Ice in Tunnel Shafts,
- Developing our EWAT process including the strategy for proving trains, and
- Building a variety of Remote Monitoring options including weather stations.

This will enable us to better inform plans for implementation of specific weather resilience works in CP7.

Figure 10
Codshall flooding

NW&C Region vulnerability assessment

In the 2014 Route WRCCA Plan this section provided details of the general vulnerability of the national rail network and NW&C Region's specific vulnerabilities to current weather impacts, and regional climate change projections.

This Plan updates the vulnerability assessment taking account of:

- Advances in climate science,
- Improvements in our understanding of the impacts of weather and future climate, and
- Changes in Network Rail's climate change policy and guidance since the last plan was published.

Network-wide weather vulnerability

The rail network and its component assets are sensitive to the effects of a number of weather types. These manifest as either primary events (one weather type) or secondary events which are the result of these and/or a combination of weather types. It should be noted that these are the mechanisms by which impacts are felt, not the actual impacts themselves. Figure 11 illustrates the primary event types and their related secondary event types.

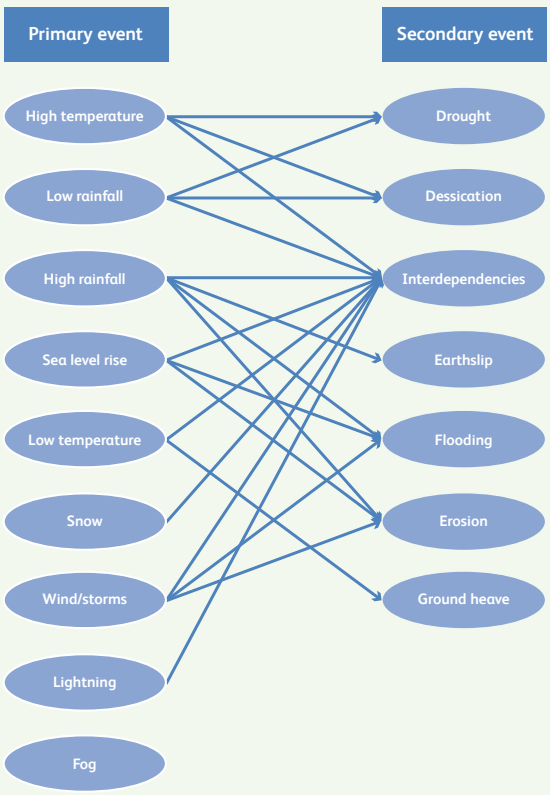


Figure 11
Examples of primary and secondary events

Managing a complex array of assets with varying ages, condition and weather vulnerabilities across a wide range of bio-geographic regions in a variety of climates is a complex challenge. Interdependencies with other sectors of the economy, for example power, telecoms and water infrastructure add to this.

Understanding current weather impacts is essential for assessing the probable effects of climate change and for the planning and implementation of appropriate cost-effective resilience investments to adapt the network to the future impacts.

The 2014 Plan outlined how we monitor the impact of weather on the performance of our network by using Schedule 8 delay compensation costs and the process we used to carry out a detailed analysis of this data to understand:

- The characteristics of weather-events that trigger failures,
- The thresholds at which failure rates change, and
- Trends in the failures of assets and the performance of the network.

The key findings of this work were that earthworks were the asset most affected by rainfall, OLE was most sensitive to wind and that temperature impacted the widest range of assets. These and the detailed outputs behind them have been disseminated to Network Rail's national asset function teams and the Routes for use in asset maintenance and investment planning.

As the above work was based upon current data, the changes to Network Rail's national guidance for the climate change planning projections have not changed the conclusions.

We continue to monitor and analyse this data and we now have a 13-year series increasing our capacity to discern trends in failures and performance. We have now made the raw data available and we are continuing to look at how we can improve its use including through trend and performance reporting on a period, quarter an annual basis.

Region weather vulnerability

The NW&C Region extends from London to the Scottish border and from the Pennines to the West coast of Lancashire and Cumbria (Figure 12). It includes a wide range of rail track classification, topography and geology from very high tonnage on 125mph multiple track electrified railway to single track freight or passenger rural Routes, and from low-lying and level coastal plains to steep mountainous terrain.

Figure 12
NW&C Region

The very diverse range of topography, from typically low lying and gently undulating land in the South to the higher ground of the Peak District, Pennines and Cumbria in the central and Northern areas significantly influences the weather conditions experienced. The location of the Region, the nature of the topography, its height and steepness, brings very variable levels of exposure to weather conditions of all kinds; for example, elevation changes from the Cumbrian coast to the high ground in the Pennines and Lake district bring a wide variability in temperature range, and exposure to high winds.

The topography is also linked to the geology of the area and this also plays an important role in determining the way in which the weather ultimately impacts the railway assets.

For the most part, clay geologies dominate the Southern and central Midlands, providing a gently undulating and low-lying topography which is bounded to the South by the chalk uplands of the Chilterns and to the West by the higher ground of the Welsh Borders. The impermeable ground and shallow gradients also encourage standing water and flood waters can remain in place for prolonged periods of time. This has the potential to adversely impact standing assets (electrification and signalling equipment) as well as rendering the railway earthwork assets vulnerable to softening and weakening of the clays and, as a consequence, an increased number of relatively slow-moving failures in embankments and cuttings.

Some distance from the sea, this low-lying area can trap stable high-pressure ‘continental’ air which has the potential to bring prolonged periods of very high temperatures in the Summer and very low temperatures in the Winter. High Summer temperatures encourage impacts such as desiccation shrinkage of clay geologies as trees extract moisture from the ground.

Further North, the lower-lying geology of the Cheshire Plain is different to that in the South and is less susceptible to the earthworks failure mechanisms seen there. However, this area is more open to the influences of the warm moist South Westerly maritime air streams which travel in across Liverpool towards the higher, steeper, topographies of the Peak District, South Pennines and in the North, the Southern boundary of the Cumbrian uplands. As these warm air masses are channeled and forced higher, they cool, forming cloud and increased precipitation.

The greater rainfall experienced in this area generally falls on steeper slopes over higher ground and can lead to flash flooding which has much higher energy and can quickly become very destructive to railway assets and other property.

NW&C Region vulnerability assessment continued

During the Winter this precipitation falls on the higher ground as snow, but the continued influence of warm air from the sea means that quite large swings in temperature can occur. This is problematic if sudden warming follows several days of cold, leading to a greater risk of ice accumulation and ice fall in tunnels, Figure 13.

Figure 13
Ice formation at a ventilation shaft in the Birkett Tunnel on the Settle to Carlisle line

The maritime air and prevailing South Westerly winds also impact the very exposed Cumbrian Coast Line, in particular where it runs along the coastal sections from Arnside to Maryport. In many locations the railway forms the first line of coastal defence and is therefore vulnerable to wave action in high winds and in particular at times of high tide. The same 'lifting' of the warm moist air occurs as the weather systems reach Cumbria, so heavy rainfall is also common here and the railway can end up being impacted by high river levels and high intensity surface water run-off.

Any of these weather conditions have the potential to bring high winds to exposed coastal and upland areas

In the furthest North Eastern part of the Region, the catchments of the Caldew and Eden run through an area of generally low lying and gentle topography. However, in contrast with the Southern parts of the Region, the geology is the product of glaciation, and the very variable geologies are susceptible to slope failure as a consequence of the very high rainfalls experienced in the foothills of the Pennines. The catchments of the two rivers are also susceptible to flooding, with severe impacts on the city of Carlisle.

Future climate change vulnerability

The complexity of the relationship between weather events and climate means that the UKCP18 data set cannot forecast future weather events. It projects modelled probabilistic trends that can be used to understand the potential future risks associated with certain climates and the likely changes in weather events/parameters. Network Rail therefore uses projections from the UKCP18 data set as a future baseline to understand potential risks and for making informed strategic decisions to increase future weather resilience.

UKCP18 provides regional projections across 13 administrative regions in Great Britain (Figure 14). The NW&C Region spans several of these regions with the majority of it falling within the West Midlands and North West England regions. These regions are therefore considered as representative of the Route for the purposes of analysing future climate projections.

Figure 14
Map of UK administration regions used in UKCP18[8]

[8]Source: Met Office © Crown Copyright 2019 [available from UKCP18 Guidance: Data availability, access and formats: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-guidance-data-availability-access-and-formats.pdf]

In the 2014 Plan charts were generated using the UKCP09 High emissions 50th percentile probability scenario for the three regions to show the projected changes in temperature and precipitation from the 2020s to the 2080s relative to the baseline climate of the 1970s (1961-1990).

For this report the charts and text have been updated in line with the current Network Rail climate change guidance which uses the current UKCP18 climate projections where available. Replacing the UKCP09 emissions scenario used in the 2014 report with the UKCP18 emissions scenarios noted in the introduction has involved a number of changes to the data used. These include:

- Using a new baseline period of 1981-2000,
- Moving from projection time periods of 30 years (2020, 2050, 2080) to shorter 20 year periods (2030, 2050, 2070), and
- The use of UKCP18 RCP 4.5 95th percentile data for sea level rise as a proxy for RCP 6.0 data (UKCP18 did not model RCP 6.0 for sea level rise).

NW&C Region vulnerability assessment continued

Mean Daily Maximum Temperature change

The mean daily maximum temperature for both regions is projected to increase in every month of the year, with greatest increases expected in the Summer months. This increase becomes larger across the century.

West Midlands

The highest mean Summer temperatures are expected to be in August for both the 2050s and 2070s with increases of 4.3˚C to 25.1˚C and 5.9˚C to 26.7˚C respectively. In Winter the highest mean temperatures will be seen in February with increases of 2.6˚C to 9.6˚C and 3.7˚C to 10.7˚C respectively.

