September 2010

ASSOCIATION OF WEST YORKSHIRE AUTHORITIES

WEST YORKSHIRE ADAPTATION ACTION PLAN

YoHrSPACE
YORKSHIRE & HUMBER IMPROVEMENT AND EFFICIENCY PARTNERSHIP

AWYA
Association of West Yorkshire Authorities

Background

What is adaptation?

Changing our responses to the impacts of past, current and future climate change is known as 'adaptation'.

Adapting to climate change involves making decisions that are sustainable, made at the right time, maximising the benefits and minimising the costs. Although as a whole climate change will bring about many negative impacts, there will also be a number of opportunities.

Climate change adaptation needs to be built into planning and risk management now to ensure the continued and improved success of local authorities, partners & communities. Adaptation can be viewed as two different measures:

Proactive – which helps existing/future vulnerability
Reactive – which enables Emergency Planning to deal more efficiently with existing climate risk

Currently, adaptation receives very little attention when compared to efforts to reduce carbon emissions. However, given the 30-40 year time-lag between carbon release to the atmosphere and the consequent impact taking effect, it is essential to acknowledge that our climate will change and that we need to understand and prepare for the impacts.

Purpose

The main purpose of this RIEP funded project was to develop and implement a West Yorkshire collaborative approach to climate change adaptation action planning.

The West Yorkshire adaptation plan will support all five West Yorkshire local authorities to achieve level 3 of National Indicator 188 – planning to adapt to climate change. By half-way through the 3 year indicator period (Sept 2009) only Leeds and Kirklees had completed level 1 and the key task for level 2, a comprehensive risk assessment. Although both authorities had taken very different approaches, it was clear that there were many similarities between the areas.

NI188 level 3 requires local authorities to develop detailed adaptation action plans as the principle task. Therefore, given the similarities between Kirklees and Leeds risk assessments and given the relatively advanced stage when compared to the rest of the sub-region, it seemed sensible to commission a piece of work to jointly develop a template action plan for West Yorkshire.

The principle aims of this project were to:

- Combine the risk assessments from Leeds and Kirklees in order to identify shared priority risks;
- Create a comprehensive Adaptation Action Plan for the five West Yorkshire Local Authorities (LAs);

- Provide well structured evidence for the LAs to progress through levels of NI188;
- Create a single unified framework for consultation, engagement and target setting with key area-wide Local Strategic Partnership (LSP) partners, particularly those working across local authority boundaries, such as the West Yorkshire Fire and Rescue Service, West Yorkshire Police and the NHS.

However, it is important to stress that the aim was never to write adaptation action plans for each authority: instead the aim was to improve the efficiency of identifying the actions that need to be taken and providing a framework for each individual authority to use to embed adaptation action within the most appropriate local plans or strategies.

Key Findings

UK Climate Projections 2009 (UKCP09)

UK Climate Projections 09 (UKCP09) is part of a Defra initiative to put in place a new statutory framework and provide practical support for adapting to climate change. UKCP09 give organisations the chance to start to plan for adapting to climate change by looking at different ways of working and changing current behaviours. The projections are split into three future time periods (2020s, 2050s and 2080s) and are based on three probable carbon dioxide (CO_2) emission level scenarios (low, medium and high).

The following graphs (figures 1, 2 and 3) show the main climate change projections for the Yorkshire and Humber region as at present there isn't any data for West Yorkshire. However there will be minimal changes or differences in any projections from the Yorkshire & Humber dataset. The figures for these graphs have been taken from the UKCP09 projections for a medium emission scenario with 50% likelihood.

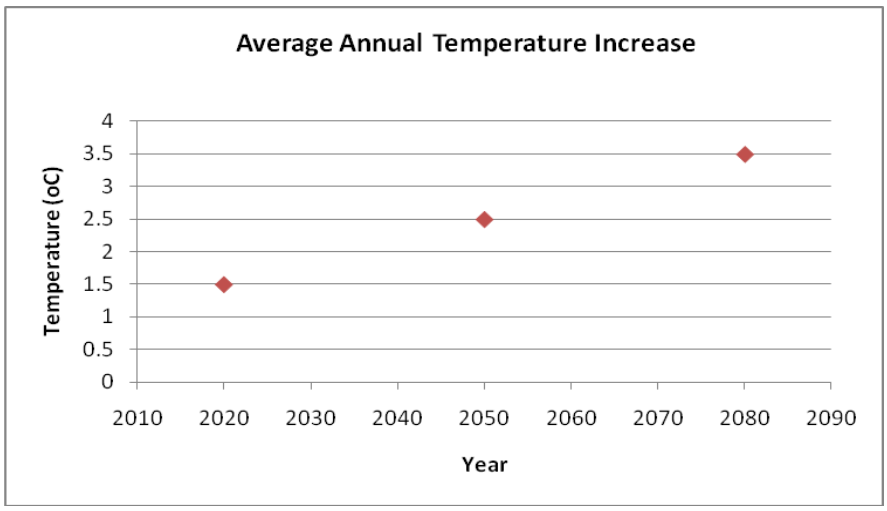

Figure 1: Changes in annual average temperature for Yorkshire and Humber up to 2080

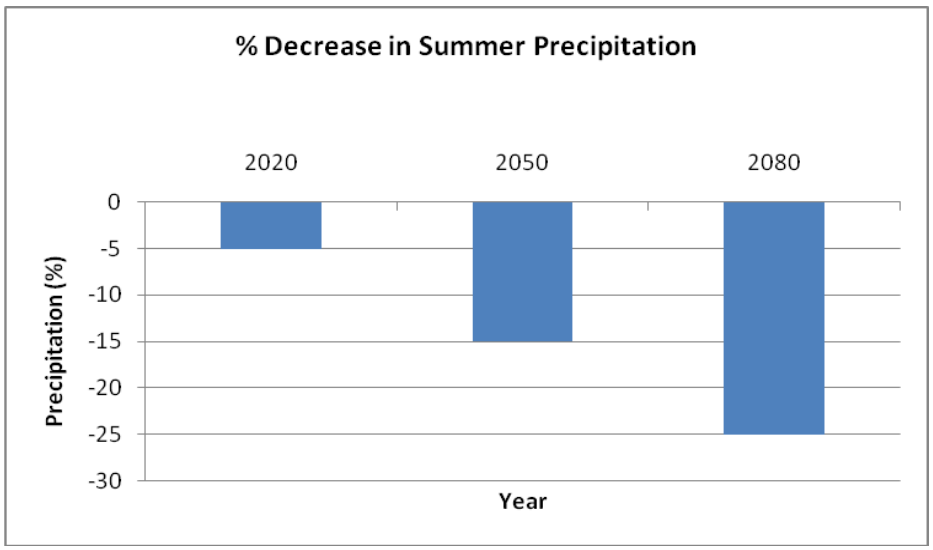

Figure 2: Changes in summer precipitation for Yorkshire and Humber up to 2080

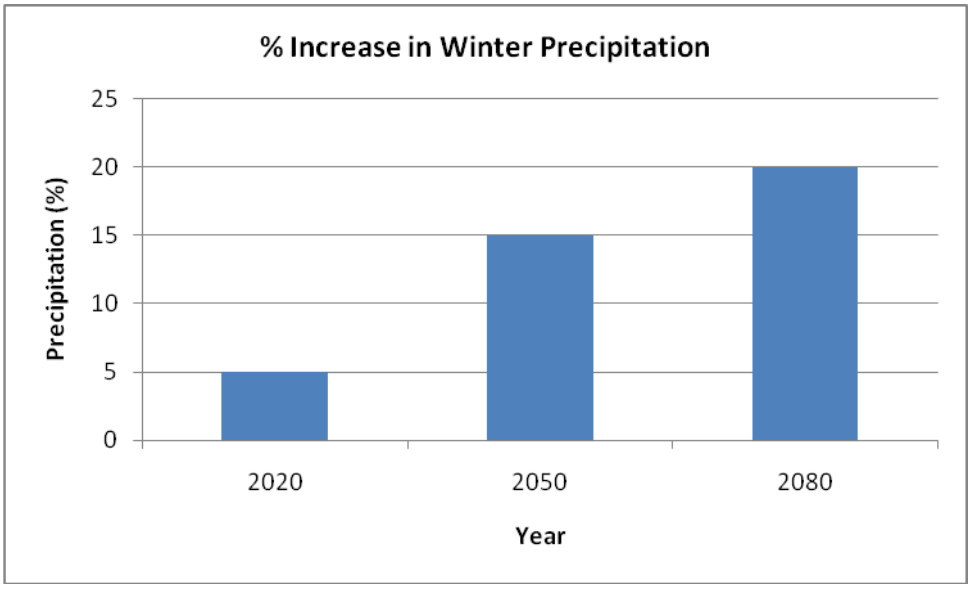

Figure 3: Changes in winter precipitation for Yorkshire and Humber up to 2080

What does this mean for West Yorkshire?

