Cranfield UNIVERSITY

Openreach Climate Change Summary

Centre for Environmental Risks and Futures

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Environment Risk Futures

Prepared for Openreach by Cranfield University

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1. Introduction

There is a growing recognition that climate change has the potential to affect infrastructure operators, such as Openreach, who have extensive networks of infrastructure and conduct complex operational activities. Indeed there is increasing interest in such risks, not only at the Government level, with the Climate Change Act (2008) introducing the Adaptation Reporting Power, but amongst regulators, investors, insurers and wider stakeholders (e.g. customers and supply chains).

This summary report explores the potential risks that climate change poses to Openreach, its infrastructure and operational activities. It also highlights a range of challenges that not only face Openreach and the wider telecoms sector, but also Ofcom and which may require further future research. The report builds upon the wide-ranging experience of the authors, including research on climate change risks for the recent UK wide Climate Change Risk Assessment, the Adaptation Reporting Power, government departments and agencies, as well as infrastructure utilities.

Throughout the report examples of how climate change risks may affect Openreach and how they are affecting and being managed by other infrastructure operators and regulators are provided. These build upon our detailed analysis of the climate risks affecting ~100 key infrastructure operators from across the UK for Defra during the Adaptation Reporting Power.

2. Climate Change in the UK

It is now very widely accepted that the climate in Britain is changing, and it is almost universally accepted by scientists that this change is in part driven by anthropogenic emissions into the atmosphere. These emissions cause an overall global warming; however the changes at any given location will be site-specific and will vary over time. Indeed, the spatial and temporal variation associated with the potential impacts of climate change impacts represents one of the key challenges facing network infrastructure operators such as Openreach. These longer term changes are themselves superimposed on underlying cycles, changes due to other causes, and substantial random variation.

It is important first though to distinguish two distinct sets of climate change impacts on the operations of Openreach over the next 5 years.

In the short term, it is climate variability that most affects the day-to-day operational risks and costs, e.g. the number of breakdowns, overhead cable damage or flooded cabinets and underground infrastructure. The gradual changes in average conditions due to anthropogenic climate change are unlikely to be significant yet. However, any increases in weather variability and more extremes, some perhaps due to other causes and/or natural cycles, would be a problem for Openreach and the wider telecoms sector. Data on observed trends is of most use in analysing risk short-term. Where conditions are variable and changing, it is important that any cost data used for forward planning takes account of this. The rather benign conditions in 2011/12 for example were not a good guide for operations in the much wetter 2012/13 or for the expected most-likely conditions over the next few years (though of course they could recur).

Longer–term, changes due to anthropogenic climate change <u>should</u> affect the current design, planning and location of the equipment Openreach is installing, e.g. not installing cabinets at sites where flooding is expected to increase, alongside operational activities associated with maintaining service levels. These longer term impacts are likely to be affected both by changes in average values and by increased variability and extremes. Ensuring adaptation is correctly embedded in the funding and planning process will be essential to avoid mal-investment.

Observed Trends

Of particular interest to Openreach operational risks are the trends in rainfall (for example decreases in summer and increases in winter); increases in heavy precipitation events; and more frequent severe windstorms in the last few decades. Provisional statistics from the Met Office show that the high levels of rainfall experienced during 2012 may not be abnormal, with four of the five wettest years occurring since 2000, and preliminary evidence suggesting that total rainfall may be increasing (Table 1) (Met Office, 2013a). Furthermore, preliminary research by the Met Office also suggests that rainfall may be falling in more intense bursts, with an increase in the frequency in extreme daily rainfall (Met Office, 2013a) (Figure 1).

A useful summary and analysis of observed trends in UK climate is available from the UK Climate Projections 09 (UKCP09) website http://ukclimateprojections.defra.gov.uk/22577.

Table 1. Annual average UK rainfall according to 30 year averages, suggesting an increase in annual rainfall of ~5% between 1961-1990 to 1981-2010 (Met Office, 2013a).

Annual average UK rainfall according to 30 year averages	
1961-1990	1100.6 mm
1971-2000	1126.1 mm
1981-2010	1154.0 mm

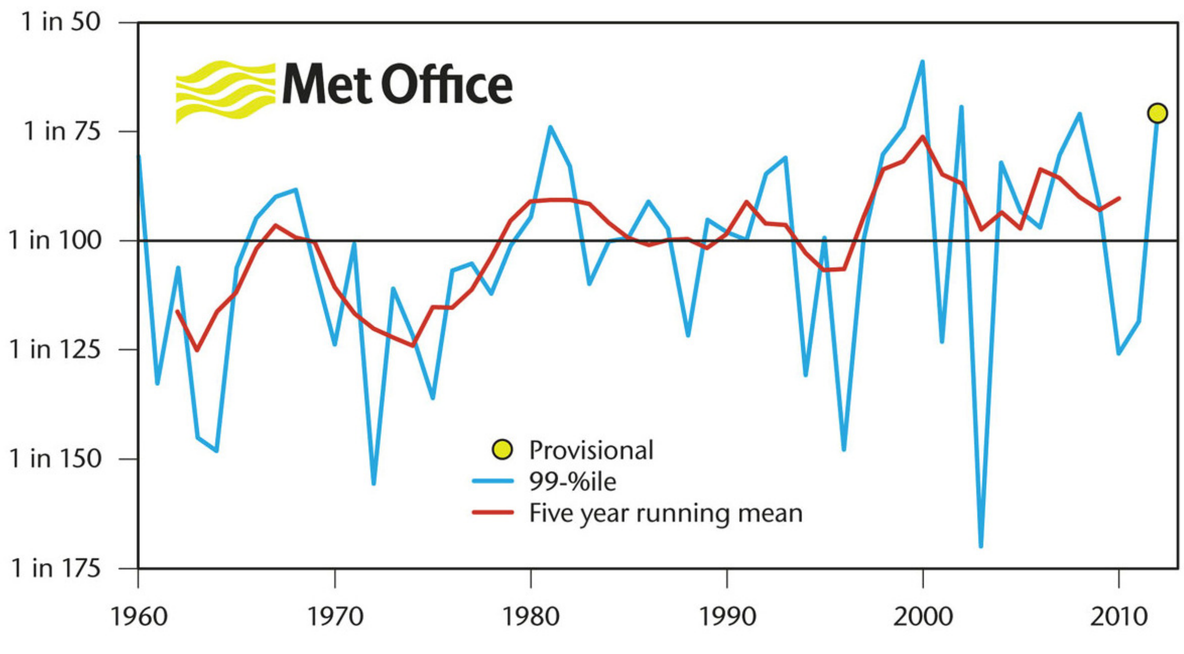


Figure 1. Changing frequency of 1 in 100 one day heavy rainfall events in each year (Met Office, 2013a).