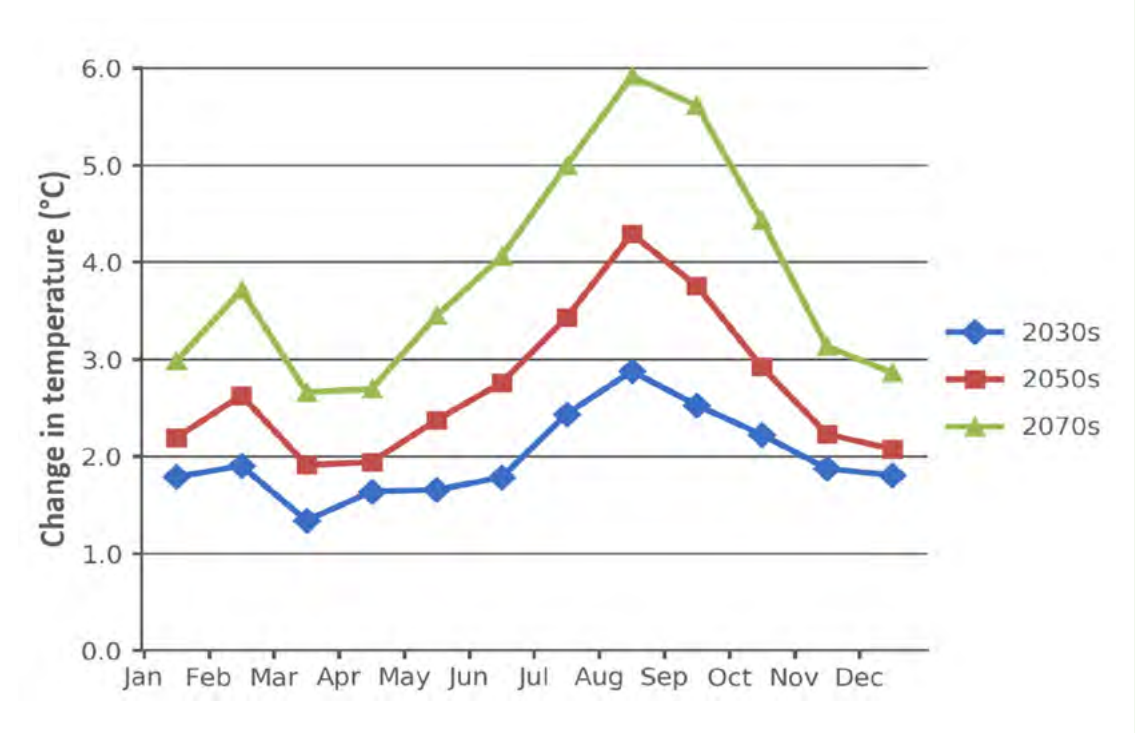
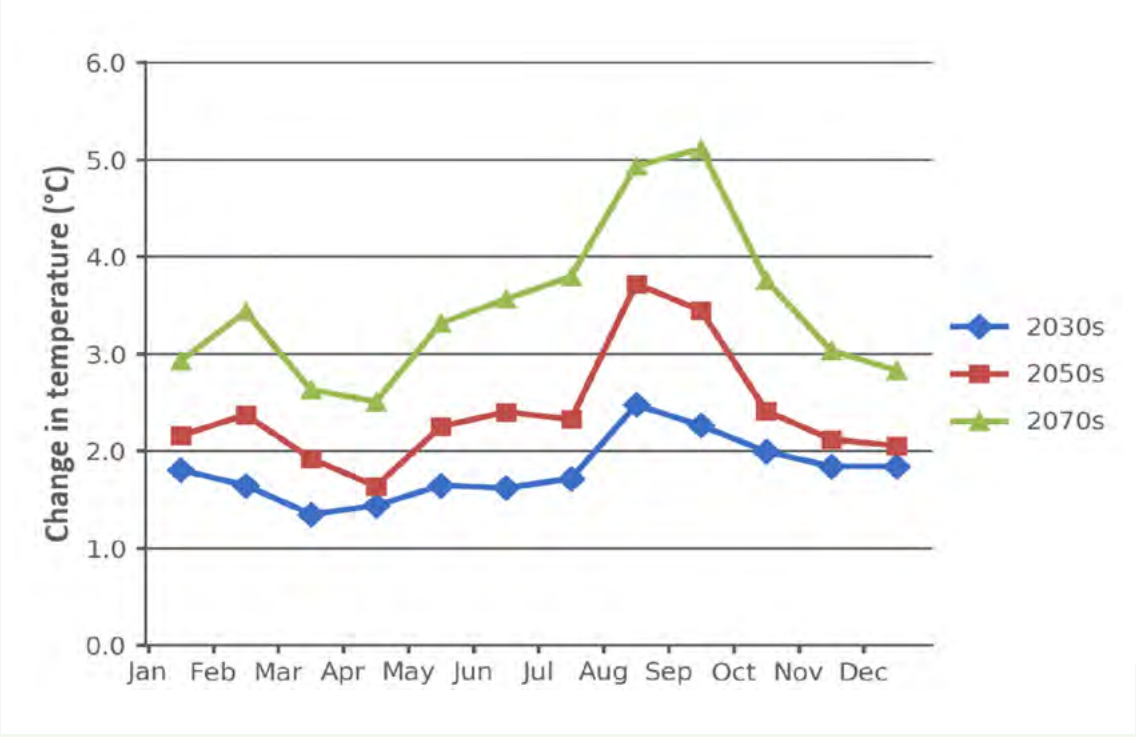


Figure 15
West Midlands, mean daily maximum temperature change (°C) (RCP 6.0 90th percentile)

North West England

The highest mean Summer temperatures are expected to be in August for both the 2050s and 2070s with increases of 3.7˚C to 22.4˚C and 4.9˚C to 23.6˚C respectively. In Winter the highest mean temperatures will be seen in February with increases of 2.4˚C to 8.7˚C and 3.4˚C to 9.7˚C respectively.

Figure 16
North West England, mean daily maximum temperature change (°C) (RCP 6.0 90th percentile)



NW&C Region vulnerability assessment continued

Mean Daily Minimum Temperature change

The mean daily minimum temperature for the regions is also projected to show increases throughout the year with the highest in the Summer. The level of increase is expected to become higher across the century.

West Midlands

The highest mean minimum temperatures for Summer are expected to be in August with increases of 2.8˚C to 13.9˚C by the 2050s and 4.2˚C to 15.3˚C by the 2080s. The lowest mean minimum temperatures will still occur in February for the 2050s with projected increases being 2.6˚C to 3.4˚C. For the 2070s, the lowest mean minimum temperatures will occur in February and December with increases of 3.8˚C and 3.0˚C respectively to 4.6˚C.

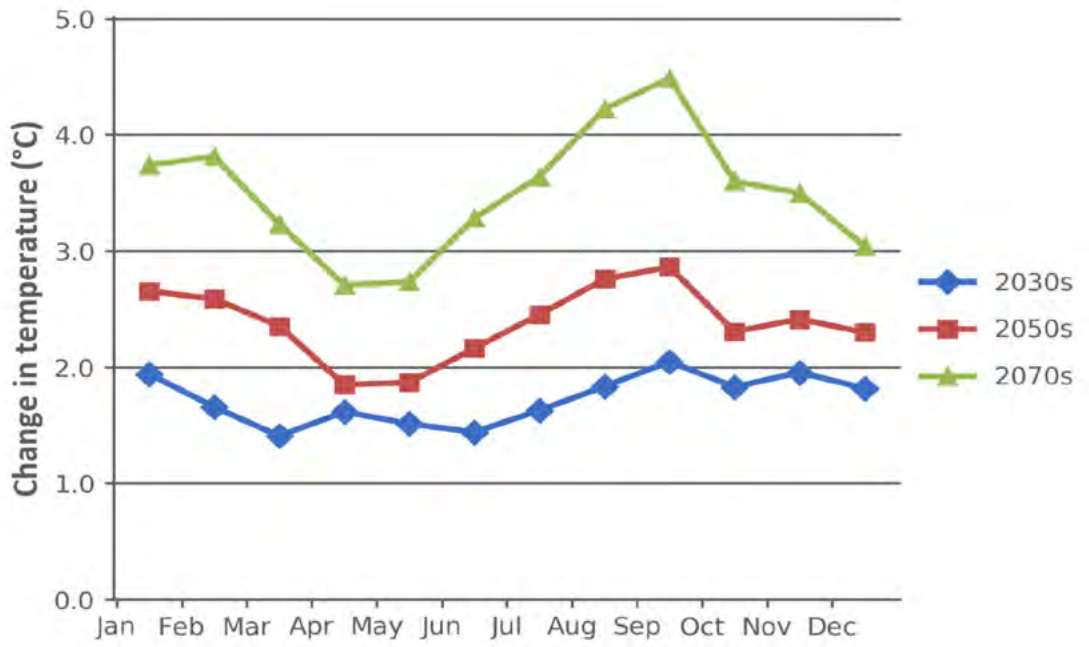
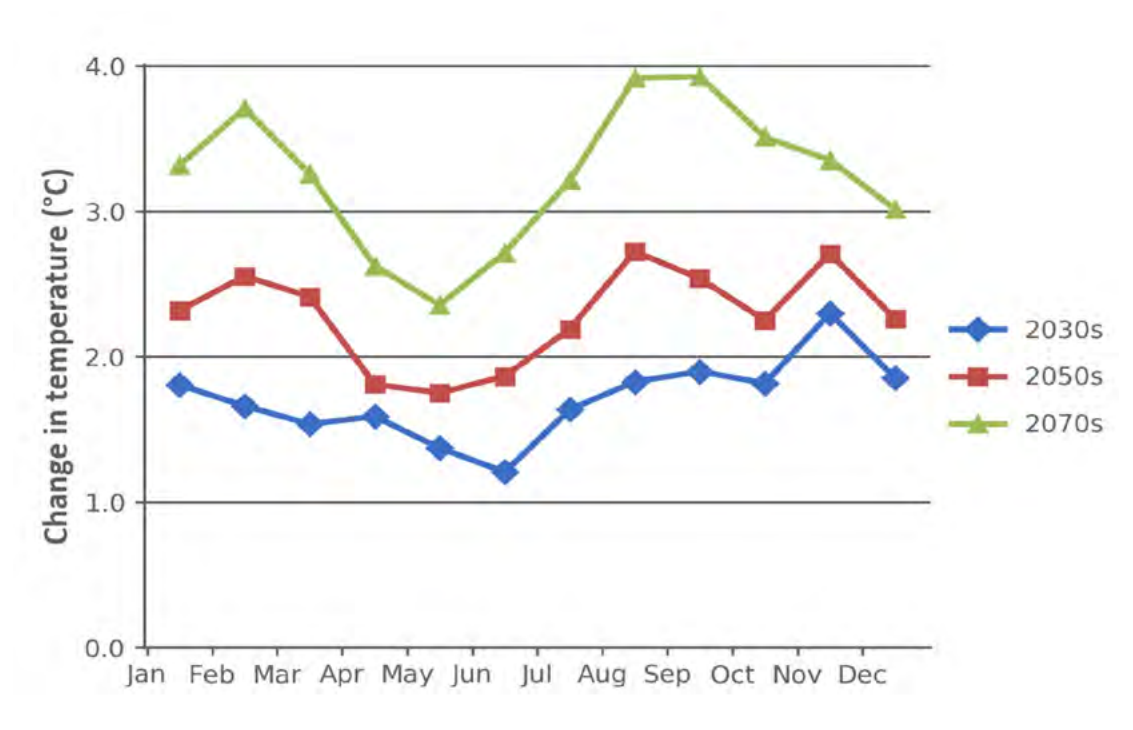