The climatic changes depicted above shows that West Yorkshire can expect increased annual temperatures, decreased summer rainfall and increased winter rainfall over the next 80 years. The major impacts of these changes for the region will occur with a greater frequency and magnitude in:

- Flooding
- Heatwaves
- Drought
- Storm intensity/frequency

These changes in severe weather will have a large effect across West Yorkshire in terms of increased:

- Damage to infrastructure
- Death rates
- Pressure on water supply
- Loss of local biodiversity and influx of new species
- Decline in air quality
- Stress on public services such as transport
- Opportunities

All of these effects are also likely to have significant implications for businesses and residents in terms of repair and maintenance costs and how services are delivered. To prevent this, local authorities, Local Strategic Partners, businesses and other organisations need to plan and adapt to the threat of climate change.

Local Climate Impacts Profile (LCLIP)

The effects of a changing climate have already impacted on West Yorkshire. In an attempt to quantify the impacts, each West Yorkshire local authority has completed a LCLIP detailing the extreme weather events affecting the local area over periods ranging from three to ten years (see table 1).

Local Authority	Duration of LCLIP
Bradford Council	1999-2008
Calderdale Council	1999-2008
Kirklees Council	2003-2010
Leeds Council	2002-2008
Wakefield Council	2006-2009

Table 1: The five West Yorkshire local authorities LCLIPs

A LCLIP is designed to support organisations such as local authorities in understanding the impacts of a changing climate on its citizens, businesses and partner organisations by identifying existing climate risk vulnerabilities.

Using the five local authority LCLIPs a summarised West Yorkshire LCLIP has been produced to give a sub-regional picture of climate impacts. It has been collated by taking any incidents reported across three or more of the local authority areas to create a set of sub-regional incident profiles. A full report can be found in appendix 1. It should be noted though that some areas of West Yorkshire will be more vulnerable to specific climate risk due to localised, physical factors.

West Yorkshire LCLIP Report Findings

There were 24 recorded climate change events across the West Yorkshire region between January 2000 and January 2010. Figure 4 shows the type and frequency of these events:

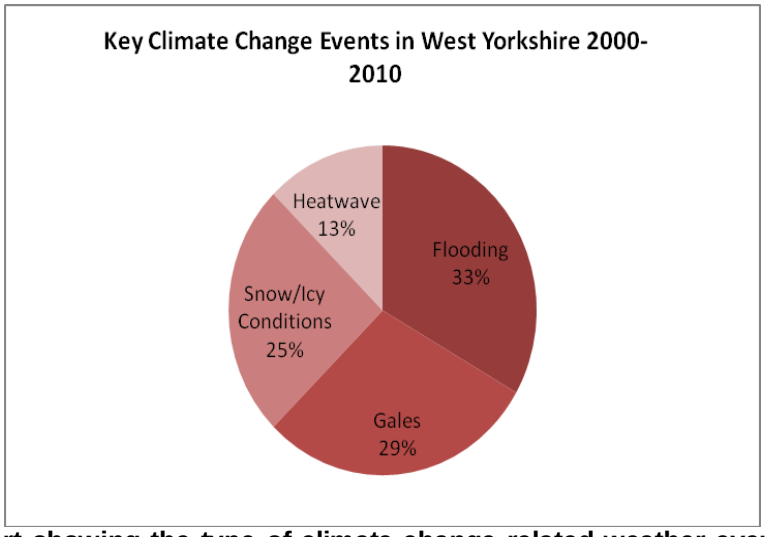

Figure 4: Pie chart showing the type of climate change related weather events that occurred across West Yorkshire 2000-2010

Key events from the LCLIP:

Flooding: Flooding is the predominant incident type. Eight separate flood records occurred, accounting for 33% of damages and impacts.

Gales: These were the next most frequent event type, being recorded on seven occasions; wind related events account for 29% of damages and impacts.

Snow/ice: Six events are related to snow, which account for 25% of damages and impacts. The likelihood of snow events is evenly distributed across the recording period.

Heatwave: Three events are related to above average temperature/heat waves, which account for 13% of damages and impacts

The time line in figure 5 below outlines the type and date of each of the climate change related severe weather incident recorded across West Yorkshire from 2000 to 2010:

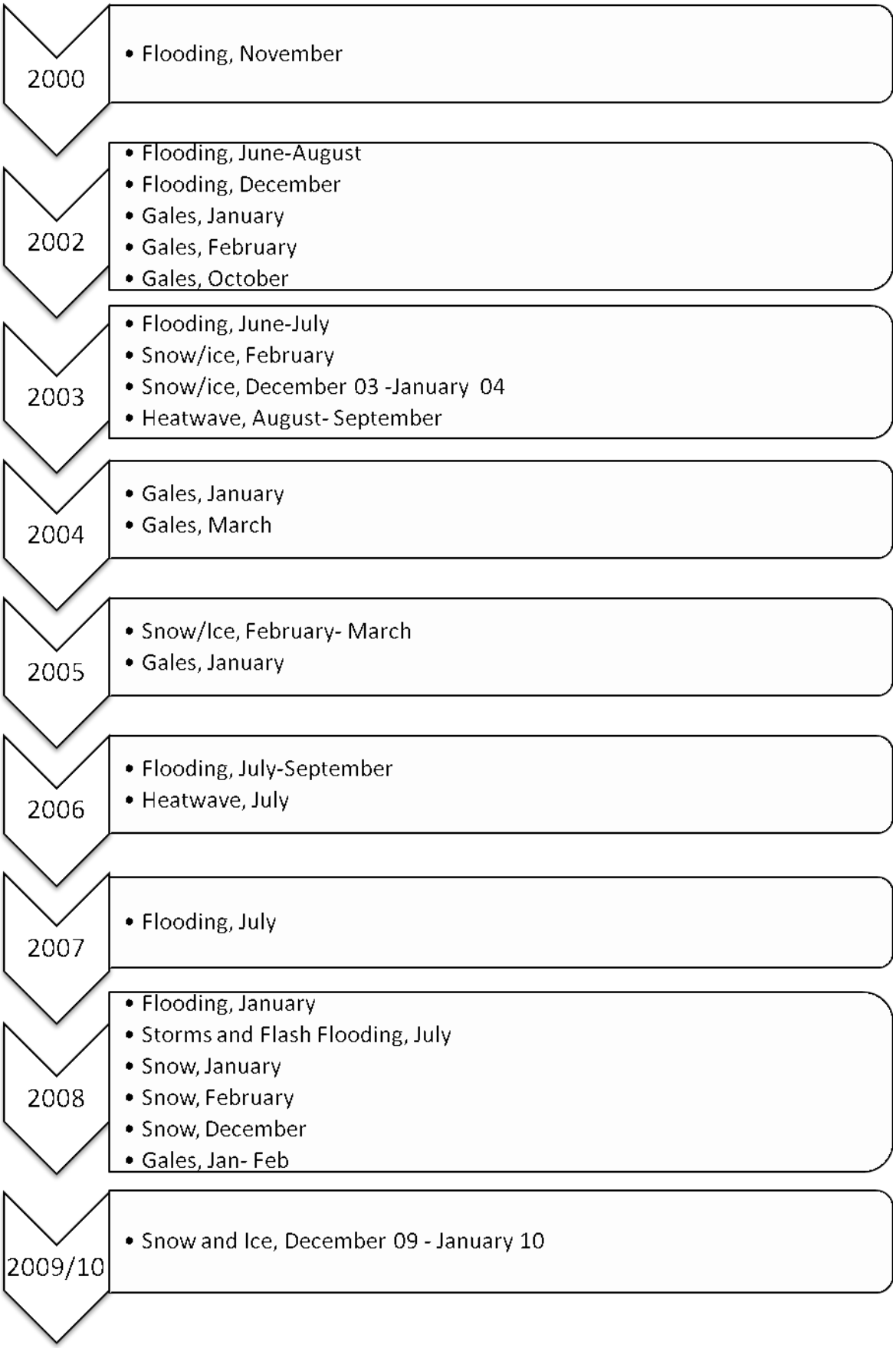

Figure 5: Climate change related severe weather events in West Yorkshire 2000 to 2010

National Indicator 188 – planning to adapt to climate change

NI188 is designed to measure a local authority's preparedness in assessing and addressing the risks and opportunities of a changing climate. Essentially it is not about altering activities to mitigate for what has happened so far with climate change it is about adapting activities to prepare for the expected effects of climate change whether they are positive or negative. See table 2 to see the progress of each local authority.

	Baseline	08/09	09/10	10/11
Bradford	Level 0	Level 2	Level 2	Level 1/2
Calderdale	Level 0	Level 0	Level 1	Level 2
Kirklees	Level 1	Level 2	Level 2	Level 4
Leeds	Level 1	Level 1	Level 1	Level 3
Wakefield	Level 0	Level 0	Level 1	Level 1/2

Table 2: Reporting against national indicator 188

The different levels of national indicator 188 are:

Level 0 – Getting started
Level 1 – Public commitment and impact assessment
Level 2 – Comprehensive risk assessment
Level 3 – Comprehensive action plan
Level 4 – Implementation, monitoring and continuous review.