Anthropogenic Climate Change Modelling

Assuming the change is driven by anthropogenic emissions, it is possible to model atmospheric behaviour into the future. The primary source of future climate projections for the UK is the UKCP09 dataset. Unlike earlier sources (e.g. UKCIP02), which just gave a single projection for each scenario, UKCP09 output is presented in a probabilistic format. It provides up to 10,000 climate projections, often assumed to be equi-probable, at a 25km scale resolution generated from a perturbed ensemble experiment using the HadSM3 Global climate model (GCM) and other climate models. This probabilistic format allows users to sample some of the uncertainty in the modelling (although not all uncertainty can be included). Since the future global socio-economic development path and success of carbon mitigation efforts are also unknown, data is present for 3 scenarios, with low, medium and high emissions. The results are produced as average monthly changes on the baseline, taken as 1961 to 1990.

These datasets can be used to model climate change risks and impacts at any given site. It should be noted however that they are not spatially coherent; e.g. the worst case at one site may not occur at the same time as the worst case at another site. For studying impacts that are more widespread, such as rainfall causing river flooding, a set of 11 spatially coherent projections have been produced.

The overall message from such modelling is that the climate in Britain will get warmer, particularly in summer. Average annual rainfall could increase or decrease slightly, with no simple pattern; the biggest changes are likely to be increased average winter rainfall in the west and decreased average summer rainfall in the south.

It is important to note however that these average changes will still be subject to short-term variability. There will still be dry periods and wet periods, even if averages change. Indeed, it is expected that the climate may become less stable, with more variability and more frequent and/or larger extreme events (Figure 2). This added variability may be more important than changes in averages when considering risk and damage.

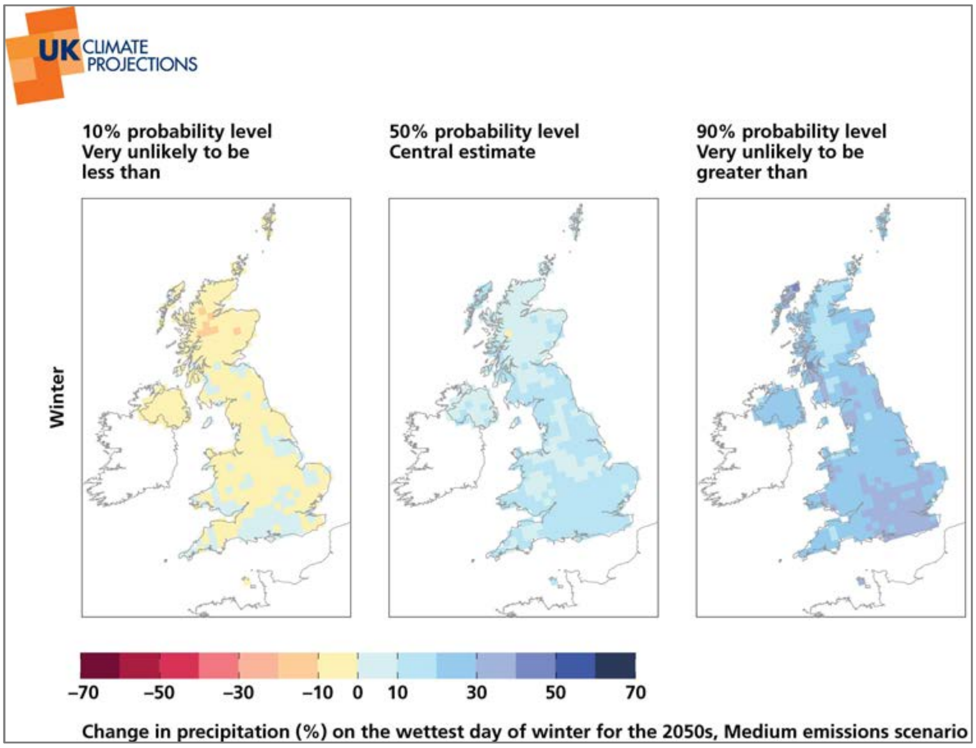


Figure 2. Change in precipitation (%) on the wettest day of winter for the 2050s, Medium emissions scenario (© UK Climate Projections 2009).

Daily weather can be modelled by superimposing the monthly climate changes on a historic (recorded) dataset, available for a number of weather stations around the UK. Note though, this procedure results in the same short-term patterns appearing in each future daily weather dataset.

Alternatively, daily (and even hourly) projections, and at a finer spatial resolution of $5km^2$, are available as outputs from UKCP09's weather generator (Jones et al, 2009). The weather generator similarly provides baseline ("control") and future scenario sequences for three different greenhouse gases emission scenarios (low, medium and high) and for selected 30 year time-slices (centred around the 2020s, 2030s, 2040s, 2050s, 2060s, 2070s and 2080s respectively). Again, a large set of alternative futures can be generated for each. This sort of data is often used for modelling changes in pluvial and fluvial flooding (simplistically, local flooding from drains overflowing and flooding from rivers).

Sea level rise projections are in the range of 18 to 25 cm by 2050 in the south, less in the north. However increased storm surges and faster erosion may increase coastal flooding more than these figures suggest. The UKCP09 modelling output does not include changes in wind speed and gusts, which is a significant omission when considering damage to overhead lines. However, as part of the UKCP09 methodology, an ensemble of eleven variants of the Met Office Regional Climate Model (HadRM3) was run from 1950-2099 to dynamically downscale global climate model (GCM) results. The 11-member Regional Climate Model (RCM), as it is known, was only run for the 2080s medium emissions scenario, but provides evidence of changes in variables that have not been fully modelled as part of UKCP09, but have important implications for Openreach. In particular, the 11-member RCM suggests reductions in observed windspeeds over mountainous areas of Scotland and Wales, with low-lying areas of England experiencing increases. The RCM also projects an increase in the number of lightning days across the UK for all seasons, with the largest increases occurring in summer. Geographically, the greatest projected increases in lightning days are expected to occur in Scotland and Northern Ireland and smallest in south east England. Whilst the RCM suggests that large reductions in fog will be experienced across the UK during summer months, the picture for winter is more complex. In particular, decreases in fog of >60% for northern Britain and Wales are projected, with increases over southern and central England. Projected changes for spring exhibit a similar geographical distribution to summer, but with greater reductions, whilst autumn months are expected to see reductions of 10-30% but with greater reductions over the Scottish highlands.