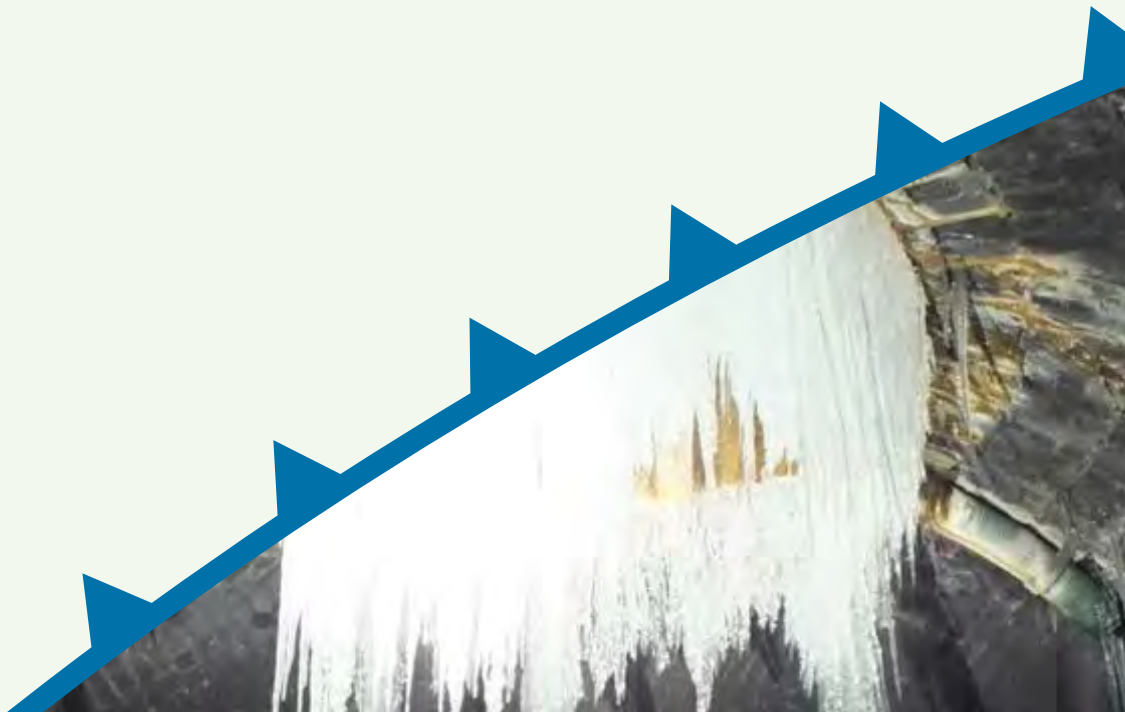
Figure 17
West Midlands, mean daily minimum temperature change (°C) (RCP 6.0 90th percentile)

North West England

The highest mean minimum temperatures for Summer are expected to be in August with increases of 2.7˚C to 13.6˚C by the 2050s and 3.9˚C to 14.8˚C by the 2070s. The lowest mean minimum temperatures will occur in January with expected increases being 2.3˚C by the 2050s to 3.2˚C, and 3.3˚C by the 2070s to 4.2˚C.

Figure 18
North West England, mean daily minimum temperature change (°C) (RCP 6.0 90th percentile)





NW&C Region vulnerability assessment continued

Mean daily precipitation

The UKCP18 narrative for mean daily precipitation in the regions is of significantly wetter Winters and drier Summers. Network Rail's chosen climate change planning scenario (RCP 6.0 90th percentile) shows the upper range of Winter rainfall increases, but does not illustrate the highest potential Summer rainfall reductions. These are best represented by the RCP 6.0 10th percentile projections.

Figure 17 therefore plots the RCP 6.0 50th percentile projections with error bars that indicate the wider range of change associated with the 10th and the 90th percentiles.

In reading the following commentary and interpreting the rainfall graphs it should be noted that they plot % difference from historic monthly average rainfall values and do not therefore give an indication of the current wettest and driest months, just the anticipated future % change.

West Midlands

In the 2050s the wettest months will be January, November and December all with mean daily rainfall of 3.2mm/day and respective increases of 33.7%, 34.7% and 21.5%. By the 2070s November and December will be the wettest months with mean daily rainfall increases of 49.6% and 35.7% respectively to 3.6mm/day. The driest month will be July by the 2050s showing decreases of 40.2% to 1.0mm/day and by 2070s July and August will be the driest months with respective decreases of 46.2% and 54.5% to 0.9mm/day.

North West England

In the 2050s January and December will be the wettest months with mean daily rainfall increases of 36.3% and 23.1% respectively to 5.7mm/day. For the 2070s the wettest month will be December with increases of 35.7% to 6.3mm/day. The driest month will be July showing decreases of 36% to 1.7mm/day by the 2050s and 47.6% to 1.4mm/day by the 2070s.

Figure 19
West Midlands, mean daily precipitation change (%) (RCP 6.0 50th percentile with the wider range showing the 10th and 90th percentiles)

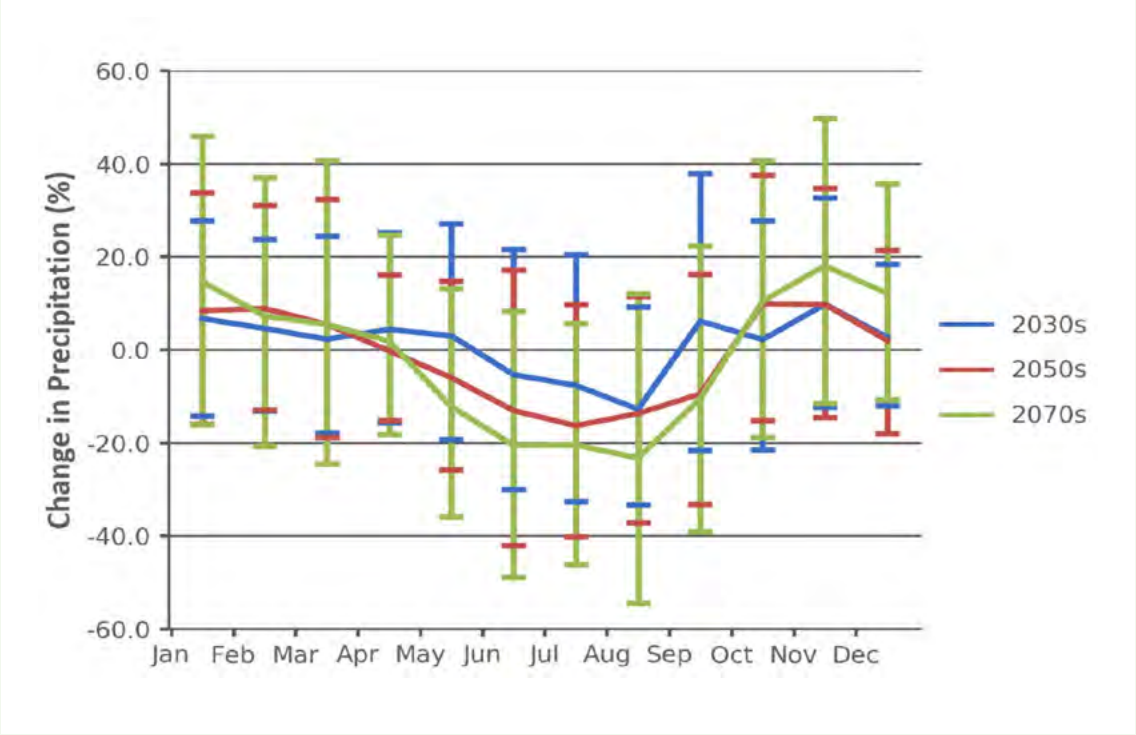
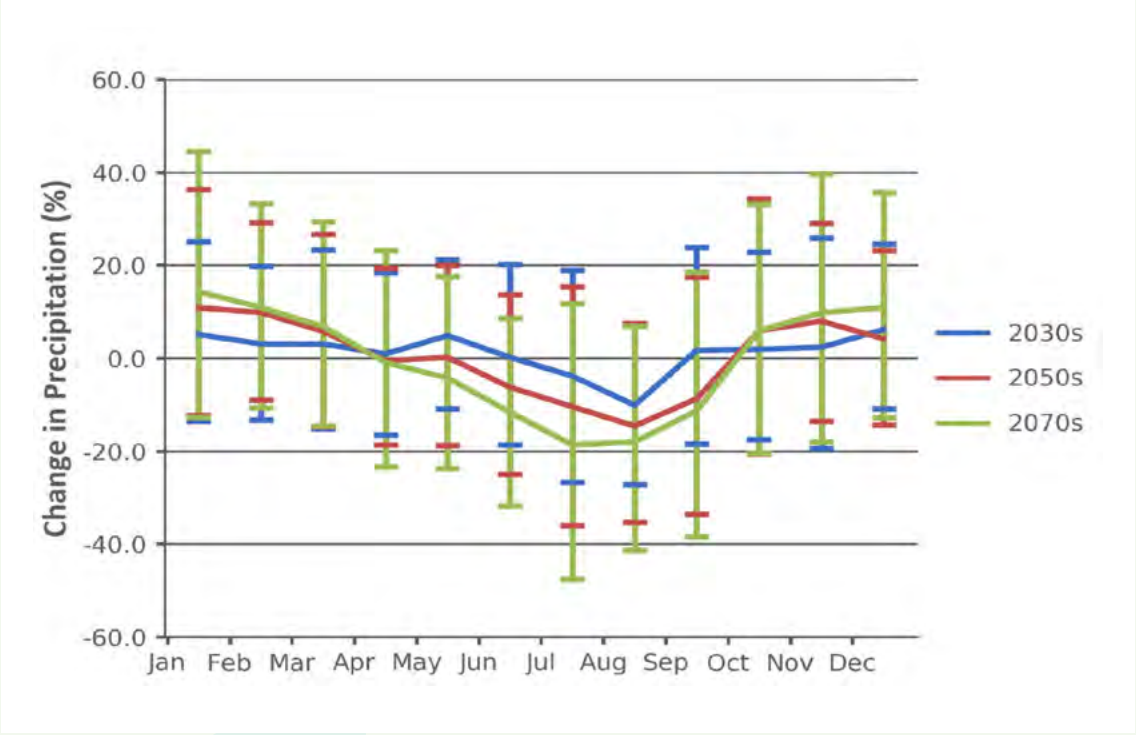


Figure 20
North West England, mean daily precipitation change (%) (RCP 6.0 50th percentile with the wider range showing the 10th and 90th percentiles)



NW&C Region vulnerability assessment continued

Storm intensity and river flows

In addition to changes in total rainfall, climate change is also expected to increase the frequency and severity of river flooding events and individual rainstorm events, Summer rainstorms show the largest increases.