Summary of Local Strategic Partnerships (LSP) Climate Change Adaptation Measures

As well as developing an adaptation action plan, a key part of NI188 level 3 is ensuring that other organisations are prepared for the impacts of future climate change. This section summarises the findings of the LSP Adaptation Research Report conducted by Kirklees Council in July 2010, an in depth report into how LSPs in West Yorkshire are working towards adapting to climate change.

NHS Kirklees

All NHS departments are required to have a winter plan in place. Each plan contains specific guidelines of procedures and mechanisms that are in place to deal with emergency situations.

Huddersfield and Calderdale Royal Infirmaries are also starting to look at the historic impacts of climate change with assistance from Kirklees Council. Officers from the NHS Kirklees have cross referenced Accident and Emergency admissions data with incident dates from the WY LCLIP report to highlight where severe weather events caused an increase in hospital admissions i.e. slips and trips in cold weather. (See appendix 3).

West Yorkshire Fire and Rescue

As part of their business continuity plan, West Yorkshire Fire & Rescue Service operate a "buddying Up" systems with neighbouring services to ensure they can deliver emergency services at all times in severe weather conditions. The

Operational Risk Management & Emergency Planning Team is also working with other Emergency Services and local authorities to ensure preparedness for severe weather events.

West Yorkshire Fire & Rescue Service is also starting to look at the historic impacts of climate change with assistance from Kirklees Council. Officers from the Fire Service have cross referenced their call out data with incident dates from the WY LCLIP report to highlight where severe weather events have affected service delivery in the past (see appendix 4). This, along with the UKCP09 data will be used when planning future service requirements.

West Yorkshire Police
West Yorkshire Police have a plan in place to cope with unexpected emergencies including extreme weather. They also assist the ambulance service in patient pick up and transport to help increase their capacity in emergency situations.

West Yorkshire Metro
The Local Transport Plan 3 team commissioned Kirklees and Leeds Councils to develop a West Yorkshire Transport LCLIP including UKCP09 data, which will be used to include climate change adaptation and shape policy in the third revision of the West Yorkshire Local Transport Plan.

Environment Agency
The Environment Agency is currently working on flood management plans for the Northern regions. They are also responsible for issuing extreme weather warnings and assisting in the implementation of procedures when coping with the severe weather.

Huddersfield University
The University has an on line learning module where students can complete work at home in the event of the buildings been closed due to adverse weather. All university new builds include rainwater harvesting where possible.

Yorkshire Wildlife Trust
Yorkshire Wildlife Trust have a procedure in place for mapping where, in terms of climate change, the most at risk species are and what needs to be done.

Peak District National Park
The Peak District National Park has a climate change plan and an adapting to climate change programme. These two plans are used to promote understanding of the landscape changes and possible adaptations likely to result from climate change.

Priority Sector Risk Assessment

In order to develop a sub-regional action plan which outlines 'appropriate adaptation measures', six priority sectors have been identified at being at greatest risk of climate change. These sectors, through its management and delivery, can also exacerbate the impacts of climate change.

The six sectors are:

1. Natural Environment
2. Built Environment
3. Transport
4. Utilities
5. Waste Management
6. Health and Social Care

Each sector has been risk assessed against the UKCP09 climate predictions and the associated impacts and consequences identified.

Future Climatic condition	2020	2050	2080
Increased summer temperature	+ 1.3°C	+ 2.3°C	+ 3.3°C
Decreased summer rainfall	- 8%	- 19%	- 23%
Increased winter temperature	+ 1.3°C	+ 1.9°C	+ 2.9°C
Increased winter rainfall	+ 4%	+ 11%	+ 15%
Increased storminess	Slight increase overtime (low confidence)		
Increased rainfall intensity	Slight increase overtime (high confidence)		

Source: **Weathering the storm: Yorkshire and Humber regional adaptation study, 2009**

Using these impacts and their related consequences, the level of risk to each sector was calculated by scoring the severity and likelihood over four timescales; now, 2020, 2050 and 2080. A full breakdown of the methodology, a blank risk assessment matrix and the full risk assessments can be found in appendix 4.

RISK RATING MATRIX

SEVERITY					
5	5	10	15	20	25
4	4	8	12	16	20
3	3	6	9	12	15
2	2	4	6	8	10
1	1	2	3	4	5
			LIKELIHOOD		

All impacts/consequences that have been ranked as a high (red) risk, scoring 16 or above, have been further examined in order to develop an action plan. Actions have been listed either as needed, planned or in place. In addition, the action plan also identifies lead partners responsible for each action and any relevant timescales, finances and review processes. However some actions need further investigation so 'insufficient data' has been listed against these actions.

The action plans for the six priority sectors can be found from pages 13 to 21.

Natural Environment

It is expected that climate change will have a significant impact on biodiversity within West Yorkshire. Protected areas, species and habitats are already under considerable pressure from changing patterns of agriculture, pollution and development. Climate change will exacerbate these problems, but may also provide opportunities for some species or habitats.

Key receptors at risk	Future climatic conditions	Impacts	Consequence	level of risk = severity x likelihood				Action done-green/planned-orange/needed-red	Lead partners	Financing	Monitoring & review
				now	2020	2050	2080				
Upland Bog	increased summer temperatures decreased Summer Rainfall	Drought	Destabilisation of blanket bog	4	12	20	20	**1) Support for the Moors for the Future partnership and other upland partnerships.** **2) Delivery of Landscape scale South Pennines project** **3) Delivery of the Blanket Bog Habitat Action Plan**	Peak District National Park National Trust Moors for the Future Local authorities	pays for itself in 20 years	ongoing
	increased winter temperatures		increased risk of fire	6	6	12	16	**1) Increase public awareness re fire risks**	West Yorkshire Fire & Rescue Peak District National Park Natural England	insufficient data	ongoing
	decreased summer rainfall		Reduced water storage capacity leading to downstream flash flooding and decreased water quality	4	4	9	16	**1) Delivery of Landscape scale South Pennines project** **2) Delivery of the Blanket Bog Habitat Action Plan**	Peak District National Park National Trust Moors for the Future Local authorities	insufficient data	ongoing
	increased summer temperature	Heatwave	Decreased species number	9	9	16	16	**1) Delivery of the Blanket Bog Habitat Action Plan**	Local authorities + partners	insufficient data	ongoing
			Loss of stored carbon	8	8	12	16	**1) Support for the Moors for the Future partnership and other upland partnerships.**	Local authorities	insufficient data	ongoing
River Corridors & aquatic habitats	Increased Winter rainfall	Flash floods	flooded infrastructure, residential and business areas	12	12	16	16	**1) Development of the Surface Water Management Plans**	Local authorities Environment Agency	insufficient data	within a year
	increased summer temperature	Drought	Reduced water storage capacity leading to downstream flash flooding and decreased water quality	4	4	9	16	**1) Delivery of landscape scale rivers, riverine corridors and associated habitat projects** **2) Leeds City Region Green Infrastructure strategy** **3) Introduction of the Water Framework Directive**	Local authorities Environment Agency	insufficient data	one to five years
Woodlands & Forest	increased summer temperatures	Drought	increased fires	6	6	12	16	**1) Awareness of specific weather alerts** **2) Increase public awareness re fire risks**	West Yorkshire Fire & Rescue Forestry Commission	pays for itself in 20 years	five to twenty years
Urban Green Spaces (includes parks and open spaces)	increased rainfall intensity	Flash floods	green open spaces flooded	9	9	16	20	**1) Identify common examples and manage public areas appropriately**	Local authorities Natural England Environment Agency	insufficient data	ongoing
Agricultural land	increased summer temperatures	Heatwave & drought	Increased water management required	4	6	12	20	**1) Leeds City Region Green Infrastructure Strategy** **2) Landscape scale biodiversity projects**	Local authorities Natural England Environment Agency Farming and Wildlife Advisory Group	insufficient data	within a year

Built Environment

For consideration of climate impacts and adaptation the built environment includes the commissioning, design, construction and operation of buildings, roads, utilities and other infrastructure. Because much of the built environment is designed for the long-term (50 to 60 years, or even longer) it is clearly vulnerable to the changes that are projected for the UK in the 21st century. An understanding of the future weather and climate is essential for those involved in planning, constructing and managing the built environment.