The issue of changes in snowfall and extreme winter events has come to the fore in recent years following significant disruptions to national transport infrastructure. Whilst such events would appear to represent the antithesis of 'global warming', there is emerging evidence that climate change and resulting changes to the jet-stream may contribute to these events. The 11-member RCM suggests reductions in snowfall events for all regions, with the largest reductions occurring in spring and autumn (> 70%), and reductions of between 40-70% in winter. Reductions are expected to be smallest in the highlands of Scotland. However, the RCM results highlight that whilst the general pattern is for a large reduction in heavy snow events, (>80% during winter and autumn and >40% in spring) there is greater intra-ensemble uncertainty.

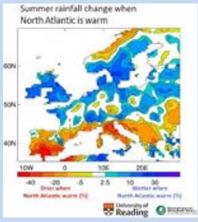
As is apparent from the above summary of UKCP09, climate change is expected to increase climate variability and extremes both spatially and temporally, which would impact adversely upon Openreach's geographically dispersed infrastructure and operations. This will potentially result in reduced return periods for extreme events. Low frequency events such as 1 in 100 year flood events for example would become more frequent, requiring increased levels of flood resilience. This is an important issue for both Openreach and Ofcom to consider because basing future investment on the return periods for past events may no longer be appropriate under climate change.

Recent extreme events are sometimes linked to climate change. However, whilst the unusual weather encountered during 2012 is potentially consistent with expectations of climate change, formally linking such extreme events to anthropogenic climate change is difficult at the present time. This is because a wide range of other factors can affect the impact of extreme events (e.g. the growth of impermeable surfaces influencing flooding in urban areas). As such, whilst it may be possible to attribute extreme vents to anthropogenic climate change in the future, at present only observed temperature increases are being attributed to climate change.

One of the significant challenges associated with climate change is its high level of uncertainty that results in knowledge and information gaps that will affect organisations, such as Openreach, who wish to assess their climate change risks. The issues of extreme winter snowfall events, wetter summers and their drivers are just two examples of areas that cutting edge climate science is attempting to understand (Box 1). In particular, research is beginning to focus on shifts in the location of the jet stream and whether these are purely random or cyclical or are also affected by climate change. Whilst understanding of this issue is in its infancy a wide range of potential influences are currently under investigation including solar variability, reductions in Arctic sea ice, long term ocean cycles and other long term cycles of natural variability (Met Office, 2013b). One emerging theory relates to the Atlantic Ocean's potential role in driving variability in European's climate at the decadal timescale, with warming of the Atlantic during the 1990s coinciding with anomalous wet summers in northern Europe and hot, dry summers in southern Europe (Sutton and Dong, 2012). Such findings suggest that this cycle may have the potential to affect the UK's weather over the next few years whilst the present warming of the Atlantic continues (Sutton and Dong, 2012; Met Office, 2013b). It is important to consider these emerging and uncertain areas of climate change science as our understanding develops, because they may have the potential to represent significant risks to organisations such as Openreach.

Detailed data on the methodology and the projections can be obtained from the UKCP09 website; http://ukclimateprojections.defra.gov.uk/

Box 1.



Recent research by the University of Reading suggests that the poor summer experienced in the UK in 2012 may be attributable to major warming of the North Atlantic Ocean during the 1990s (Sutton and Dong, 2012). It is just one of a number of potential factors influencing the UK's weather that were recently the focus of a workshop hosted by the Met Office and which are represent a key area of ongoing research for the climate science community.

Source: Reading University

3. Potential Risks

The projected changes in the UKs climate, discussed above, have the potential to impact upon Openreach's network and operations, with resulting implications for both capital and operational expenditure, customer quality of service and possible regulatory penalties, such as those encountered during 2012. In this section, the risks to these two core elements of Openreach's business, and the specific infrastructure/activities within them are considered. This summary builds upon our analysis of Adaptation Reports submitted under the Adaptation Reporting Power (Climate Change Act, 2008), together with existing studies that have considered climate risks to Information Communications Technology (ICT), and research on climate change risks to infrastructure operators and utilities (AEA Technology, 2010; Royal Academy of Engineering (RAE), 2010; Wherry, 2012).

Risks to Network Infrastructure

Local telephone exchanges – whilst owned by BT, Openreach house equipment in 5,600 local telephone exchanges, with each serving approximately 20,000 customers. Local telephone exchanges are vulnerable to climate change in a number of ways including:

- **Increased daily maximum temperatures increasing equipment operating temperatures and potentially causing malfunction or premature failure** – this may result in the requirement for air conditioning with accompanying investment and energy costs together with environmental impacts associated with increased energy use.
- **Increased temperature and humidity affecting equipment –** could represent a risk for Openreach. However, AEA Technology's report on ICT infrastructure and climate change (AEA Technology, 2010) notes that Industry standards for ICT equipment include specific tolerances to temperature and humidity. Thus, AEA Technology (2010) argue that it is reasonable to assume that the majority of devices typically used in the UK already have operating tolerances to temperature and humidity which will accommodate UKCP09 predicted temperature changes – both peak and average – provided they are appropriately installed and maintained. However, this may require further research by Openreach.

- **Flooding of vulnerable sites –** pluvial and fluvial flooding together with extreme rainfall and sea level rise may result in flooding of vulnerable sites, damage to associated equipment and operational problems. Particular concerns include pluvial flooding in urban areas (Box 2), whilst low lying areas of south east and eastern England are at risk from sea level rise, and possible increased storm surge, together with increased coastal erosion and flood risk (AEA Technology, 2010).

Box 2.

Landuse can have a significant influence on weather and climatic risks, most notably flooding. Of particular concern is the growth of impermeable surfaces, such as those found on housing estates, which reduce the ability of land to absorb rainwater and funnel rainfall into surface drainage systems. This can result in the overloading of drainage systems and pluvial flooding.

- **Landslides –** a landslide is the movement of a mass of rock, debris, artificial fill or earth down a slope, under the force of gravity (Cruden and Varnes, 1996). This 'en masse' movement (or slope failure) may be induced by physical processes such as excess rainfall, snow melt, or it may be a consequence of human interference with slope morphology (e.g. constructing over-steepened slopes), which affects slope stability. Landslides will occur when the inherent resistance of the slope is exceeded by the forces acting on the slope. As we have witnessed this year, increased levels of water in the environment have led to more landslides than normal.