The Environment Agency (EA) produces guidance on the rainstorm intensity and river flow uplifts that should be used to account for climate change. This guidance is being reviewed due to the release of UKCP18 climate change data, however, at the time of publishing this plan the guidance is still based on the UKCP09 Medium emissions scenario. This recommends that rainstorm intensities for the administrative regions covered by the NW&C Region should be increased by; 10 % for the 2050s and 20 % for the 2080s. Climate uplifts[9] for river flows are provided by river basin and those relevant to the NW&C Region are shown in Table 1.

Table 1
River flow uplifts (UKCP09)

River basin	2050s uplift	2080s uplift
Severn	25 %	35 %
Humber	20 %	30 %
North West England	30 %	35 %
Solway	25 %	30 %

Sea level rise

Sea level rise varies around the coast due to differences in coastal morphology and isostatic rebound since the last ice age. As this is also affects the degree of sea level rise, UKCP18 projections have been obtained for 3 coastal locations in the administrative region covered by the NW&C Region.[10]

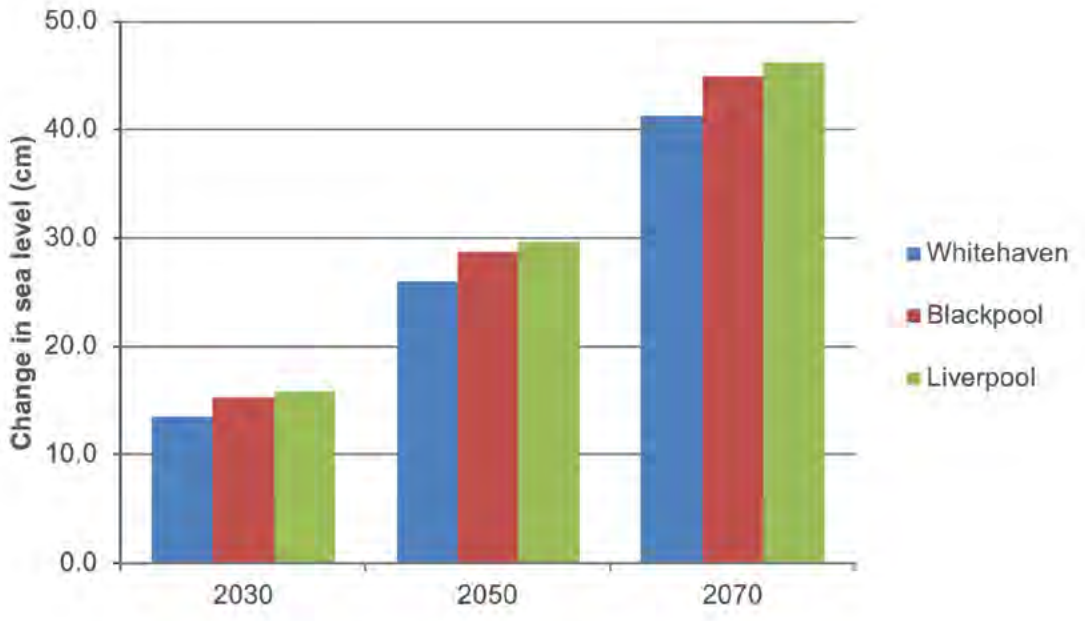
North West England

Liverpool will see the highest rises by 2050 and 2070 of 29.7cm and 46.2cm respectively and Whitehaven will see the lowest at 26.1cm and 41.3cm.

[9]EA higher central climate change estimate as the most comparable to Network Rail's climate change planning scenario.

[10]Sea level rise data in UKCP18 is not available for RCP 6.0, instead RCP 4.5 is used as a proxy on the recommendation of the Met Office. This is the most compatible with the Network Rail Primary planning scenario.

Figure 21
Sea level rise projections for North West England (cm), RCP 4.5 95th percentile



NW&C Region impact assessment

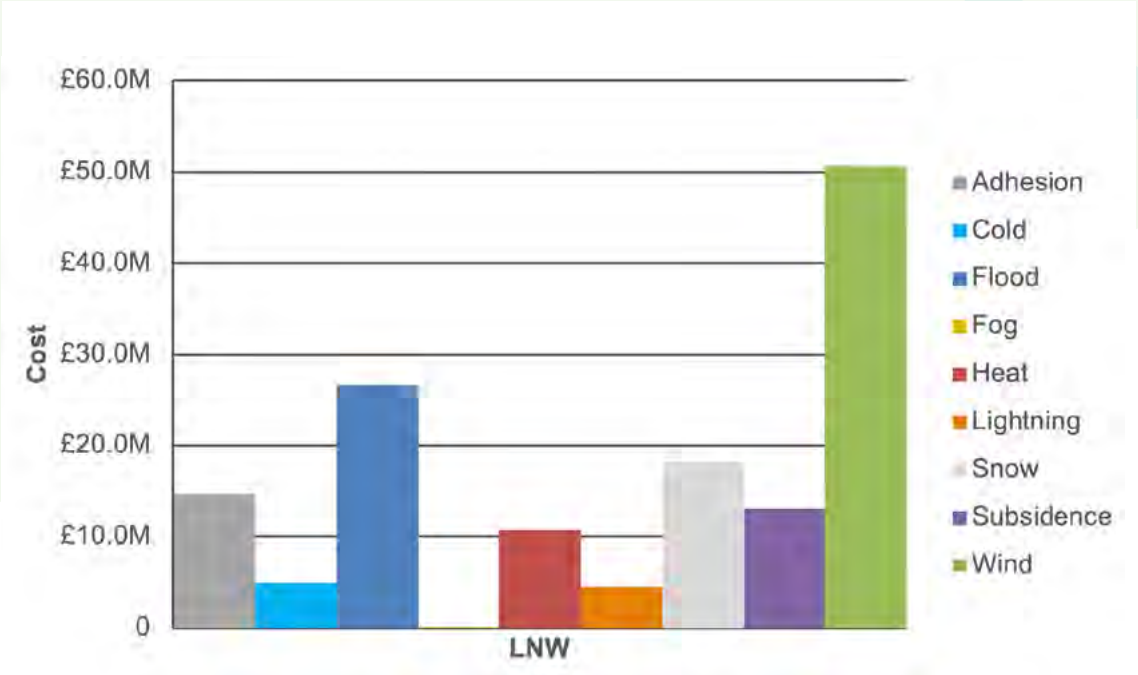
This section provides an update of the NW&C Region weather impact assessment findings published in the 2014 NW&C Region WRCCA Plan, including annual performance impacts and identification of higher impact locations in the Region.

Performance impacts

The impact of weather events on our network's performance is monitored using delay minutes and Schedule 8 delay compensation costs as proxies.

As these data include the duration and location of each disruption, and attribute cause, they give a high degree of granularity for use in analysing weather impacts and trends.

Figure 22
NW&C Route weather attributed Schedule 8 costs- 2006/07 to 2018/19



The updated analysis shows that wind related incidents still cost the most and that the costs of wind and flooding related incidents have risen sharply. Flooding has now cost significantly more than snow. As the largest impact by far, wind has cost a total of £50.6m in the last 13 years, almost double the cost of flooding related incidents (£27m) over the same period.

Climate modelling cannot provide future weather forecasts, but it does give us projections for the trends in future weather patterns. Combining these trends with our analysis of current weather impacts allows us to understand the future vulnerability and possible impacts upon the NW&C Region.

In the 2014 plan eight financial years of Schedule 8 data were analysed to give an assessment of the weather impacts for the LNW Route. This Plan updates that assessment using additional data from the past 5 years, see Figure 22.

There is a high degree of confidence in the UKCP18 projections for temperature, rainfall and sea level rise, but lower levels for wind, lightning and snow fall. Planning for the latter parameters should still be undertaken, but outputs should be more flexible to acknowledge the higher possibility of alternative climate outcomes.

The findings from the combined analysis of current weather impacts and UKCP data (UKCP09 for wind, lightning and snow and UKCP18 for temperature, precipitation and sea level rise) will be used in the prioritisation of resilience actions as summarised in Table 2 below.

Table 2
Prioritisation of weather-related impacts on NW&C Region

Impact	Schedule 8 Cost per year[11]	Climate projection[12]	Prioritisation
Wind	Average £3.90m Highest £9.0m	Changes difficult to project, however generally expected to increase	High
Adhesion	Average £1.23m Highest £2.40m	Complex relationship between multiple causes and their climate projections	Medium
Snow	Average £1.40m Highest £7.0m	Changes difficult to project, but increases in Autumn, Winter and Spring minimum temperatures suggest reduced snow days	Medium
Lightning	Average £0.34m Highest £1.43m	Changes in storms difficult to project, however generally expected to increase	Medium
Cold	Average £0.41m Highest £1.90m	Increases in mean daily minimum temperatures across the regions in Autumn, Winter and Spring range from 1.8°C in April and May to 2.9°C in September for the 2050s and 3.8°C in February to 4.5°C in September for the 2070s	Low
Subsidence	Average £1.0m Highest £4.77m	Increases in mean daily rainfall across the regions for late Autumn, Winter and early Spring months, for example; 16.0 % in April and 37.5 % in October by the 2050s becoming 23.2 % in April and 49.6 % in November by the 2070s. Increased frequency and intensity of Winter and Summer storms. Decreases in mean daily rainfall for late Spring through to early Autumn, for example; 18.8 % in May to 42.1 % in June by the 2050s becoming 23.7 % in May and 54.5 % in August by the 2070s	High
Heat	Average £0.82m Highest £3.6m	Increases in mean daily maximum temperatures across the regions range from 2.1°C to 2.6°C (Winter) and 2.3°C to 4.3°C (Summer) by the 2050s. In the 2070s this becomes 2.8°C to 3.7°C and 5.9°C respectively	Medium
Flooding	Average £2.05m Highest £8.6m	Increases in mean daily rainfall for late Autumn through to early Spring and increased intensity and frequency of Winter and Summer storms (see subsidence)	High
Fog	Average <£0.01m Highest £0.1m	This is a complex picture with low confidence,[13] however possible seasonal changes across the regions for the 2080s have been indicated as: Winter +2 % to -25 %, Spring -37 % to -47 %, Summer -56 % to -69 % and Autumn -19 % to -25 %	Low

It should be noted that the rate charged for Schedule 8 delays increased in 2015 and that this will have been responsible for some of the increase in delay costs. However, this affected all weather-related delays equally and does not affect their relative impact rankings.