Key receptors at risk	Future climatic conditions	Impacts	Consequence	level of risk = severity x likelihood: now	2020	2050	2080	Action done-green/planned-orange/needed-red	Lead partners	Financing	Monitoring & review
domestic buildings	increased summer temperatures	heatwave	reduced comfort in buildings for occupants	9	9	16	20	**1) Promotion of Passihauv developments.** **2) Ensure new builds are built to highest possible Code for Sustainable Homes level** **3) Change orientation of building to ensure reduction is solar gain** **4)Local Development Framework adoption**	Local authorities	insufficient data	one to five years
	decreased summer rainfall	drought	water shortages	6	6	12	16	**1) Increased use of ponds, roadside swales.** **2) Install grey water systems and water harvesting system**	Local authorities Housing developers	insufficient data	ongoing
	increased winter rainfall	floods	buildings on low-lying areas at risk of flooding	8	8	12	20	**1) Leeds City Region Eco-settlement scheme** **2) Homeowners complete a personal flood plain** **3) New policy on floods as part of the Local Development Framework.** **4) Creation of surface water management plans.** **5) Install larger soakaways, french drains around buildings to take water away.**	Local authorities Environment Agency Housing developers	insufficient data	one to five years
commercial building	increased winter rainfall	floods	increased damage to buildings	2	6	9	16	**1) Install flood resilient measures and retro existing buildings.** **2) Carry out routine inspections and manage known 'pinchpoints'**	Environment Agency Local authorities	no economic benefit	ongoing
	decreased summer rainfall	drought	Stress on water supply	1	4	6	16	**1) Leeds City Region Green Infrastructure strategy.** **2) Increase the use of rainwater harvesting and storage** **3) Water efficient fixtures and fittings installed.**	Local authorities	insufficient data	ongoing
Building Planning and Design	increased rainfall intensity	flash flooding	Existing flood defences can't cope	2	6	9	16	**1) Amended parts L, F & G on Building Regulations will cover energy efficiency, water use and ventilation** **2) Greater promotion of the BREAAM standards**	Local authorities	insufficient data	one to five years
	increased storminess	Gales/high winds	increased damage to buildings	4	6	12	16				

Transport

Transport is vital for both urban and rural communities in West Yorkshire. Our transport system is vulnerable to severe weather, in recent years snow and flooding has caused road closures, heatwaves have buckled rail lines and fog and strong wind have closed the airport and bridges.

Key receptors at risk	Future climatic conditions	Impacts	Consequence	level of risk = severity x likelihood				Action done-green/planned-orange/needed-red	Lead partners	Financing	Monitoring & review
				now	2020	2050	2080				
Road network	increased rainfall intensity	Increased risk of highway flooding resulting from new developments, or improvements	Transport disruption & flooding of frontage property	9	9	12	16	**1) Provision of appropriate sustainable urban drainage, allowing temporary storage & controlled release**	Highways Authorities Local authorities	insufficient data	ongoing
	increased storminess	Buffeting/toppling of vehicles in high winds. (Motorways mainly at risk)	Traffic disruption, potential closure of highways, especially on motorways & derestricted roads	12	12	16	25	**1) Consider use of natural shelter belts or wind diffusers in vulnerable areas** **2) Appropriate use of highway warnings (VMS), improved enforcement of speed restrictions & vehicle bans when dangerous**	Highways Authorities	insufficient data	insufficient data
	increased storminess	Trees, frontage property or street furniture damaged, or blown on to road network	Traffic disruption, potential closure of highways	9	12	16	20	**1) Select robust highway trees in exposed locations and ensure careful pruning of trees in vulnerable areas.** **2) Consider new design standards for resilience of street furniture & building fabric** **3) A Severe Weather Plan for High Winds**	Highways Authorities Local authorities	insufficient data	ongoing
	increased rainfall intensity increased winter rainfall	Localised flooding of road network, resulting from flash flooding , minor fluvial or overland flooding events	Highway flooding causing traffic disruption, potential closure of highways. Most vulnerable after dry or very wet period, leading to rapid runoff	9	12	16	20	**1) Use of VMS / CCTV / UTC Intranet Service to direct traffic away from affected areas.** **2) Emergency planning procedures to help coordinate flood response.** **3) Develop bespoke actions to reduce vulnerability to flash & overland flooding.**	Highways Authorities Local authorities	insufficient data	insufficient data
Road network (& damage to frontage property)	increased rainfall intensity	Blocked Highway gulleys & culverts, due to intense or prolonged heavy rainfall events.	Local flash flooding, disruption to transport, damage to frontage property. Most vulnerable after dry period, with rapid runoff & first flush debris blocking drainage, or when ground is saturated	12	16	16	20	**1) Identify vulnerability of gully/culvert to flooding.** **2) Fortnightly cleansing of vulnerable culvert grids, improved gully cleansing procedures**	Highway Authorities	pays for itself in 5 years	Immediate
Road network Rail infrastructure	increased winter rainfall	Fluvial flooding of highways or rail lines, normally caused by heavy & prolonged winter rainfall	Serious flooding of highway network & rail lines adjacent to major rivers	15	20	20	25	**1) Identify vulnerable locations & design appropriate flood alleviation measures & supporting emergency procedures**	Network Rail Local authorities	insufficient data	insufficient data
Road network Rail infrastructure	increased rainfall intensity increased winter rainfall	Increased risk of landslips during of heavy rainfall & saturated ground	Can cause local serious disruption or closure of highways or rail lines	6	9	12	20	**1) Identify vulnerable locations & stabilise embankments using appropriate geotechnical solutions, or tree planting.**	Highways Authorities Network Rail	insufficient data	insufficient data
Road network Rail infrastructure	increased summer temperature decreased summer rainfall	Subsidence of roads/rail lines during prolonged hot dry spells.	Surface and structural damage to the road and rail networks resulting in the need for increased maintenance or repair, and disruption to travel.	4	9	12	16	**1) Identify vulnerable locations, use of appropriate raft foundations resilient to soil heave.**	Highway Authorities Network Rail	insufficient data	insufficient data
Road network	increased rainfall intensity	Structural damage to bridges caused	Potentially high costs of repair and disruption to	9	12	16	20	**1) Increased frequency of bridge scour inspections from annual to 6 monthly.**	Highways Authorities Department for Transport	insufficient data	insufficient data

Rail infrastructure	increased winter rainfall	by increased river scour & debris blockage	travel.					2) Debris clearance following flood events. 3) New design standards to improve bridge resilience to high river flows			
Rail infrastructure	increased rainfall intensity increased winter rainfall	Localised flooding of rail network , scouring & erosion of ballast	Disruption or closure of rail line, and potential damage to infrastructure. Disruption to power supply on electrified lines.	9	12	16	20	1) Improve drainage, use of SUDS, and re-direct source of overland flooding. 2) Contingency plans to enable efficient pumping of water from affected sites.	Network Rail	insufficient data	insufficient data
	increased summer temperature	Rail lines buckling	Speed restrictions, disruption or closure of rail line, and potential damage to infrastructure.	4	8	15	20	1) Plant trees and shrubs along vulnerable exposed lengths of track to provide shading. 2) Adjust pre-tensioning of rail line.	Network Rail	insufficient data	insufficient data
	increased storminess	Trees, etc blown on to rail network	Disruption to travel, speed restrictions, potential risk to trains and passenger safety in the event of a collision.	6	12	12	16	1) Regular maintenance checks of structure stability. & condition of trees, pruning of vulnerable trees	Network Rail	insufficient data	Immediate
		Rail power lines affected by high winds and lightning strikes	Disruption to travel & speed restrictions on network.	4	9	12	16	1) Regular maintenance checks. 2) Design guidance for overhead lines/gantries may need to be amended to account for potential future changes.	Network Rail Department for Transport	insufficient data	ongoing
Air infrastructure	Increased storminess	Risk of increasing gales/cross winds at LBIA	Short period airport closures, difficulty in aircraft landing, LBIA runway perpendicular to prevailing winds	9	12	16	16	**Inappropriate to shelter, must wait for winds to subside, wind direction to change, or divert to appropriate Airport**	Airport Authorities	insufficient data	insufficient data
Public comfort and safety	increased storminess	Risk to pedestrians and cyclists of being blown into carriageway.	Increased risk of accidents & casualties, posing a risk to safety.	6	12	12	16	1) Identify vulnerable crossings/stretches of highway and erect guard rails, etc where necessary. 2) Consider use of wind diffusers, or natural shelterbelts in exposed locations	Highways Authorities	insufficient data	insufficient data
	increased summer temperature	Heatwaves - lack of shaded waiting facilities with seating for public transport users.	Passenger discomfort and potential reduction in uptake of public transport during severe weather events.	6	9	12	16	1) Ensure shaded and seated waiting facilities are available at exposed locations.	Metro	insufficient data	one to five years
								1) Real time bus information systems to avoid people having to wait in the heat for an unnecessarily long time.	Metro	pays for itself in 5 years	ongoing
	increased summer temperature	Overheating in bus and local rail stations	Heat stress problems, especially for very young & old persons	6	9	12	16	1) Design in adequate natural ventilation systems, without resorting to use of air conditioning. 2) Provide water during periods of heatwave.	Metro	insufficient data	five to twenty years
	increased summer temperature	Poor thermal comfort within mass transit systems / public transport.	Heat stress problems, especially for very young & old persons	9	12	16	20	1) Include specifications for adequate ventilation and/or air conditioning, tinted windows, etc. in tender specifications.	Metro Train operating companies	insufficient data	one to five years
	increased summer temperature	Heatwaves - increased risk of photochemical pollution episodes & resultant poor air quality	Increased risk of health problems & morbidity for vulnerable groups of the population	6	9	12	16	1) Raise priority of air quality issues in local decision-making and implement schemes to reduce levels of air pollution.	Highways Authorities Local authorities	pays for itself in 5 years	Immediate
								1) Implement text alert scheme for people with respiratory illness during pollution episodes.	Local authorities	pays for itself in 5 years	Immediate
								1) Use real time information for public transport to avoid vulnerable passengers having to wait at the roadside/rail stations during pollution episodes.	Metro Local authorities	insufficient data	one to five years

Utilities

Provision of utilities, such as water, waste water disposal and gas and electricity becomes increasingly difficult to manage during extreme weather events. Utilities need to be better prepared for more disruptions based on the increased frequency of severe weather events.