- **Reduced soil moisture affecting earthing potential -** drier soils are more resistive and restrict the flow of current potentially requiring the installation of additional earthing metalwork. This issue is currently being investigated by the electricity Distribution Network Operators (DNOs) and may require further research to determine whether it affects Openreach's assets such as local telephone exchanges (Western Power Distribution, 2011).

- **Lightning damage –** caused by localised strikes on overhead lines affecting connected equipment resulting in increasing fault numbers.

Underground network – Openreach operate an extensive underground network, comprising both copper and fibre communication distribution cables, cable chambers, ducts and manholes. Potential climatic vulnerabilities include:

- **Flood risk –** posed by pluvial and fluvial flooding, extreme rainfall and sea level rise, resulting in flooding of vulnerable sites, damage to associated equipment and operational problems. For example, increased extreme daily precipitation in winter (and higher frequency of "very wet days") may pose an increased risk of flooding of low-lying infrastructure, access-holes and underground facilities (AEA Technology, 2010, p17). Under a climate with warmer summers, the intensity of summer convective rainfall events will increase, leading to increased potential for flash flooding. Four of the five wettest years in the last 100 years have occurred since 2000 (Met Office, 2013).

- **Increased precipitation and rising groundwater levels –** cable ducts are not waterproofed, thus rising groundwater levels, caused by persistent rain or flooding, may result in flooding of cable chambers and ducts. Not only can this cause moisture ingress into cables and increase the proportion of infrastructure that is routinely submerged but it can also damage cable ducts and chambers, thus increasing maintenance and operating costs. AEA Technology (2010) note that this is particularly problematic during times of snow melt or flooding. The effect of precipitation on levels of soil moisture varies according to the type of soil present (Figure 3) and antecedent conditions.

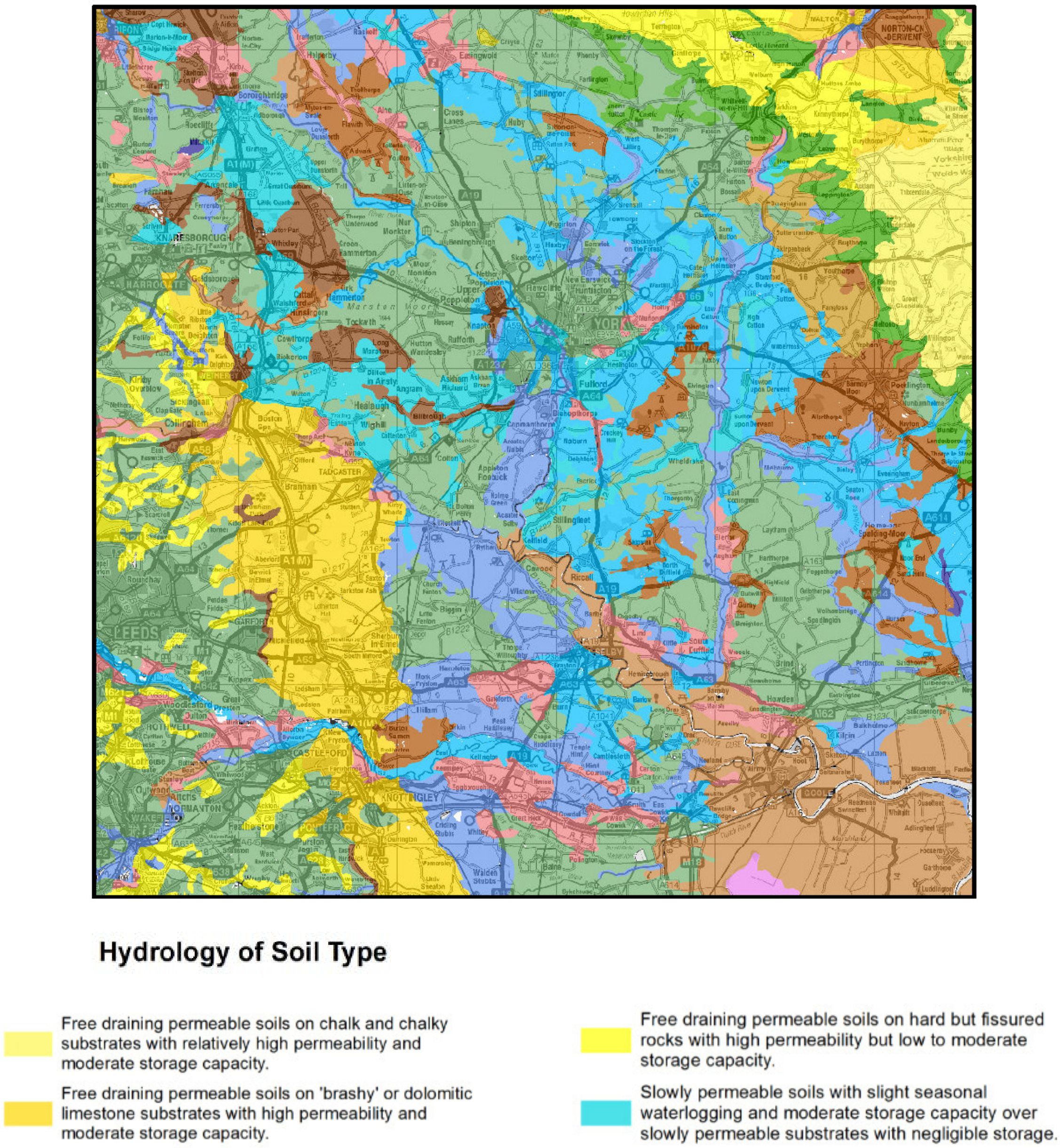


Figure 3. Hydrology of different soil types, which affects the potential for waterlogging, is extremely spatially distributed, and may require further research by Openreach. HOST data © Cranfield University and the Controller of HMSO, 2013.

- **Damage caused by soil movement and subsidence –** certain clay soils have the ability to shrink and swell with changes in soil moisture caused by increased wetting and drying associated with warmer wetter winters and drier summers (Figure 4). In turn, this can potentially fracture ducts leading to intrusion of soil, water and tree roots, increasing maintenance requirements and making it difficult to run cables/reroute and undertake repairs. Furthermore, ground movement can cause mechanical damage to cables, an issue identified by electricity DNOs during the Adaptation Reporting Power (e.g. Western Power Distribution, 2011). Climate change scenarios indicate that there will be greater changes in soil volumes throughout the seasons in future (Hallett, 2013).
- **Landslides –** see above.
- **Increased vegetation growth affecting buried infrastructure –** emerging research by electricity DNOs suggests that climate change may result in increased vegetation growth, which may result in increased tree and root growth, with the potential to cause damage to Openreach's buried infrastructure.