[11]Based on Schedule 8 costs per year over the last 13 years from 2006/2007 to 2018/2019.
[12]UKCP09 projections still used for wind, snow, lightning and fog as UKCP18 does not contain updates.
[13]Probabilistic data is not available from the UKCP09 data sets, this has been sourced from a supplementary UKCP09 report and represents the average of 11 models run using the Medium emissions scenario.

NW&C Region impact assessment continued

Identification of higher risk locations

Since the publication of the last Plan the NW&C Region network has continued to experience extreme weather events that have challenged weaknesses in our assets and operations. Climate change projects more frequent and intense extreme weather events, so understanding the impacts of current and future events is critical to investment decision making.

The impacts of weather on our Region are captured via the delay minute and Schedule 8 cost data and input into our METEX GIS system along with gridded observed weather data. The outputs of this allow high impact frequency/cost sites to be identified and targeted for detailed assessment to:

- Verify the attribution of the delay(s) to a weather impact(s),
- Determine the root cause of the delay,
- Identify if resilience action has been taken in the past or is already planned, and
- Generate and prioritise appropriate resilience actions.

In addition to the above assessments we have also identified potential future risks and resilience actions based on climate change projections and Route knowledge.

Combining these findings allows us to proactively identify potential investments that would address current weaknesses and mitigate and/or enable the mitigation of future risks. This approach is critical in creating a railway that is safer and more resilient to weather impacts now and in the future.

Heat impact assessment

Between 2006/07 and 2018/19 heat related incidents accounted for an average of 16,789 delay minutes and £0.82m in Schedule 8 costs per year. This was 5.3% of LNW Route's annual weather-related delay minutes and 7.5% of the annual average cost.

Track asset

Rails expand as they warm up; they also absorb heat and in the bright Summer sun and can reach temperatures far in excess of air temperatures. If the correct precautions are not taken, both Continuous Welded Rail (CWR) and jointed track can buckle as a result of the expansion. As a buckle normally occurs whilst a train is passing over the site there is a risk of derailment

In order to prevent buckles, CWR is kept at a "Stress Free Temperature" (SFT) of between 21°C and 27°C; for current climatic variation in the UK and this will continue through CP6. The current climate change predictions adopted by Network Rail suggest that over the next 60 years the annual temperatures will become hotter on average in all seasons, with a longer Summer period, later Autumn and earlier Spring. It is anticipated that on occasion Summer temperature extremes will still bring speed restrictions to the network.

More research is needed into the development of a track management regime appropriate to the future climate predictions if the number of days on which heat related speeds are imposed is to be maintained or reduced. Measures such as a gradual increase in SFT or increases in the mass of track (for example through reduced sleeper spacing) may be options to achieve better performance as annual average temperatures increase.

The maintenance and renewal regime in CP6 is being carefully reviewed to try to optimise the use of scarce access opportunities to provide the best balance between renewal and rail stress management. However, the severe limitations on track access will remain or even worsen as traffic levels and tonnage increase and so there are limits to the performance benefits (i.e. the reduction in the number of ESRs) which can be realised.

Vegetation

The triggers that lead to leaf fall are complex and climate change may influence them in a number of ways. Higher overall temperatures throughout the year will increase the length of the growing season. Warmer and wetter Springs and Autumns may promote more profuse vegetation. Hotter and drier Summers will change the mix of species and the vigour with which they grow. All of these factors will affect the change in leaf fall pattern, possibly driving it later into the season. However the reduction in day length is also a trigger to leaf-fall and as this will not change leaf-fall is expected to continue to be an issue.

The expected gradual change in the mix of tree species, with colder climate trees unable to survive in the Southern part of the Route and better adapted species becoming more vigorous, could lead to a greater incidence of dying trees. This would raise the risk of falling trees capable of reaching the track if they if they are not already removed by our Vegetation Management Programme.

More vigorous growth may be problematic where plant growth occurs on structures or rock slopes accelerating deterioration through root jacking of masonry and joint sets on rock faces and requiring more frequent maintenance interventions.

Earthworks

Moisture abstraction by the root systems of trees increases during hot weather and in susceptible geologies (e.g. clays) can lead to shrinkage and hence settlement of the ground, in particular embankments. Desiccation effects such as these lead to a deterioration in track quality with an increased likelihood of speed restrictions if maintenance regimes are not adapted to allow for them.

Desiccation settlement impacts on earthworks will be exacerbated as wetter Winters are accompanied by higher Summer temperatures with a greater likelihood of drought conditions.

NW&C Region impact assessment continued

Buildings

High temperatures have little impact on building fabric although other assets within the portfolio such as platform surfacing can be affected by differential expansion. This can lead to heave and displacement of elements such as platform copers and tactile paving. Renewed or new-build platforms will incorporate expansion joints to accommodate these movements but for those adversely affected there will be a safety risk for station users with access limitations imposed and a potential short-term impact on station capacity.

Much of the impact of hot weather on the buildings portfolio is secondary and related to lineside structures intended for or adapted to housing electrification or signalling plant and equipment. Currently these are usually passively ventilated, but the equipment is often susceptible to over-heating. A trend towards higher average annual temperatures will bring an increased requirement for active cooling through forced air ventilation or air conditioning.

Structures

As with buildings the impacts of heat on structures are limited, however the majority of the masonry asset stock will lack the movement joints required for modern materials and required by current design codes of practice. This can be problematic on particularly large structures such as retaining walls where, in rare cases, it can cause bulging and separation of areas of masonry. There is no planned programme of intervention on these types of asset failure and these will be managed within the routine capital funding.

Signalling and Telecoms

As previously mentioned high temperatures can impact signalling electronics in lineside buildings and relay rooms which are not adequately cooled or ventilated. Many signalling assets are also contained within metal location cases which are also prone to over-heating. This risk can be increased if additional Signalling and Telecommunications (S&T) equipment is added to location cabinets over time, putting extra strain on any existing cooling systems. To combat the build-up of heat at these locations on NW&C Region, air conditioning, extractor fans, solar powered forced air ventilation and 'hoods' that shield the equipment housing case from direct sunlight have been fitted to keep the location and equipment cool.

Track mounted signalling equipment is also vulnerable to direct heat and both solid state interlockings and axle counters can fail as a consequence of hot weather, leading to performance issues.

Hot weather also impacts signalling assets which are integral to other asset groups such as the track system. Switch diamonds are prone to impairment of function and Insulated Block joints are vulnerable to damage due to rail expansion.

Electrification and Plant

As with the signaling system, many electrification and plant assets are housed in Relocatable Electrical Buildings. Substations may also be housed in lineside buildings or may be containerised. At many of these locations natural or forced air ventilation using ambient temperatures may be inadequate to maintain temperature levels suitable for the continued function of the components, causing failures leading to performance impacts.

OLE catenary and contact wires rely on designed tensions to maintain function and prevent damage to train pantographs. Hot weather causes expansion of these components and a loss of tension where wire runs become lengthened over time or tensioning weight systems reach their limit of travel. Current systems are designed to operate between 18 and 38 degrees, but as with track stressing, developing a system to operate within a wider temperature range is likely to require a revised approach to routine maintenance and design.

Cold and snow impact assessment

Between 2006/07 and 2018/19 cold related incidents accounted for an average of 12,832 delay minutes and £0.38m in Schedule 8 costs per year. This is 4.1 % of our annual average weather-related delay minutes and 3.4 % of the annual average cost. Over the same period snow related delays averaged 46,078 minutes and £1.40m in Schedule 8 costs per year. This is 14.6 % of the annual average weather-related delay minutes and 12.7 % of the annual average cost.

Although current climate change models suggest that Winters will be shorter, and that frost and snow days will reduce, the current levels of severity of low temperatures remain possible. A gradual reduction in cold weather-related delay minutes appears likely, but the combination of high Winter rainfall and occasional rapid freeze and thaw remains a concern, particularly for the civils assets (earthworks, buildings, structures, and drainage).

Whilst the frequency of snowfall is projected to decrease, it will still be possible and extremes of precipitation in cold weather may lead to increased snow loading **on building roofs**. Structural assessments allow for current loadings, but a climate change provision must be considered as those with inadequate strength this could be susceptible to collapse. Cold weather carries further risks for buildings assets such as icing of platforms and the potential for frost heave displacement of surfacing including paving. This is a safety risk for passengers and a further risk is of train strike of platform copers.

Figure 23
Ice build-up – Birkett Tunnel

NW&C Region impact assessment
continued

High Winter intensity of precipitation, whether rain or snow, would lead to a greater than current groundwater recharge, continuing the potential for excessive ice formation in certain tunnels and on other structures, and frost damage to structures and **rock slopes**. This would reduce asset life and potentially cause debris to fall on the track. Snow melt is of particular concern where drainage systems are not appropriately designed. Overwhelmed **drainage** and high groundwater levels may give rise to flooding or contribute to earthwork instability.

Snow and ice build-up obscuring **signals** and impairing the movement of mechanical switches and signal equipment are a routine hazards now and will continue to be so. Icicle build up in tunnels and on bridges may also compromise the function of OLE equipment or damage train pantographs and this is the most significant type of incident in terms of delay minutes incurred and schedule 8 costs recorded. When severe cold weather is forecast, additional bespoke icicle patrols are instigated as a risk control measure in known areas prone to icicle formation.

Figure 24
Snow driven inside a points operating machine

Flooding and sea level rise impact assessment

Between 2006/07 and 2018/19 inland and coastal flood related incidents accounted for an average of 65,390 delay minutes and £2.05m in Schedule 8 costs per year. These represent 20.7 % of our annual average weather-related delay minutes and 18.6 % of the annual average cost.

Figure 25
Coastal flooding, Cumbria

Flooding

As already mentioned Winter precipitation and the frequency and intensity of Winter and Summer storms is likely to increase. In the Winter months this could mean greater ground saturation, higher groundwater levels, increased run off, higher river levels, faster river flows and increased flood risk.

In the Summer months an overall reduction in rainfall with a higher likelihood of drought conditions will lead to hard drier land. This combined with high intensity Summer storms is likely to lead to more 'flash flood' type events during that season.

NW&C Region impact assessment
continued

Track components remain largely unaffected by increased rainfall, provided that there is clean free-draining ballast, the formation is constructed to a fall and the drainage system is well maintained and effective.

Higher Winter and storm precipitation will therefore require much greater attention to ballast condition and the quality of track renewal including, continued good practice in formation preparation to ensure that increased rainfall can be rapidly discharged to drainage systems.

Appropriately designed and maintained **drainage** is essential to ensure that increased rainfall is managed effectively, and a 'whole system' approach is required to ensure that:

- The drainage captures water as it enters the rail corridor,
- The earthwork cutting slopes, bridges, tunnels and culverts along with ancillary lineside assets (e.g. Electrical and Plant and signalling equipment) are adequately protected from the impacts of both surface and groundwater,
- The track system is able to be drained effectively within tunnels, cuttings, stations and sidings,
- Water is conveyed away from the railway without causing damage to embankments or other railway assets,
- Third parties down-stream of the railway are adequately protected from flows discharged, and
- Drainage systems have adequate capacity for the flow anticipated and are adequately maintained to ensure that the capability exists to carry that water away.