Key receptors at risk	Future climatic conditions	Impacts	Consequence	level of risk = severity x likelihood: now	2020	2050	2080	Action done-green/planned-orange/needed-red	Lead partners	Financing	Monitoring & review
Reservoirs	increased summer temperature	Drought	Increased demand for water and declining water stocks	4	6	9	16	**1) Build new reservoirs; 2) Invest in water efficiency in homes and businesses**	1 Yorkshire Water 2 Building owners	insufficient data	Ongoing
	decreased summer rainfall	Drought	Reduced water availability (impact on people, gardens, agriculture	4	6	12	16	**1) Invest in water efficiency in homes and businesses; 2) Develop/plant drought resilient species**	Building and land owners	insufficient data	Ongoing
	increased rainfall intensity	Flooding	Washout of sewage to watercourses	6	9	16	20	**Tbc in consultation with Yorkshire Water**	Yorkshire Water and Environment Agency	insufficient data	insufficient data
	increased summer temperature	Enhanced evaporation	Decreased river water levels leading to poor water quality and slower reservoir recharge	4	6	12	20	**Tbc in consultation with Yorkshire Water and Environment Agency**	Yorkshire Water and Environment Agency	insufficient data	insufficient data
Electricity grid	increased summer temperature	Heatwave	Surge in energy demand for A/C leads to brownouts	2	6	12	16	**1) Cultural change to wear fewer clothes in summer and to not expect cold offices; 2) Provide air conditioned public shelters; 3) New buildings built to remain cooler in summer; 4) Older buildings retrofitted with solar shades etc**	1 Employers 2 Local authorities 3-4 Building owners with support from local authorities	insufficient data	Ongoing
	increased winter rainfall	Flooding	Inundation of sub-stations leading to blackouts and direct inundation of data centres	9	9	16	20	**1) Risk assessments for specific data centres; 2) flood resilience measures implemented or data centres relocated.**	Utilities and IT companies	insufficient data	One to five years
Nuclear power stations	increased summer temperature	Heatwave	Emergency shutdown to avoid overheating leading to brownouts	3	6	12	16	**1) n/a for Yorkshire but may need to deal with consequences**	n/a	n/a	five to twenty years
Urban drainage network	increased rainfall intensity	Flooding	Overwhelmed urban drainage network (impacts on ecology and urban flooding)	15	15	20	25	**1) Reduce runoff rates by intercepting water through enhanced use of SUDS. 2) Improve capacity of drainage network. 3) Protect properties/infrastructure at greatest risk of inundation**	Local authority planning and land drainage functions	insufficient data	Ongoing

Waste management

The potential impacts of climate change on waste management, especially increased temperatures and localised flooding, will have a great impact on both municipal and household waste management.

Key receptors at risk	Future climatic conditions	Impacts	Consequence	level of risk (severity x likelihood) now	2020	2050	2080	Action done-green/planned-orange/needed-red	Lead partners	Financing	Monitoring & review
Refuse workers	increased winter rainfall	Flooded roads	Staff unable to get to work	12	16	16	20	**1) Conduct staff travel surveys to asses vulnerability 2) Ensure facilities are accessible by multiple transport modes**	Local authorities Metro	Insufficient data	one to five years
Putrescible waste	increased summer temperature	Higher incidence of vermin	More demand on pest control services	9	16	20	20	**1) Inform residents how to store waste so that it doesn't attract vermin**	Local authorities External waste contractors	Insufficient data	one to five years
	increased summer temperature	Higher incidence of vermin	Greater risk of pest borne diseases to staff and residents	6	9	12	16	**1) Make staff aware of potential symptoms of vermin borne diseases and actions to take 2) Ensure waste is stored in ways less likely to encourage vermin**	Local authorities External waste contractors	Insufficient data	one to five years
Road infrastructure	increased rainfall intensity	Localised flash flooding	Sites have operations disrupted or suffer closure.	12	16	16	20	**1) Identify sites at risk 2) design appropriate contingency measures for these sites 3) Ensure that new facilities are built in areas with low flooding risk 4) Allow sufficient capacity at other sites to enable continued waste management operations**	Local authorities	Insufficient data	one to five years
	increased winter rainfall	Serious fluvial flooding	Waste collections missed over prolonged period	12	16	16	20	**1) Identify areas at risk 2) Ensure catch up capacity is built into collection route design**	local authorities External waste contractors	Insufficient data	one to five years
	increased winter rainfall	Flooded roads	Sites have operations disrupted or suffer closure for a prolonged period.	15	20	20	25	**1) Identify sites at risk 2) design appropriate contingency measures for these sites 3) Ensure that new facilities are built in areas with low flooding risk 4) Allow sufficient capacity at other sites to enable continued waste management operations**	local authorities external waste contractors emergency planning team, highways authorities	Insufficient data	one to five years
Waste processing sites	increased winter rainfall	Flooding of site	operations disrupted or site closes	10	15	15	20	**1) Identify sites at risk 2) design appropriate contingency measures for these sites 3) Ensure that new facilities are built in areas with low flooding risk 4) Build in sustainable drainage at sites 5) Allow sufficient capacity at other sites to enable continued waste management operations**	local authorities external waste contractors	Insufficient data	one to five years

Health and Social care

The potential impacts of climate change on human health are multiple and diverse. Changes in types and incidents of disease and events such as floods and heatwaves may have a negative impact on health. There may also be benefits associated with warmer winters and people spending more time outdoors in summer.

Key receptors at risk	Future climatic conditions	Impacts	Consequence	level of risk = severity x likelihood				Action done-green/planned-orange/needed-red	Lead partners	Financing	Monitoring & review
				now	2020	2050	2080				
Care staff	increased winter rainfall	Widespread flooding of transport infrastructure	Staff unable to get to work; increased workload with fewer staff	6	6	12	16	**1) Research to identify alternative sites that staff could access in an emergency. 2) Process developed to**	Health and social care organisations	Insufficient data	five to twenty years
	increased summer temperature	Overheated premises	Less effective patient care and need for more water/breaks	2	4	9	16	**1) Analyse risk in existing stock and retrofit measures to reduce summer overheating. 2) Ensure new build is able to cope with higher temperatures.**	Health and social care organisations	Insufficient data	One to five years
	increased winter rainfall	Widespread flooding of transport infrastructure	If roads flood, more difficult to attend emergencies	6	9	16	16	**1) Invest in boats/helicopters in order to be able to avoid floods 2) Flood protection measures provided**	Regional Resilience Forum Environment Agency and local authorities	Significant capital cost	One to five years
Vulnerable people (elderly, mental health patients, drug users etc)	increased summer temperature	Overheating of domestic properties	Uncomfortable and even dangerously hot homes increase pressure on health services	8	12	20	25	**1) Investigate and promote measures to reduce summer overheating. 2) Ensure new build is able to cope with enhanced temperatures. 3) Create a GIS enabled register of vulnerable people who may need extra visits in event of heatwave and a plan for delivery.**	Local authority through planning powers. GP consortia, social care and NHS	Insufficient data	One to five years
	increased summer temperature	Heatwave and poor air quality	Increased risk of respiratory related illness	6	9	16	20	**1) Consider respiratory conditions within current Heatwave Plan**	NHS	Cost neutral	five to twenty years
	increased winter rainfall	Increased severe flooding of residential areas	Most vulnerable people marooned in their homes	10	15	15	20	**1) Create a GIS enabled register of vulnerable people who may need priority rescuing/services in event of a flood and a plan for delivery.**	GP consortia, social care and NHS	Insufficient data	One to five years
	increased winter rainfall	Increased severe flooding of residential areas	Housing inequalities exacerbated as many of most deprived areas in flood plains	6	9	12	16	**1) Flood protection measures provided**	Environment Agency and local authorities	Significant capital cost	One to five years
Young people	increased summer temperature	Sunburn/ heatstroke	Additional short-term burden and possible long-term increase in skin cancers	6	9	9	16	**1) Skin protection campaigns in summer months 2) Schools have shaded areas outside and encourage children to wear hats/sunscreen**	Health and social care organisations Schools	Insufficient data	five to twenty years
Care facilities and buildings	increased summer temperature	Overheating of care premises	Buildings become uncomfortable for staff and patients and in extreme cases dangerous	6	9	12	20	**1) Ensure new care facilities are built to cope with higher temperatures. 2) Retrofit measures into existing care facilities to reduce overheating when carrying out planned maintenance. 3) Increase green infrastructure to reduce temperatures (LCR Green Infrastructure Strategy)**	Health and social care organisations Local authorities	Insufficient data	One to five years
	increased summer temperature	Conditions conducive to bacterial growth etc	Higher temperatures encourage pests and associated diseases in hospital and care environments	6	9	12	16	**1) Rigorous and well monitored hygiene standards in health care facilities**	Health and social care organisations	Insufficient data	five to twenty years
	increased winter rainfall and increased	Flooding: interruption to electricity,	May need to close some health/social care facilities	15	15	20	20	**1) Identify utilities at risk from flooding. 2) Install flood resilience measures to at risk sites.**	Utility companies. Regional Resilience Forum.	Insufficient data	Every two years