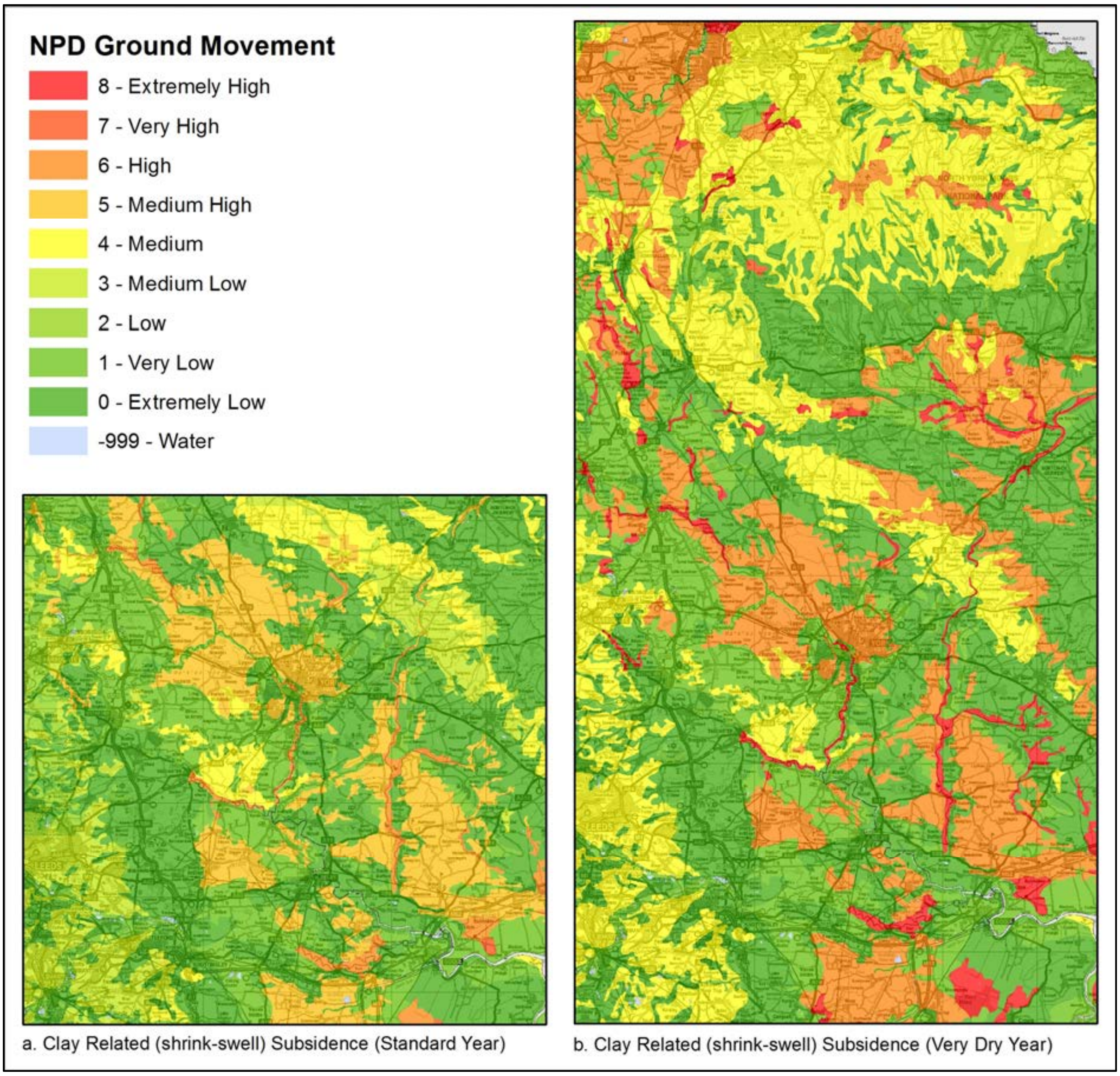


Figure 4. The change in clay related subsidence risk as a result of hotter and drier summers. Natural Perils Directory data © Cranfield University and for the Controller of HMSO, 2013.

- **Increased erosion threatening buried assets –** Openreach's network includes assets that are both buried adjacent to paths and roadways, cross rivers or are located in areas of coastal erosion. Increased erosion (Figure 5) may threaten such assets and there have been cases where increased river bed and bank erosion and damage to third party river crossings (bridges) have exposed or damaged buried pipes belonging to utilities (Box 3). Such risks have been experienced by the gas transmission and distribution sector, as well as telecoms, and may warrant further research and require increased inspection schedules or even diversions.