Current design standards require new drainage to be designed for peak storm intensities and also to include an uplift in capacity for climate change. Improved asset knowledge and greater investment is essential to ensure that these elements are included in future works.

The Drainage and Off-track team are working closely with the Maintenance delivery teams to ensure that newly identified or reconstructed drainage assets are prioritised for inspection and maintenance on the basis of condition change, with the most rapidly deteriorating assets prioritised for maintenance intervention. This approach is detailed in the Region Drainage Management Plans which are tailored to the conditions on each maintenance delivery area.

Earthworks are very vulnerable to the uncontrolled accumulation of water from sheet flows across adjacent land towards the railway in low lying areas, or more concentrated flows at low points along the railway boundary. Earthworks can be protected against these impacts by an active maintenance and/or renewal programme for existing drainage assets which are installed to protect them, or through the incorporation of flood defence mechanisms on embankments where standing flood water is likely.

At locations where drainage assets on earthworks are assessed as being under-capacity, a systematic risk-based programme of refurbishment and renewal will bring a gradual improvement in resilience to the impacts of flood water.

Effective drainage is also key to the resilience of Buildings assets to adverse or extreme rainfall events which can lead to the flooding of lineside buildings, platforms, subways and occasionally car parks. A greater focus on renewals and maintenance tasks in conjunction with the Train Operating Companies (TOC's) will bring benefits in CP6 and beyond in reducing the likelihood of flooding incidents. Significant problem assets, where identified continue to be dealt with in the course of routine survey, evaluation and renewals.

Figure 26
Chalk wash out failure, Watford – September 2016

NW&C Region impact assessment continued

Figure 27
Flooding at Carnforth station subway

As with the Buildings assets problems with the drainage of **structures** typically form part of the routine evaluation of structures examinations. Any works required to manage the accumulation of surface water on structures are delivered via the capitally funded maintenance refurbishment or renewal.

Where flooding occurs in river catchments however the greater risks to structures are associated with scour of bridge, retaining wall and other foundations or the lateral loadings on metallic bridge decks which are at, or below, river flood levels. Network Rail manages a programme of scour risk assessment for structures, and critical locations are included in the CP6 plan as part of the overall prioritised programme of work. The risk assessments make allowances for extreme conditions, modelling against a 1:150 year return storm event with an uplift applied for climate change.

For both **signalling** and **electrification** plant and equipment the primary short-term risks are associated with inundation during times of extreme rainfall. This can be exacerbated by the failure of mitigation measures such as natural gravity/infiltration drainage systems or pumps installed for the purpose.

Although the CP6 renewals will be evaluated to ensure that flood risk is accommodated in pump capacity, there is no planned programme to upgrade systems across the network to allow for climate change. Increases in groundwater levels as a consequence of increased rainfall will require a review of pump capacities for climate change throughout the Route. On locations such as the Merseyrail network such studies will be extremely complex with significant one-off cost implications for future control periods.

In DC third rail areas, track flooding will lead to tripping out of the power supply.

Sea level rise

Predicted sea level rises will have an impact on coastal and low-lying areas in the Western part of the Region. At the level changes predicted they are unlikely to cause damage to railway assets but will present a risk to the railway when considered in conjunction with increased storm intensity and frequency.

Inundation will also become increasingly likely at locations where land is ‘impounded’ by the railway and sea level rise reduces the effectiveness of surface water discharge through Network rail assets (e.g. embankments) to estuaries.

There remains an increased likelihood that greater pumping capacity will be required as the EA implements a policy of managed retreat under which it may remove its support for pumping schemes in low-lying areas, such as the Alt Crossens catchment area in Lancashire. Again, there has been no consideration of such cross-party arrangements in the planning for CP6, but NW&C Region remains an active member of the Cumbrian Strategic Flood Partnership and continues to build strong links with the EA and other relevant statutory bodies.

Subsidence and Earthworks failure

Between 2006/07 and 2018/19 subsidence-related incidents (earthslip, desiccation etc) accounted for an average of 23,282 delay minutes and £1.0m in Schedule 8 costs per year. This is 7.4% of our annual average weather-related delay minutes and 10% of of the annual average cost.

In addition to the flooding impacts identified in the section above, **earthworks** are very vulnerable to increased groundwater levels leading to slope failures. As with surface and flood water, earthworks can be protected against these impacts by improvements to drainage provision and the strength of the soils. This can be through re-design of the slopes (for example slackening the slope gradient of cuttings) or through the addition of mechanical means of stabilisation (additional fill material, stiffening elements including piles, soil nails and other soil reinforcement).

The programme of work being undertaken in CP6 seeks to continue to maintain the overall earthworks asset condition through the implementation of improvement works as outlined above, and through a much greater provision of drainage measures. This is being undertaken in CP6 through close working between the Earthworks and Drainage teams. It will be a joined up approach to the identification and evaluation of drainage assets and planning of maintenance, refurbishment and renewal of drainage at high risk locations.

Soft rock strata such as the Chalk, mudstones and marls which are frequently encountered in cuttings are susceptible to shallow weathering, and this has been on-going since the railways were constructed. Increased rainfall levels lead to saturation of the surface weathered materials with the potential for accelerating this weathering as well as increasing the likelihood of failure of this weathered layer.

It is intended to review the distribution of all of these material types in CP6 and to develop a risk profile for the Route to assist in future planning of engineering interventions due to weathering. This will inform prioritisation of investment decisions in CP7 and beyond.

Remote condition monitoring applications in CP6 will receive further investment provision for the installation of movement indicators on high risk earthworks assets.

Earthwork cuttings located within soluble geologies such as Gypsum, Halite (Rock salt), hard and soft Limestones (including Chalk) may be subject to inundation flooding by groundwater following sustained periods of high rainfall. This can lead to sudden collapse of the superficial infill materials which choke the upper elements of fissure / cave systems within these materials leading to subsidence.

It is intended to review the distribution of all of these material types in CP6 and to develop a risk profile for the Route to assist in future planning of engineering interventions due to inundation collapse in CP7 and beyond.

The seasonal subsidence effects caused by vegetation have already been discussed as part of the high temperature impacts on the Route. We have a mature and robust programme for vegetation management and this has been prepared with reference to the impacts on **earthworks** and relevant national guidance. Whilst seasonal subsidence impacts will continue to be felt on cohesive embankments, the Vegetation Management Programme should be completed in advance of significant climate change temperature increase, and a gradual reduction in the number of desiccation related **track** subsidence incidents is anticipated.

Earthworks embankment failures will cause a loss of support to track and potentially other structures and cutting slope failures will cause loss of ground at cutting crests with potential impacts on third party land and property. The primary cause of earthworks failure is elevated or unmanaged ground and surface water. These issues have already been discussed in the section on flooding above.

NW&C Region impact assessment continued

Wind impact assessment

Between 2006/07 and 2018/19 wind related incidents accounted for an average of 85,287 delay minutes and £3.90m in Schedule 8 costs per year. This is 27 % of our annual average weather-related delay minutes and 35.3 % of the annual average cost.

Whilst it is difficult to model wind speed into the future the expected trend is for increased gust speeds and increases in the frequency and intensity of storms as heating of oceans and atmosphere increases the energy available in the system.

Lineside vegetation is directly vulnerable to high winds. Trees can fall onto the track in the path of trains, and damage critical infrastructure.

Figure 28
Windblown trees on OLE

Whilst it could be anticipated that tree fall impacts will increase under more frequent extreme events, NW&C Region has a **Vegetation** Management Plan in place. This seeks to selectively fell lineside trees to achieve a profile which retains only trees of a height such that they would not reach the track if they were blown over. At current funding levels this target will be achieved across the Route by the start of CP9 (2034).

The specification further requires regular maintenance treatments to limit the likelihood of future tree growth in close proximity to the tracks and to encourage only low shrubs, bushes and grassland there. This has the potential to improve biodiversity whilst limiting the future maintenance burden for signal sighting, level crossing sighting and proximity to OLE, all of which can give rise speed restrictions.

Unfortunately, Network Rail has no legal authority to manage third party trees on adjacent land, many of which are tall enough to reach critical infrastructure should they fall. There is currently no plan to manage this, and so there remains a safety risk to train drivers and passengers should a train de-rail on hitting a fallen tree, and a significant performance risk in the event that trees fall onto lineside infrastructure.

The frequency and extent of damage to the Civils asset groups, including **earthworks**, **structures** and **buildings** is likely to increase due to the combination of higher peak tide levels and wind-driven storm surge/wave action. NW&C Region has developed Coastal Management Strategies to consider the scheduling and disposition of coastal defences and this is integrated into the CP6 Business plan with high risk locations identified for remediation.

During periods of high winds, particularly when blowing from the West, the risk of coastal erosion and sea defence overtopping will start to have a serious impact on performance with safety speed restrictions imposed. Train services on the Cumbrian Coast line, for example, are likely to be increasingly disrupted with services suspended or speed restrictions imposed in order to protect against wave damage to trains, and because of the risk of wash-out of ballast and **track** formation. In extreme cases, high wind coupled with high tide can lead to failure of the sea defences and loss of support to the railway.