	rainfall intensity	water, other utilities									
	increased winter rainfall and increased rainfall intensity	Flooding of premises	May need to temporarily close or relocate some health/social care facilities	15	15	20	20	**1) Identify properties at risk of flooding.** **2) Retrofit measures to at risk buildings to reduce likelihood of flooding.** **3) Ensure new care facilities are not at risk of flooding.**	Health and social care property managers. WY Resilience Forum.	Minimal capital costs. Avoid significant flood damage costs.	One to five years
	increased winter rainfall	Increased severe flooding of residential areas	Minor and major flooding will impact on individual households and communities and lead to displacement, social isolation and mental health issues.	10	15	15	20	**1) Flood protection measures provided** **2) intensive social and healthcare support for affected communities after flooding event**	Environment Agency local authorities Health and social care organisations	1 Significant capital cost 2 revenue costs	One to five years
	increased rainfall intensity	Localised flooding	may lead to mobilisation of dangerous chemicals from storage or remobilisation of chemicals already in the environment, e.g. pesticides	8	12	12	16	**1) Ensure that chemical stores are properly bunded and not at risk from flooding** **2) Regular water quality monitoring following flood events**	Organisations that store chemicals Environment Agency Local authorities	Insufficient data	One to five years
Disease vectors	increased winter temperatures	Less prolonged cold therefore no die-back of disease vectors	More incidence of disease	6	9	12	20	**1) Monitoring of disease vector levels** **2) More active pest control when outbreaks occur**	Local authorities	Insufficient data	One to five years
	increased summer temperature	New diseases more commonplace	More alien ailments (eg West Nile Virus)	8	12	12	16	**1) Border control to prevent spread of ailments and monitoring of outbreaks** **2) Research into alien ailments and awareness raising with health professionals**	Health Protection Agency	Insufficient data	One to five years

Opportunities

As a whole, it is clear that climate change will bring a number of impacts and negative consequences. However positive consequences or opportunities should not be ignored.

Warmer temperatures may be welcomed by many people across West Yorkshire, as it increases opportunities for outdoor activities. The tourism industry may also benefit from warmer weather conditions which could create new jobs and increase economic stability. The natural environment many also benefit for changes in climatic conditions through the creation of new habitats and the mitigation and introduction of new plant and animal species. A change to growing conditions may also provide opportunities for new, potentially lucrative crops in agriculture.

A number of opportunities have been identified for each priority sector. These have been listed as opportunities as there are positive opportunities or the level of risk has reduced overtime. A summary of these opportunities can be found in table 3.

	Receptor	Future climatic conditions	Impacts	Benefit
natural environment	River corridors and aquatic habitats	increased winter rainfall	Fluvial flooding	Creation of seasonal wetlands
	Woodlands and forests	increased rainfall intensity	warmer weather conditions	Creation of seasonal wetlands
		increased winter temperatures		increased growing opportunities for biomass
		decreased summer rainfall		
	Urban greenspace	increased summer temperature	warmer weather conditions	increased demand for the greenway and public rights of way network
built environment	Domestic buildings	increased winter rainfall	Milder winter	Reduced damage from frost
	Commercial buildings	increased winter rainfall		Reduction in salt use
	Domestic and commercial buildings	increased summer temperature	warmer weather conditions	increased opportunity of renewables
Utilities	Utilities	increased winter temperatures	Reduced heating demand	Lower gas demand
	Wind farms	increased storminess	Higher average wind speed	potential to generate more electricity
	Gas supply	increased winter temperatures	Higher average wind speed	Reduced demand for heating

Health and social care	Health & social care	increased winter temperatures	Warmer homes	Lower incidence of fuel poverty and cold-related ill-health
	Health & social care	increased winter temperatures	Less snow and ice	Reduced trips and falls and fewer broken hips
	Health & social care	increased summer temperature	More time spent outside	healthier lifestyle and reduced obesity
	Health & social care	increased winter temperatures	Longer growing season	More potential for locally grown seasonal food
Transport	Road network	increased winter temperatures	Increase in marginal frost nights/flushing of salt and potential for increased use of de-icing agents	Reduction in pollution of watercourses near roads & L/B Airport
		increased winter temperatures	Chloride damage to concrete highway structures	Reduction in the structural damage to concrete structures
		increased winter temperatures	Increase in marginal frost nights & wet snowfall affecting highway network	Reduction in the risk of vehicular and pedestrian accidents and causalities
		increased winter temperatures	Increase in marginal frost nights/flushing of salt & potential for increased use of de-icing agents	Reduction in pollution of watercourses near roads and Leeds Bradford Airport, contamination highway boundaries

Table 3: climate change opportunities

Next Steps

Through the development of the West Yorkshire adaptation action plan, a number of areas for further investigation have been identified. These areas are detailed below:

- **Review Process**

The priority risk assessments need to be regularly monitored, identifying any additional information, such as the location and magnitude of impacts and related consequences from recent severe weather events. It would be useful to set up an annual monitoring process for each major sector. Based on the annual review, it maybe necessary to re-assess the scoring of the existing risk assessment. If new information becomes available through the amendments of the UKCP09, it would be advantageous to re-score the risk assessments for the periods 2020, 2050 and 2080.

An annual review of the West Yorkshire adaptation action plan would be essential to update the progress made by existing, planned & proposed climate proofing actions. This process would be best undertaken by the local authorities, who will have local knowledge on sector impacts and consequences. Taking account of the present economic situation, it is important to target the most vulnerable locations in West Yorkshire with the most cost effective climate proofing measures.

It would be advisable to set up specialist working groups for each sector across West Yorkshire. For example, work initiated by the Integrated Transport Authority/Metro, (conducted by Leeds and Kirklees) has suggested a Transport Climate Proofing working group should be created through operation of the WY Local Transport Plan 2011-26. This working group would require experts from transport asset management, emergency planning and climate proofing backgrounds.

- **Future project development**

In order to make best possible use of the UKCP09 and the design of cost effective adaptation measures for all sectors, the following areas need to be better understood and investigated:

1. Weather Thresholds

Improved monitoring of severe weather related impacts, including the magnitude & consequences for all sectors, should be logged against relevant weather related thresholds. There is a need to investigate at what point significant damage will occur. For example, at what temperature will a road surface melt? Therefore it is essential that local authorities document the impact of severe weather conditions in terms of financial, reputational and staff costs.

2. Other impacts and factors

The magnitude of damage will not necessarily relate simply to a severe weather event. For example, the case of melting/rutting roads, there could be several additional factors that contribute to the impact. These include:

- Max/min temperatures
- Intensity of solar radiation
- Aspect & gradient of highway
- Colour & type of highway surface
- Static weight & number of vehicles

Therefore, when logging of asset damage, consideration needs to be given to potential exacerbating factors, before cost effective adaptation measures can be designed.

3. Weather Generator

The UKCP09 includes a tool known as the weather generator, which is able to simulate future climate, for running 30 year periods, during the 21st century. This facility can be used to identify the likely frequency & magnitude of specific weather thresholds being exceeded. The weather generator has the capability of assessing multiple weather related parameters. With improved knowledge of projected exceedances of weather thresholds, the weather generator shall aid development of cost effective climate proofing measures.

4. Tolerable Risks

Using the above information, probabilities of specific weather events can be calculated. For example, 10%, (Very unlikely), 50%, & 90% (Very likely). When considering at what level to climate proof, it is important to relate to the asset 'Design life'. For example, road surfacing is designed for 10 to 20 years, whilst a bridge is normally designed 120 years. There is a need for asset managers to assess:

- Links between weather threshold probabilities & magnitude of damage
- Use of Risk Assessment/Cost benefits
- Agree a 'weather threshold probability' for a specific asset design life

5. Vulnerability Mapping

There is an aspiration to develop Vulnerability Mapping for all West Yorkshire major sectors & related services. Vulnerability mapping has the potential to identify 'hotspots' for existing & future climate risks. The following factors need to investigated, they include:

- Details of existing vulnerability (Use of LCLIPs)
- An understanding of compounding environmental factors
- Use of UKCP09 to assess future climate risks, their magnitude & probabilities
- Use of 3D modelling tools, to assess impacts of climate risks. Eg, simulate flood return periods, wind flow/stress modelling, model heatflux/heatwaves

Appendices

APPENDIX ONE:

West Yorkshire Local Climate Impacts Profile

The historical impacts of severe weather

Created by Kirklees Council
20/08/2010

West Yorkshire Local Climate Impacts Profile

Introduction

A Local Climate Impacts Profile (LCLIP) is designed to support, local authorities in understanding the impacts of a changing climate on its citizens, businesses and partner organisations. The purpose of producing an LCLIP is to highlight opportunities to:

- Understand, prepare and plan for local climate impacts
- work both individually and in partnership to:
  - identify local climate change adaptation measures, and
  - Allocate resources - both time and money - to support such adaptation measures.