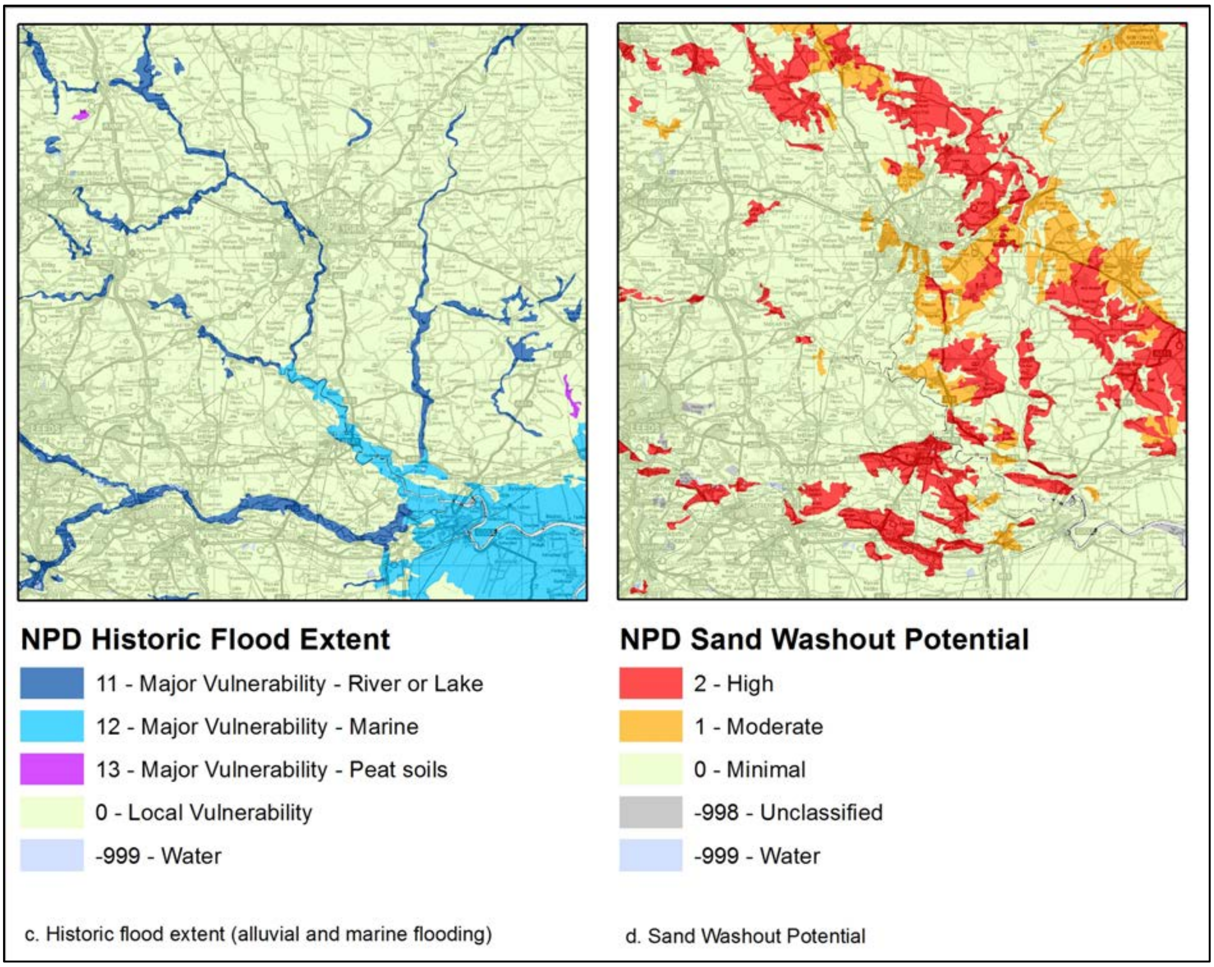


Figure 5. Historic flood extent and sand washout erosion potential. Natural Perils Directory © Cranfield University and for the Controller of HMSO, 2013.

Box 3.

Source: BBC

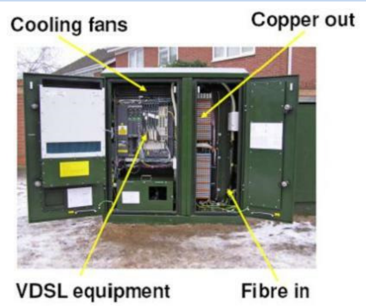
In 2009 extreme rainfall caused flooding across North Wales, Cumbria and the Scottish Borders region. In Cumbria six bridges were washed away and some carried communications cables. 3,500 telephone lines were disconnected. In one instance, the services carried by the Calva Bridge took seven days to restore as new cables needed to be installed under the riverbed (AEA Technology, 2010).

- **Corrosion to ferrous assets –** corrosion rates are temperature dependent. Predicted higher temperatures may lead to increased rates of corrosion on ferrous assets. Soil plays a key role in determining the vulnerability of an asset to corrosion, as some soils are more aggressive than others. Such risks may not affect copper assets, such as shielded telephone lines, to the same extent because copper is a noble metal, which exists naturally in the environment and is highly resistant to corrosion in the soil environment except in abnormally aggressive soils.

Primary Connection Points (PCP) – Openreach operate ~90,000 Primary Connection Point (PCP) cabinets that are typically roadside cabinets containing either copper or fibre optic links. Those containing copper are non-powered, whilst cabinets housing high-speed broadband contain fibre optic links and powered equipment (Box 4). PCP cabinets typically serve circa 500 customers and like local telephone exchanges represent a possible point of failure on the network. Potential climate change vulnerabilities include:

- **Increased equipment operating temperatures causing malfunction or premature failure** - potentially resulting in the need for active cooling or air conditioning with accompanying energy costs and environmental impacts through energy use.
- **Flood risk –** the ground-mounted nature of PCP cabinets makes them vulnerable to pluvial and fluvial flooding, extreme rainfall and sea level rise, which as Box 3 illustrates, can result in Quality of Service (QoS) and operational challenges affecting both customers and Openreach.

Box 4.



Source: www.trefor.net

A recent MSc thesis at Cranfield University investigating climate change risks to ICT infrastructure highlighted flood risks as a posing a challenge for rural businesses, with a Director of a small technology company noting:

"We're in a village and we do get quite a lot of extra heavy rain nowadays than we used to and occasionally that fills the BT box nearby and if it does do that firstly our broadband fails and then secondly we can lose phone line" (Wherry, 2012).

- **Erosion and landslides –** the impact of landslides and erosion on PCPs.
- **Increased humidity and extreme temperature variations affecting older technologies –** some electricity DNOs have highlighted that some of their equipment, housed in a similar manner to Openreach's PCPs, is sensitive to extreme of day-time/night-time temperature variations and resulting condensation (UK Power Networks (UKPN), 2010). Heavy fog is currently a problem facing Openreach because it can ingress into plant that is not affected by rainfall, and as such, could pose an issue under climate change as daily temperature extremes may increase.
- **Lightning damage –** caused by localised strikes on overhead lines affecting connected equipment resulting in increasing fault numbers (Box 5).

Network termination point in houses – are vulnerable to:

- **Localised flooding because of their low mounting height within buildings.**
- **Lightning damage –** due to strikes to overhead lines.

Overhead Network – Openreach operates an extensive network of overhead lines, comprising both copper and fibre optic cables strung between 8m high wooden telegraph poles that function as distribution points. The overhead network is vulnerable to climate change in a number of ways including:

- **Moisture ingress into cables –** precipitation, snow, ice and fog can result in cable degradation, damage and network faults. As noted above, Electricity DNOs and Openreach have highlighted that condensation may become a problem with possible extremes of day-time/night-time temperature variations under climate change that may contribute to this risk.
- **Increased frequency of high winds resulting in additional faults and service degradation –** overhead infrastructure including wooden telegraph poles and cabling could be adversely affected by high winds, resulting in temporary service degradation or equipment repair and replacement. This could be exacerbated by increased vegetation growth and changes in snow and ice conditions that may occur in future as a result of climate change.
- **Heavy snow and ice accretion causing intermittent faults –** can produce intermittent faults due to loose connections and concurrent icy conditions and strong winds can compromise the structural integrity of overhead lines and supports. For example, electricity DNOs have highlighted that ice accretion on trees can result in additional faults due to falling debris.
- **Lightning damage –** affecting overhead lines and connected equipment resulting in increased fault numbers (Box 5).