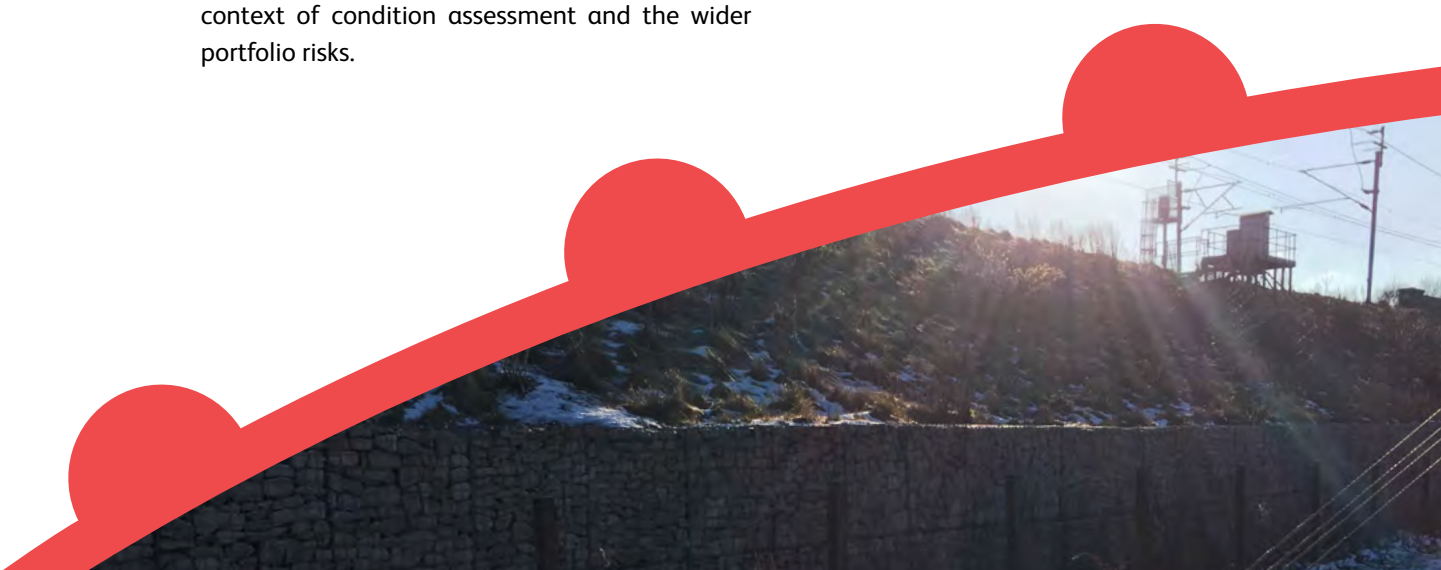
The Structures team, who manage the LNW coastal defences programme, are members of the Cumbrian Coastal Strategy Planning and Review Group and liaise closely with the other members (Cumbria County Council, EA, Lead Local Flood Authorities [LLFA]) to present an integrated approach to the management of coastal defences. There is, however, no discrete and prioritised programme of coastal defence work in CP6 and each scheme has to be evaluated and balanced against a limited budget and other demands across the portfolio.

High winds can bring risks to certain other structures and building types including foot bridges which are frequently lightly loaded but which present a high profile to prevailing winds and can get blown over. Parapet and boundary walls are also at risk of being blown over and this can be exacerbated where security fencing has been added to the top of masonry structures. Neither of these risk groups are specifically addressed in CP6 with individual cases being considered in the context of condition assessment and the wider portfolio risks.

Larger roofed buildings such as train sheds at stations are vulnerable to wind damage and any concerns are managed through the annual visual and 5 yearly detailed inspection programmes. Considerable work has been undertaken on these large vulnerable structures in CP5 and there are no plans for any targeted campaigns of work in CP6, with individual locations being included on merit as part of the wider business plan and balanced against the wider Route portfolio.

At coastal locations it is to be expected that there will be a gradual increase in asset failure in both the **electrification and plant**, and **signalling** asset groups due to the very hostile environment generated by storms. There is however no planned programme to improve resilience against wind in CP6. Whilst tree fall remains the primary yet indirect cause of wind-damage to the OLE, a large proportion of delay is caused by debris accumulation on the equipment (e.g. branches, polythene, trampolines) which cannot be easily managed. In addition, there is the potential for 'blow-off' of OLE during extreme conditions which can lead to dewirement due to pantograph mis-alignment and entanglement with the contact wire support system (catenary, droppers and registration arms).

From an operational perspective, high winds may lead to damage of rolling stock and containers being blown off freight trains. Such events are unusual, but the potential needs to be managed as the frequency and severity of high winds increases.



NW&C Region impact assessment continued

Lightning impact assessment

Between 2006/07 and 2018/19 lightning related incidents accounted for an average of 11,796 delay minutes and £0.34m in Schedule 8 costs per year. This is 3.7% of our annual average weather-related delay minutes and 3.1% of the annual average cost.

Lightning strikes will remain as unpredictable as at present but, with a greater frequency of higher energy storm events likely, the number of lightning strikes could be expected to rise. Trees struck by lightning may fall onto the track or onto vulnerable lineside plant and equipment but the NW&C Region **Vegetation** Management Programme will lead to a gradual reduction in risk and the delay associated.

A limited number of metallic **structures**, for example Runcorn Bridge, are equipped with lightning conductors. The buildings portfolio maintains a register of lightning conductors and these are tested for effectiveness annually as part of a preventative maintenance programme.

Signalling assets are routinely equipped with surge protection and whilst there is a desire to upgrade its provision across the network this is not now planned as a programme in CP6, being addressed only on a reactive basis as and when a fault is identified. All new signalling systems will however be designed with surge protection in line with current standards. Similarly there is no plan in CP6 to improve overall lightning strike protection on **electrification** assets, but all renewed systems will incorporate protection to current standards.

Adhesion impact assessment

Between 2006/07 and 2018/19 adhesion related incidents accounted for an average of 54,097 delay minutes and £1.14m in Schedule 8 costs per year. This is 17.1 % of our annual average weather-related delay minutes and 10.3 % of the annual average cost.

Whilst higher overall temperatures throughout the year and an increase in rainfall averages will promote a longer growing season with more profuse vegetation the NW&C Region Vegetation Management Plan described in the section above on vegetation should substantially reduce the impacts on operations. The programme selectively removes leaf-fall species which cause adhesion issues and the Route specification targets, in particular, the approaches to stations.

Strong winds are the major cause of leaf fall, however some trees will shed during extreme rainfall events and so storm events will continue to bring a risk of poor adhesion and track circuit failures for the period that the vegetation remains unmanaged. The worst adhesion issues will continue to reach a peak in the early Autumn.

Third party trees also have the potential to cause adhesion problems and as previously mentioned, Network Rail has no legal rights to manage them to reduce risk.

Fog impact assessment

Between 2006/07 and 2018/19 fog related incidents accounted for an average of 178 delay minutes which is less than 0.01 in Schedule 8 costs per year. This is less than 0.1 % of LNWs annual average weather-related delay minutes and less than 0.1 % of the annual average cost.

Climate change predictions suggest that all seasons will see reductions in fog days on the NW&C Region with the exception of the possibility of some small increase in the Midlands during Winter months. However, these are low confidence projections (see climate data).

Fog only presents an issue from an operational perspective affecting signal sighting and limiting track-based activities which are reliant on good visibility.

Signalling activities will continue to be managed in accordance with the current systems and there are no plans to alter the rulebook and the processes included.

NW&C Region WRCCA actions

As the impacts of weather events are location specific NW&C Region will be responsible for identifying and carrying out the WRCCA investments necessary to deliver the continued and improved resilience of their assets and operations.

Network Rail's central functions will assist and enable the NW&C Region in this by providing asset policies and design standards that have weather resilience and climate change considerations embedded within them, by carrying out root cause analysis of national weather and asset data and through the review and adoption of appropriate new technologies.

This section summarises the WRCCA actions undertaken by the LNW Route in CP5 and those that we have planned for CP6. The first two tables in this section show the:

- Progress against the; CP5 WRCCA actions identified in the 2014 Plan (Table 3), and
- WRCCA actions planned for CP6 (Table 4).

The third table, Table 5, contains potential additional actions that the NW&C Region has identified as desirable to deliver WRCCA resilience, but which are not funded in the current CP6 business plan. The delivery of these actions may be planned for one or more Control Periods in the future and they will require further development and business case evaluation before making a funding submission in the appropriate Control Period.

The final table (Table 6) details actions that have been apportioned to Network Rail, and hence the NW&C Region, in the Defra NAP. Some of these will align with CP6 planned and funded actions (Table 4), some will align with the actions in Table 5 and others will require further consideration in CP6 and beyond.

Table 4 and Table 5 cross reference with Table 6 to indicate the relationship between the NW&C Region actions and the delivery of the NAP actions.

Table 3
2014 WRCCA Plan
CP5 actions review

Action name	Target completion date	Actual completion date	Comments
All Impacts			
• Climate requirements in Route Requirements Document (RRD)	Ongoing	Ongoing	RRDs exist within all asset disciplines. These are live documents which are regularly updated and incorporate Network Rail standards compliant requirements to address Climate Change predictions. All staff have access to a full range of PPE suitable for all routine working conditions.
• PPE/seasons preparedness	Ongoing	Ongoing	The programme of installation experienced problems of supply and integration into existing Network Rail comms networks. A programme is underway in y1, CP6 to deliver a trial installation area, with options for roll out later in the control period.
• Weather stations	Within control period	Deferred to CP6	
Flooding			
• Liaison with Flood Authorities	Ongoing	Ongoing	Quarterly meetings or ad-hoc meetings established with LLFA and strategic flood bodies, including Cumbrian Strategic Flood Partnership and Environment Agency Midlands and North West.
• Drainage data validation	April 2015	Completed	Drainage data capture trial completed and volume of missing drainage data quantified. Route -wide programme developed to deliver a comprehensive boundary to boundary drainage asset data set. Planned completion March 2023.
Earthworks			
• Complete 'Blue-line' Validation	March 2015	Completed	Route mileage earthworks identification exercise completed. Comprehensive data set now available.
• Third Party Risk Register	April 2015	Completed	Development phase completed and shared nationally. NW&C Region system adopted for national roll out in CP6.
Coastal and Estuarine			
• Severe tide response	October 2015	Completed	Tidal response incorporated into weather services (Met Desk). Formal attendance of structures and other asset owners on Emergency conference calls for adverse weather (EWAT).
• Develop Frontage Management Plans	October 2016	Ongoing	Coastal asset management plan produced (Oct 2016). Coastal, Estuarine and River Defence plans are under prioritised development. Close liaison with Regional Flood and Coastal Committee is being maintained for a joint approach to coastal defence management in Cumbria.
Wind			
• Manage Network Rail vegetation	March 2019	Ongoing	Prioritised plan developed in CP5 to deliver compliance with Network Rail vegetation standards. Risk based planning applied to incorporate OLE, signalling and high consequence Routes. Ongoing vegetation clearance will complete Regional programme in by CP9.
• Manage 3rd Party tree risk	March 2019	Ongoing	Trees managed as part of over-arching Vegetation Management Plan.
High Temperatures			
• Management of hot weather mitigations on track	Ongoing	Ongoing	Hot weather preparedness incorporated into track renewals programme planning to ensure that access opportunities exist to undertake works and that correct rail stressing is applied.
Cold and Snow			
• Ice mitigation trial (Nansulate)	April 2015	On-going	Trial effectiveness reliant on evaluation during appropriate weather conditions. Insufficient data captured so far and trial continues. Alternative trial options are being evaluated at Summit Tunnel case location.
• Points operation strategy development	November 2014	On-going	Installation of mitigations undertaken on critical assets as they are identified.
Adhesion			
• Enhanced Vegetation Management scheme	March 2019	On-going	Actions incorporated into Region Vegetation Management Plans (see 'Wind' above).
• Application of Adhesion Modifier	March 2016	Ongoing	Conventional applicator programme maintained throughout CP5. Geo-location now incorporated into fleet renewals procurement specification for CP6.