An LCLIP is developed in two stages:

Step one involves research and evidence gathering through different media resources over a set time period, usually between five and ten years. Where local press archives recorded weather extremes and their effects on the community, the information is turned into an incident profile. These incident profiles are then compared by date with Met Office data to gain a clear scientific picture of the extreme weather event. A cross comparison with historical data is then done to help rule out routine, rather than climate change related events.

Step two involves researching, where possible, the quantitative (who, over what time scale and at what cost) and qualitative costs (reputational risks and benefits) of each incident.

Each local authority across West Yorkshire has completed an LCLIP detailing the extreme weather events affecting the local area over periods ranging from three to ten years (see table 1)

Local Authority	Duration of LCLIP
Bradford Council	**1999-2008**
Calderdale Council	**1999-2008**
Kirklees Council	**2003-2010**
Leeds Council	**2002-2008**
Wakefield Council	**2006-2009**

Table 1: The five West Yorkshire Local Authorities LCLIPS

Using these five local authority LCLIPs the West Yorkshire LCLIP has been produced to give a sub-regional picture of climate impacts. It has been collated by taking any incidents reported across three or more of the local authority areas to create a set of sub-regional incident profiles.

West Yorkshire LCLIP Report Findings

There were 24 recorded climate change events across the West Yorkshire region between January 2000 and January 2010. Figure 1 shows the type and frequency of these events:

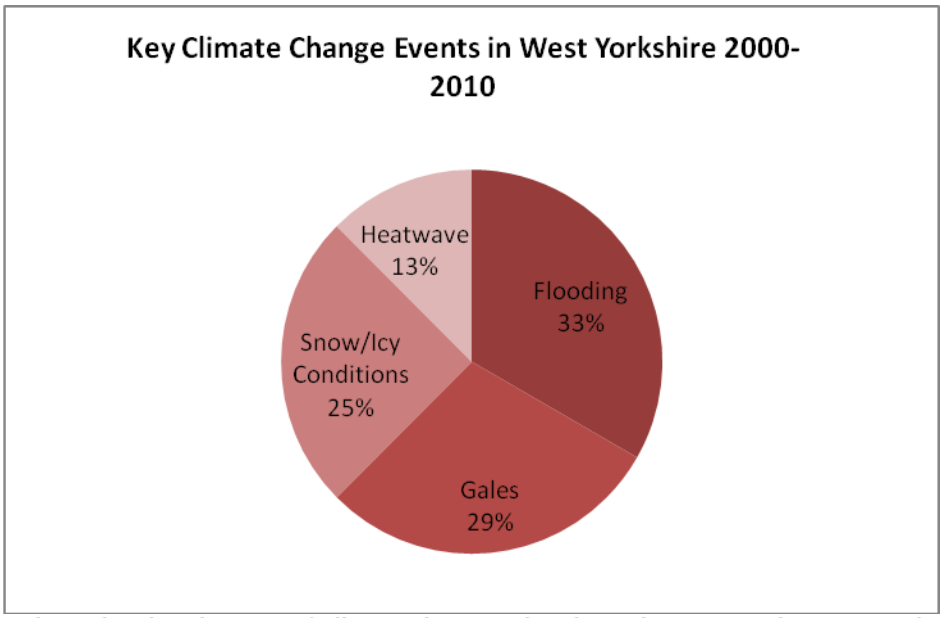

Figure 1: Pie chart showing the type of climate change related weather events that occurred across West Yorkshire 2000-2010

Flooding: Flooding is the predominant incident type. Eight separate flood records occurred, accounting for 33% of damages and impacts.

Gales: These were the next most frequent event type, being recorded on seven occasions; wind related events account for 29% of damages and impacts.

Snow/ice: Six events are related to snow, which account for 25% of damages and impacts. The likelihood of snow events is evenly distributed across the recording period.

Heatwave: Three events are related to above average temperature/heat waves, which account for 13% of damages and impacts.

Incident Profile Summaries

For each of the 24 recorded events an incident profile has been created containing the following details:

- Date of incident
- Met Office weather description
- Recorded local and national media headlines
- Description of weather
- Services and Organisations likely to be impacted

Each of the incident profilees are summarised below (for full incident profiled see appendix A):

Incident 01: Flooding, November 2000

"*Floods cause rail service to halt*"- Halifax Courier

Flooding throughout the Yorkshire region occurred between the 2nd and 4th November due to unusually high rainfall accorss the UK. September to November 2000 was the wettest period on record since 1914 (Met Office).

Local media at the time were reporting severe traffic congestion, road closures and delays and cancellations to bus and rail services. The most severe incident reported was the collapse of the A6033 Rochdale Road due to constant rainfall, costing £500,000 to rectify.

Incidents 02 & 03: Summer and Winter Flooding, 2002

"*Summer floods hit North*" - BBC News
"*Flood alerts issued as downpours swamp Yorkshire*"- Yorkshire Post

June to August 2002 saw intense rainfall over very shot periods of time, which simply overwhelmed drainage systems across the region. In August, West Yorkshire and the North West experienced 121mm of rainfall in 24 hrs, a one in 280-year event (Met Office, 2002). In December, the region experienced a 50% increase on average rainfall, with eighteen flood warnings issued by the Environment Agency.

Reports highlighted problems across the region including, flooding of domestic and commercial property, road blockages and rail line closures.

Incidents 04, 05 and 06: Winter Gales, 2002

"*Storm rocks Calderdale: Driver has lucky escape as tree falls on car... River Calder swells as wild weather strikes*"- Halifax Courier

Gusts of up to 90 mph were experienced across the UK throughout January, February and October 2002.

Local and National media reported sever delays and cancellations for the bus and rail networks between Leeds and Doncaster, due to falling debris and damaged power lines. Many roads and bridges across the Yorkshire region were also closed to vehicles following several overturned lorries and incidents of trees hitting cars.

Incident 07: Summer Flooding, 2003

"*Rainstorm causes rush-hour flooding*"- Huddersfield Examiner

June and July 2003 saw very intense periods of rainfall and storm activity for the North of England due to a prolonged low pressure system.

Widespread flooding was reported across the West Yorkshire region causing delays to Arriva, GNER and Virgin train services, which had to be stopped from entering the region at Newcastle. Many roads were closed due to damage from flowing water.

Incidents 08 and 09: Snowfall and Icy conditions, winter 2003

"*Snow brings M1 chaos as drivers feel crunch*"- Yorkshire Post
"*2004 starts in dark for thousands*" – Yorkshire Post

In February 2003 a complex low pressure system moved in from Iceland causing widespread snowfall and Icy conditions for the UK. From December 2003 to January 2004 up to 20cm of snow accumulated across the North of England, Scotland and Wales.

The transport sector was the hardest hit industry with many reported road and motorway closures including the M1, M62 and the A635, leading to severe traffic congestion. The rail network had engineering trains fitted with snow ploughs on standby to unblock lines. Buses in and around Leeds were cancelled on New Years Eve leaving many people stranded.

Incident 10: Heatwave, Summer 2003

"*99 degrees…..we're sizzling in the sun*"- Yorkshire Post

5th August to 9th September 2003 experienced extreme hot weather, with Leeds and Bradford recording temperatures in excess of 27ºC.

Road and Rail Networks across the Yorkshire region were subject to delays and diversions due to grassland fires. National Rail imposed speed limits for trains due to the threat of bucking tracks. Nationally in summer of 2003, the rail network experienced 165,000 delay minutes compared to the cooler summer of 2004 which experience 30,000 delay minutes.

Incidents 11 and 12: Gales, January and March 2004

"*Weather causes transport havoc*"- BBC News

Northern parts of the UK experience gales of up to 100 mph on the 28th January and 22nd March 2004.

The gales caused widespread damage across West Yorkshire, pulling down power lines and toppling vehicles. This caused numerous power cuts and major delays on the road networks, parts of Leeds city centre were closed due to falling debris and emergency services were

called to many road traffic accidents and reported unsafe structures.

Incident 13: Snow/Blizzard Conditions, February and March 2005

"*Road chaos after 'Siberian' night*"- Huddersfield Examiner

Unexpected blizzard conditions occurred over eastern England and the Pennines bringing up to 30cm of snow.