Box 5.

Source: Unknown.

In June 2013 lightning cut power to 4,900 homes in Falmouth and Penryn in Cornwall due to strike affecting Western Power Distribution's transformers in Redruth (BBC News, 2013).

- **Increased temperatures resulting in thermal expansion of cables –** increased temperatures and heatwaves may result in thermal expansion of cables, causing cable sag and reduced ground clearance.
- **Soil waterlogging and subsidence threatening the stability of poles -** future soil conditions may have implications for stability leading to potential ground movement around assets and structures.
- **Landslides and erosion –** the impact of landslides on 8 m distribution poles may be significant.
- **Changes in precipitation increasing proportion of infrastructure that is routinely submerged increasing maintenance and operating costs**.
- **Flooding –** caused by pluvial and fluvial flooding, sea level rise or extreme rainfall leading to increased flooding of vulnerable sites, damage to associated equipment and operational problems.
- **Flood events undermining tree roots leading to additional faults due to falling trees –** this may represent an issue should periods of high winds or storms occur following flood events or periods of high soil moisture that will weaken tree roots.

- **Increased vegetation growth –** trees and other vegetation near overhead lines needs to be managed to prevent faults occurring when they touch or fall onto overhead lines. Research underway by electricity DNOs indicates that climate change is leading to an increase in the growing season - approximately 10 days since 1960s. This is reflected in a significant increase in tree related faults on the UK electricity network, between 1990 and 2006, resulting in increased vegetation removal activities (ENA, 2011) (Box 6). Such issues may also affect Openreach's overhead networks.

Box 6.

According to SP Energy Networks typically 25% of all low voltage overhead interruptions and 6% of high voltage interruptions are related to vegetation induced faults.

Vegetation management currently represents SP Energy Networks' single biggest capital expenditure (SP Energy Networks, 2011).

Source: Unknown

Radio and microwave links – whilst only used in limited circumstances, such as serving business customers in rural areas, microwave and radio links may be vulnerable to climate change in a number of ways including:

- **Effects on radio signals and propagation –** caused by a range of factors including:
    - **Increased mean and maximum temperatures and increased storm activity**
    - **Changes in precipitation, particularly extreme daily precipitation in winter and higher frequency of very wet days, snowfall and fog.**
    - **Increased humidity**
    - **Changes in vegetation growth**
- **Flooding of vulnerable sites –** resulting in damage to associated equipment and operational problems.
- **Increased wind speeds or prevalence of high winds –** potentially affecting the alignment of antennas out of alignment or result in the need for stronger masts.
- **Lightning damage –** affecting radio and microwave equipment.

Risks to Operational Activities

Allied to potentially affecting network infrastructure assets, climate change also poses wide-ranging risks to Openreach's extensive operational activities, which includes approximately 25,000 engineers who maintain the company's network. In particular, its network engineering staff's work including network connection installation and repairing faults is extremely weather dependent, whilst climate change may also affect Openreach's office-based staff. Such issues are of importance because they can affect QoS, time to repair/fault duration, maintenance regimes and operational activities, with possible regulatory penalty and resourcing implications. Indeed, the events of 2012 illustrated the significance of such risks, with Openreach experiencing a wide array of operational challenges including increased travel time to repairs, the need to use of out of area engineers, who may be unfamiliar with area plans and plant, and contractor challenges. In addition, evidence suggests that risks affecting wider operational activities (e.g. office-based activities) are often overlooked by companies assessing when their climate change risks (Defra, 2012).

One key issue that Openreach will need to consider is that planning of weather dependent activities, such as digging trenches or fixing overhead power lines, has previously been able to assume that past weather patterns are a reliable guide to future weather patterns. Under future climate change, and perhaps already, that is no longer the case. Greater variability, more extremes and new record events can be expected. This is likely to require greater flexibility in planning work, more "float" in critical path schedules, and a larger allowance for contingencies. Other potential operational risks include:

- **Increased temperatures impacting working conditions –** in particular, increased temperatures may result in uncomfortable staff working conditions, particularly field engineers, with knock-on implications for productivity and potentially health and safety. This may represent a significant issue for field engineers who may be at risk from sunstroke and heat exhaustion in future. Such risks could result in increased demand for air conditioning, with accompanying financial and energy costs, and requirements to change staff Personal Protective Equipment (PPE) (Box 7). Furthermore, some Reporting Authorities highlighted the potential risk of litigation.

- **Increased temperatures affecting information technology equipment –** in particular servers, requiring additional cooling.

- **Increased temperatures impacting field engineering –** gas distributors and transmitters, who assessed their climate change risks during the Adaptation Reporting Power, noted that high temperatures could affect the chemicals used by their field engineering teams. As such, this may represent an area for Openreach to investigate.

Box 7.

Source: USA Today

Heatwaves, such as the one encountered in France may impact upon field staff.

- **Flooding/heavy rainfall leading to the inability to manage business as usual activities effectively –** For example, repair times may be increased, putting pressure on engineering teams and operational staff as offices and assets requiring repair may become difficult to access, increasing travel times, or inaccessible (Box 8). Furthermore, street works may be hampered by changes in soil stability and waterlogging affecting trenches.

Box 8.

Source: news.com.au

Queensland Floods: Restoration work was hampered because crews were unable to enter substations and telephone exchanges until they were declared safe and water had receded. Engineers were unable to start work on fibre cuts for several days due to flood water.

Source: www.b4gal.org.uk

A two hundred per cent increase in broadband repair volumes occurred in some areas due to heavy rainfall. Street level cabinets proved particularly prone to flooding. BT declared Matters Beyond Our Reasonable Control (MBORC) in 12 out of 73 Senior Operations Manager (SOM) patches. Average fix times increased due to the sheer number of incidents (Openreach, 2012).

- **Increased windspeed and storms impacting field repairs –** the ability of engineering staff to access repair locations and undertake working at height may be affected by increased windspeed and possible storms. In addition, increased windspeeds affecting street furniture, temporary safety barriers and signage may pose dangers to ground based engineers and members of the public.
- **Snow, sleet, ice and freezing fog affecting access to offices and field repairs –** have been encountered by organisations in other infrastructure sectors.
- **Landslides and erosion –** impacting the ability of engineering staff to access repair locations.