Table 4 – Planned WRCCA investment for CP6 – 2019 to 2024

Vulnerability	Location	Action to be taken	Cost of action	Expected benefit	Target completion date	Resilience change	NAP action reference
Heat	Regional	Track Renewals programme phasing review to allow greater provision for rail stressing.	Neutral	Greater availability of access provision, reduction in Heat speed TSRs.	31/03/24	Local increase in resilience due to better managed stressing rail regime.	-
Heat	Regional	All renewal of signalling and electrification plant in lineside buildings to be considered for incorporation of cooling systems.	10 % uplift on project value	Greater resilience to high Summer temperature and reduction in system failures with consequential performance improvement.	31/03/24	10 % reduction in E&P and signalling related performance delay through Control Period.	-
Heat	Regional	Re-tensioning of contact wires for OLE.	£TBA	Reduction in imposition of heat speeds due to contact wire tensions.	CP6 20 % – 31/03/2020 40 % – 31/03/2021 60 % – 31/03/2022 80 % – 31/03/2023 100 % – 31/03/2024	Restoration of wire tensions to compliance with current requirement for 18°C to 38°C resilience.	-
Heat, Subsidence, Wind, Adhesion	Regional	Management of vegetation on high risk Route sections across c. 20 % of the Route mileage.	£25M	Reduced incidence of windthrow of trees, reduced adhesion issues, reduced damage to lineside infrastructure, increased biodiversity.	CP6 Cumulative % of total Route mileage 4 % – 31/03/2020 8 % – 31/03/2021 12 % – 31/03/2022 16 % – 31/03/2023 20 % – 31/03/2024	Improvement in safety and performance risk levels due to tree and leaf-fall, and reduction in desiccation subsidence risk.	-
Subsidence	Regional	Installation of slope movement monitoring equipment.	£2.5M	Reduction in number unforeseen earthworks failures, Reduction in TSRs/ESRs, improved performance.	Ongoing rolling programme	Improved operational management.	NRNAP4
Subsidence	Regional	Implementation of remedial works portfolio at locations at risk of earthworks failure.	£150M	No net increase in the risk of subsidence/failure from aging earthworks Assets.	CP6 20 % – 31/03/2020 40 % – 31/03/2021 60 % – 31/03/2022 80 % – 31/03/2023 100 % – 31/03/2024	Neutral, although all renewed earthwork designs to be to current standards (120 year design life) including consideration of 20 % uplift in drainage capability for climate change.	NRNAP5
Subsidence	Regional	Identification and prioritisation of solution subsidence risk.	£10M	Identification of high-risk locations and delivery of remedial works to remove local risk.	31/03/24	Modest incremental Improvement in resilience of network against subsidence risk.	-
Subsidence	Central and West Coast South Routes	Vegetation management and embankment remedial works at Blackthorn / Piddington and Althorp embankments.	£30M	Removal of TSR risk due to loss of track quality.	CP6 30 % – 31/03/2020 60 % – 31/03/2021 100 % – 31/03/2022	No recurrence of subsidence impacts anticipated over design life (120 years).	NRNAP5
Winds	Regional	Development and implementation of High wind weather alerts for the buildings portfolio.	£1M	More rapid response to incidents with reductions in performance delays.	01/04/24	Improved operational management.	-
Winds	Regional	Elevation of critical wind speed for imposition of electrification ESRs.	Neutral	Reduced performance impact during adverse weather incidents.	01/04/20	Improved operational management.	-
Flooding	Merseyrail network	Improvements to the pumping system for the underground elements of the network.	2M	Reduced flooding frequency.	CP6 20 % – 31/03/2020 40 % – 31/03/2021 60 % – 31/03/2022 80 % – 31/03/2023 100 % – 31/03/2024	Improved flood resilience to 1:50 return storm event.	NRNAP2
Flooding	Regional	Completion of drainage asset data collection to permit targeted maintenance.	£5M (asset data only)	Tracking of drainage asset condition to permit targeted maintenance activities at highest risk locations.	CP6 25 % – 31/03/2020 50 % – 31/03/2021 75 % – 31/03/2022 100 % – 31/03/2023	20 % improvement over CP5 volumes of drainage maintenance undertaken across control period.	-
Flooding	Regional	Continued evaluation of flood risk at locations identified for electrification renewals activities and design of flood mitigation measures.	£TBA	No loss of function during flood event. No renewal works required post incident.	31/03/24	Specific locations now resilient to 1:200 year return storm event.	NRNAP3
Flooding	Regional	Continued evaluation of flood risk at locations identified for signalling renewals activities and design offlood mitigation measures.	£Included	No loss of function during flood event. No renewal works required post incident.	CP6 20 % – 31/03/2020 40 % – 31/03/2021 60 % – 31/03/2022 80 % – 31/03/2023 100 % – 31/03/2024	Specific locations now resilient to 1:200 year return storm event.	NRNAP3
Flooding	Regional	Inclusion of scour prevention works to all locations assessed as Scour Level 1 sites.	£TBA	Reduced risk of structural failure during flood events. Improvement in performance.	CP6 20 % – 31/03/2020 40 % – 31/03/2021 60 % – 31/03/2022 80 % – 31/03/2023 100 % – 31/03/2024	Structure foundations designed to be resilient against 1:150 year return storm event.	-

Table 5
High priority action not funded in CP6

Vulnerability	Location	Potential action	Target completion date	Predicted benefit	NAP reference
Heat	Regional	Active programme for installation of cooling systems to protect existing signalling and electrification electronics.	31/03/24	Greater resilience to high Summer temperature and reduction in system failures with consequential performance improvement.	-
Flooding	Regional	Active programme of raising existing location cases to mitigate risk of flood inundation.	31/03/24	No loss of function during flood event. No renewal works required post incident.	NRNAP3
Cold	Regional	Active programme to install improved drainage at all tunnel shafts to minimise ice formation.	31/03/24	Reduction in safety risk of derailment and injury to drivers/public damage to trains.	-
Wind Sea Level rise Subsidence	Cumbrian Coast	Active programme of improvement of coastal defences against storm surge.	31/03/24	Reduced risk of subsidence and loss of support to track. Improved performance, reduced safety risk.	-
Lightning Strike	Regional	Active programme of testing and renewal of surge protection on signal cabling.	31/03/24	Improved resilience of signalling systems to lightning strike with performance benefits.	-

Table 6
NAP actions

Objective	Action	Timing	NR NAP Reference	Monitoring and metrics
Network Rail will continue to address flood risk across its network by:	Ongoing monitoring of adverse weather through visual and thermal imaging.	CP6	NRNAP1	NR report on performance on a quarterly basis. This includes a running performance of each operator and the punctuality of its services. These are summarised in annual reports each year, allowing for yearly comparisons.
	Building pumping stations in flood-prone locations.	CP6	NRNAP2	
	Building in measures to address flood risk in new lines installing equipment at higher levels to avoid flooding.	CP6	NRNAP3	
Network Rail will continue to comprehensively manage its assets against geotechnical faults as part of its Asset Management Excellence Model, this will include:	Ongoing identification of sites vulnerable to landslips with use of Light Detection and Ranging surveys, in-place motion sensors, CCTV and ground investigations.	CP6	NRNAP4	
	Slope stabilisation management via drainage, or steel rods, soil nails or slope re-profiling.	CP6	NRNAP5	
	Service continuity management by rerouting services which are likely to be affected by embankment failure (via CCTV monitoring).	CP6	NRNAP6	
	Ongoing engagement with academia to research possible slope stabilisation techniques, in addition to modelling the response of slopes under different meteorological conditions.	CP6	NRNAP7	
Transport interdependencies:	Network Rail's Safety, Technical and Engineering Horizon Scanning Group will continue to identify, assess and manage external risks to Network Rail throughout their regional Strategic Business Plans for Control Period 6.	CP6	NRNAP8	

Management and review

Corporate management and review

Successfully implementing WRCCA across the whole of Network Rail requires a long-term commitment to the regular review and management of the process at all levels of the business. This will ensure the timely delivery of the technical and cultural changes necessary to develop cost-effective WRCCA strategies and actions which will avoid unacceptable increases in safety risk, system unreliability or the compromising of downstream risk mitigation strategies.

Network Rail is committed to ensuring that we will appropriately govern and assure implementation of these plans. Although we are going through a reorganisation and the future governance structure is unclear, the Route WRCCA Plans are owned by the respective Director of Engineering and Asset Management and the Office of Rail and Road (ORR – Network Rail's regulator) will monitor each Route's progress in implementation during CP6.

Effective governance of the wider WRCCA programme including Route WRCCA Plans will be embedded within the new governance structure. Based on existing structures, the following high-level management, review and reporting will be undertaken:

- Regions will provide updates on implementation of their WRCCA Plans to the ORR and the central WRCCA Team twice a year (at the end of Periods 6 and 13),
- A report combining progress from all Regions will be presented to the National Asset Management Review Group and Quality, Health, Safety and Environment Integration Group (or future equivalents) twice a year,
- Progress in implementing milestones will be included in regular WRCCA reviews by the Network Rail Executive Leadership Team and the National Safety, Health and Environment Periodic Report (or future equivalent),
- Region WRCCA Plans form a key control in managing Network Rail's Enterprise Risk relating to weather related impacts on the railway which is managed through Region and National level Business Assurance Committees (or future equivalent),
- The WRCCA Working Group will review progress and identify any improvements which would be approved by the National Asset Management Review Group and Quality, Health, Safety and Environment Integration Group (or future equivalents) or Executive Leadership Team as appropriate, and
- The central WRCCA Team will use the information in the Region Reports to inform the next National Climate Change Risk Assessment being compiled by the Committee on Climate Change and as part of its Adaptation Report under the Climate Change Act which is due to be submitted to Defra by 2021.

Network Rail will also look to engage with the wider rail industry, specifically Train Operating Companies and Freight Operating Companies, to discuss the Region WRCCA actions to identify opportunities for collaboration to facilitate effective increase of rail system resilience.

NW&C Region management and review

The NW&C Region submission for the strategic business plan has been established and agreed by the Director of Engineering and Asset Management following detailed review of asset requirements by the individual Route Asset Managers. A requirement of the funding approval has been that a robust renewal plan be proposed for the five year control period. To ensure that a tight control of delivery cost and volume is maintained a comprehensive governance process has been put in place to manage scheme delivery, deferral and scheme and business plan scope change with a rigid and peer reviewed change control process.

In NW&C Region a 6-monthly review of the delivery progress of WRCCA measures against plan will be undertaken as part of the change control and business plan management process. This will inform and feed into the S&SD integration plan.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