Supply Chain Risks

It is increasingly apparent that organisations will need to consider the potential risks from climate change to their wider supply chains, particularly given complex supply chains and the outsourcing of business functions. These are issues that Openreach and Ofcom may wish to explore in greater detail because other utilities have identified concerns regarding reliance on single suppliers because such organisations may be vulnerable to climate change (Box 9) (e.g. Wales and West Utilities, 2011). As a result, it will be important for resilience to be built into supply chains, which may have cost implications.

Box 9.

Source: New York Times

With 25% of global hard disk production occuring in Thailand the 2011 Bangkok floods highlighted the potential risk that climate change poses to international supply chains.

Interdependencies

The telecommunications sector is a key infrastructure interdependency for other sectors as well as public services and members of the public. Such interdependencies, and the role of the telecommunications network in underpinning them are of increasing concern because extreme weather events, such as the 2007 floods have highlighted the potential for 'cascade failures', where a failure in one type of infrastructure can impact another (RAE, 2010). As such, there is a need for Openreach to develop an understanding of its interdependencies both with respect to telecommunications representing a key interdependency, and its activities being highly dependent on other organisations and infrastructure operators to maintain its network (e.g. electricity and transport) (Box 10).

Box 10.

'ICT is absolutely reliant on the continuing availability of electricity. Currently mobile and fixed network distribution and exchange points have only one hour battery back up' (RAE, 2010, p20).

4. Potential Benefits and Opportunities

A number of potential benefits or opportunities arising from future climate change may exist for Openreach and the telecom sector. These include:

- **Reduced rainfall –** in the longer term, predictions for reduced rainfall in the south and east during summer months may make installation and maintenance activities simpler, although the increased uncertainty, variability and weather extremes might limit the extent to which this could be relied on when planning.
- **Reduced disruption from snow, ice and fog –** for example reduced disruption and operational difficulties caused by extreme winter conditions may benefit current maintenance regimes by allowing maintenance during winter months. However, it should be noted that uncertainties exist with respect to extreme winter conditions and this represents a key area of climate science research.
- **Opportunities for increasing resilience –** a number of opportunities for increasing asset resilience were identified by Reporting Authorities during the Adaptation Reporting Power and may also exist for the Openreach and the wider telecoms sector.
- **Adaptation opportunities –** the provision of opportunities and incentives for the telecoms sector to adapt to climate change could be an important area for consideration by regulatory authorities.
- **Incentives to conduct research –** sectors including energy and water have benefitted from the provision of incentives that have facilitated research into climate change risks and adaptation strategies.
- **Enhanced shareholder returns and reputational benefits –** Ofgem have highlighted potential opportunities for enhanced shareholder returns for water companies, based on improvements in network efficiency, reliability and consumer service. Such opportunities may exist for Openreach and the telecoms sector.
- **Greater collaboration and engagement –** evidence from the Adaptation Reporting Power process suggests that the consideration of climate change has resulted in greater engagement between Reporting Authorities, regulators and government as well as between and within sectors (Defra, 2012).

5. Potential Challenges

Climate change potentially poses a number of challenges for Openreach and the telecoms sector. Whilst they fall outside the scope of this summary report, Openreach and Ofcom may wish to consider conducting further research exploring the following areas:

Technical

- **Reduced lifespan of assets –** climatic changes such as increased temperatures or reduced return periods for events (e.g. flooding) will result in increased asset deterioration and reduced asset lifespan, potentially posing maintenance/replacement and investment challenges.
- **Design standards –** in parallel with changing asset lifespan, existing design standards may need to be reviewed or modified in light of future climate change. This has been recognised as an issue for the electricity DNOs (Box 11).
- **Spatio-temporal distribution of climate change risks –** the distributed nature of Openreach's network and operations, and the challenges encountered during 2012 (e.g. having to move engineers around the country), suggest that further research exploring the spatio-temporal distribution of Openreach's climate change risks and vulnerabilities, including extremes, may prove valuable.

- **Attributing Quality of Service to climate and weather events -** further research to understand correlation of different fault types and QoS issues (e.g. delays to repairs) to different weather events and future climate change is complex but may provide useful information going forward.
- **Organisational and technical barriers to the implementation of adaptation responses –** organisations have highlighted barriers and challenges associated with developing their adaptive capacity. For Openreach these may include the difficulties associated with its ability to plan for and react to the types of extreme events and increased variability that will be encountered under climate change.

Box 11.

Source: Unknown

SSE Power Distribution notes that the cable ratings currently used in the UK are based on assumptions of soil and air temperature and soil thermal resistivity made 50 years ago (SSE, Power Distribution, 2011). As a result, the Energy Network Association (ENA) plans to review design standards in time for the next price review (ENA, 2011).

Financing Investment in Adaptation and Resilience

- **Adaptation timescales –** a common issue identified by Reporting Authorities related to the challenges associated with investment lifecycles, most notably and long-term adaptation versus short-term cost and affordability issues (Defra, 2012). This is represents a key issue for consideration by Openreach and Ofcom.
- **Ability to finance investment in resilience and adaptation –** as has been highlighted in this report, Openreach needs to be able to finance investment in both short and long term adaptation and resilience measures if it is to maintain a robust network and service organisation which can respond to the stresses of climate change.

Regulatory Issues

- **Short-term regulatory horizons/price control timescales –** the combination of both short and long term investment challenges associated with climate change may pose challenges for the current regulatory regime and associated pricing controls under which Openreach and the telecoms sector operates.
- **Price versus resilience –** further research will be required to explore the need to balance price and resilience to climate change.
- **Allowances and incentives promoting research and investment in adaptation and resilience may be necessary -** for example, Ofgem has funded such measures in the water sector and similar approaches may be required in the telecoms sector (Box 12).
- **Regulatory support for climate change adaptation and resilience –** as outlined above, support from Ofcom will be required if a robust and resilient telecoms network is to be maintained under future climate change.

Box 12.

Source: Reuters

Following the 2007 floods the electricity distribution industry has identified flooding of substations as a very real risk. Implication of this is that exchanges flood risk should be evaluated and has resulted in electricity Distribution Network Operators (DNOs) undertaking a ten year programme of work to improve substation resilience to flooding, funded by Ofgem allowances of approximately £110 million (ENA, 2011).

6. Conclusion

In conclusion, climate change has the potential to impact upon both Openreach's network of infrastructure and its operational activities. Indeed as 2012 has illustrated, extreme weather events and the potential risk of future climate change will pose an array of challenges for Openreach and the wider telecoms sector. In particular, maintaining existing levels of QoS will not only require investment to ensure that new and existing infrastructure is robust and resilient to climate change, but may require additional expenditure to maintain operational activities and respond to the increased variability and extreme events that are foreseen in future.

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