Reports highlight severe traffic congestion at the time with 11 mile tail backs on the M62 around Leeds. Roads over higher parts of Huddersfield were closed and National rail brought in emergency workers to de-ice trains and tracks to ensure services continued.

Incident 14: Gales 6-14th January 2005

"*Gales leave trail of devastation*"- Huddersfield Examiner

Gales up to 80 mph were recorded across the region.

Northern England took a battering, with transport and power supplies disrupted. Among the incidents reported were overturned lorries on the A1 in North Yorkshire and delays to train services on the east coast main line in North Yorkshire and Huddersfield because of damage to overhead power lines. The M62 had 15 mile tail backs eastbound from Scammonden due to overturned vehicles.

Incident 15: Flash Flooding, summer 2006

"*Downpour brings rush-hour chaos for drivers*"- Yorkshire Post

Storms, high temperatures and periods of intense rainfall throughout July, August and September 2004 caused wide spread flash flooding across the West Yorkshire region.

The road networks were disrupted with reports of rush hour chaos for commuters with flooding on the M62 and A58 around Leeds. There were delays and cancellations to the east coast main line due to flooding, and rail services between Leeds and Manchester were disrupted due to a landslide caused by intense rainfall.

Calderdale Council reported a £250,000 clean up operation following the floods.

Incident 16: Heatwave July 2006

"*Huge blaze hits moorland near village*"- Huddersfield Examiner

July 2006 was the hottest month on record across many UK regions since 1914 with temperature in Yorkshire reaching up to 30ºC (10ºC high than the normal monthly average).

The Met Office declared a level three alert, one step down from a national emergency.

Gritters were deployed across Yorkshire to spread sand in order to prevent tyres from sticking to melting tarmac. Speed restrictions were implemented across Yorkshires' rail network for fear of buckling tracks.

Incident 17: Major flooding event June 2007

"*Disruption and deluge stretches 999 services to their limits*"- Yorkshire Post

The Yorkshire and Humber region experienced over three times the average June rainfall in 2007, with some areas having their wettest June on record. The rainfall resulted in thousands of homes and businesses being flooded and disruption to road and rail transport. Several deaths were attributed to the flooding.

Many roads across the region were closed including the M1, M62, A1 and A63, main roads through Kirklees, Leeds and Wakefield were also closed causing severe traffic congestion. Leeds and Sheffield train stations were evacuated and all services cancelled, Northern Rail could not provide alternative services due to traffic congestion and road closures.

Incidents 18 and 19: Flash Flooding January and August 2008

"*Flash floods bring chaos to the roads*" - Huddersfield Examiner

"*Dewsbury train station closed - updated flood warning*" - Huddersfield Examiner

The Met Office reported above average rainfall and stormy conditions for both January and August 2008 resulting in flooding in the North of England. 29 flood warning were in place across the UK throughout August.

Flash flooding caused delays and cancellations to public transport with many train services replaced with buses across Leeds, Calderdale and Bradford. Many roads were also closed with Hebden Bridge been the worst affected area.

Incidents 20, 21 and 22: Snowfall and Icy conditions, winter 2008

"*Snow chaos on Yorkshire roads*"- Yorkshire Post
***"Snowfall brings chaos to region*"-Yorkshire Post**

Met Office data shows that January, February and December 2008 were extremely cold months. Up to 10 cm of snow fell across the North of England with the Yorkshire and Humber region been worst affected.
Roads were closed across Kirklees including the A635 and the A6024. Many schools across the region were closed and emergency service had an increased number of phone calls. Local and National media warned drivers of hazardous conditions on the M62.

Incident 23: Gales 21st January-1st February 2008

"Gone with the Wind!"- Huddersfield Examiner

Very strong gusts up to 80 mph recorded across the Yorkshire and Humber region.
Flights in Leeds were grounded and Main line rail services across Yorkshire were disrupted as the winds brought down power lines. Leeds City centre roads and pavements were closed due to falling debris causing delays to bus services.

Incident 24: Snowfall and Icy conditions, 17th December 2009 to 15th January 2010

"Heaviest Snow fall and longest cold snap in 20 years. Max temp 13.5 minimum temp -18"- BBC

From Thursday 17 December 2009 to Friday 15 January 2010 the UK experienced a spell of very low temperatures and significant snowfalls which affected almost the whole country. This was the most widespread and prolonged spell of this type across the UK since December 1981/January 1982.
The snowfalls and widespread freezing conditions caused very significant disruption across the UK throughout this period. Transport was particularly badly affected with snowfalls causing numerous road closures, and train and flight cancellations. The West Yorkshire region experienced cancellations to train and bus services with no alternative travel provided. The West Yorkshire Ambulance Service cancelled all but emergency pick up's and Dewsbury hospital cancelled all non emergency appointments. Many roads across the region were blocked with abandoned cars and many motorists were trapped in their cars overnight.

Impacts

It is clear from the information gathered that extreme weather events have had a significant impact on services and organisations in West Yorkshire over the last ten years. The main impacts of extreme weather events across the region appear to be:

- Damage to infrastructure e.g flooding of properties,
- Disruption to travel and accesability across the region e.g. traffic congestion and public transport cancellations, and;
- Dificulty or failure in delivering essential services e.g. provision of health and social care

Reported services and organisations affected by theses impacts are:

- Local authorities,
- Local rail and bus operators,
- West Yorkshire Metro,
- Network Rail,
- The Highways Agency,
- Emergency Services,
- Utility Companies, and;
- Local businesses

For local authorities, extreme weather poses a huge impact in terms of cost and service delivery. The key services affected by extreme weather are:

- Highways
- Parks and Open Spaces
- Schools
- Adult Services
- Environmental Services
- Housing
- Asset Management
- Health, Safety and Emergency Planning

Cost Analysis

The Stern Review on the Economics of Climate Change, published by HM Treasury in October 2006, signalled official acceptance of the imminent catastrophe of climate change. The report also highlighted that the costs of inaction against climate change far outweighs the costs of action. At a minimum, a failure to tackle climate change [Stern calls this “business as usual”] could cost 5 per cent of global GDP by 2050.
In August 2008, Manchester City Council and the Commission for the New Economy published a ‘Mini-Stern’ report, which found that failure to adapt to the legislative, policy and physical aspects of the climate change agenda could have profound effects, with potential losses of £20bn to the economy of the City Region by 2020 and £70bn for the North West as a whole.
Assessing the cost of climate change related weather events on any service or organisation is extremely difficult. Many of the actions taken during these times such as road closures, provision of alternative transport and drain unblocking are reactive

rather than proactive, with many costs unrecorded or absorbed into “business as usual” expenditure.
Below are some of the recorded costs found as part of the research for this report:
Calderdale Council reported the following costs over a ten year period:

- A £443,000 cost to Highway and Engineering Services over three flooding events (June 2000, July 2006 & January 2008)
- £890,730 Insurance claims on the Council estate over a 9 year period
- £178,915 third party insurance claims within a 9 year period.

Kirklees Council reported through their LCLIP that between 2003 and 2008, extreme weather events had cost the authority £ 283,030 - £ 1,255,200 a year. These costs were mainly incurred through highway repair and maintenance.
Leeds City Council reported incurred costs of £1,588,383 following the June 2007 floods (incident profile 17). This included extensive repairs to highways.

Key Messages and Recommendations

Future climate predictions from the UKCP09 state that over the next 80 years the Yorkshire and Humber region is going to experience the following changes in climate:

Future Climatic Condition	2020	2050	2080
Increased summer temperature	+ 1.3°C	+ 2.3°C	+ 3.3°C
Decreased summer rainfall	- 8%	- 19%	- 23%
Increased winter temperature	+ 1.3°C	+ 1.9°C	+ 2.9°C
Increased winter rainfall	+ 4%	+ 11%	+ 15%
Increased storminess	Increase overtime		
Increased rainfall intensity	Increase overtime		

These climatic changes are likely to cause increased frequency and intensity of the severe weather types already experienced across the Yorkshire and Humber region. The effects that these changes will have include:

- Damage to infrastructure
- Increased death rates
- Pressure on water supply
- Loss of local biodiversity and influx of new species
- Decline in air quality
- Stress on public services such as transport
- Decline in current agricultural activity.

All of these effects are also likely to have significant implications for businesses and residents in terms of repair and maintenance costs and how services are delivered across the district. To prevent this, local authorities, businesses and other organisations in the West Yorkshire need to plan and adapt to the threat of climate change.

Changing our responses to the impacts of past, current and future climate change is known as 'adaptation'.

Adaptation to climate change involves making decisions that are sustainable, made at the right time, maximising the benefits and minimising the costs. Although as a whole climate change will bring about many negative impacts, there will also be a number of opportunities. Adaptation needs to be built into planning and risk management now to ensure the continued and improved success of service delivery for local authorities across the region. To adapt to climate change local authorities and their partners need to:

- Acknowledge that responding to extreme weather events is already having a high impact causing budget issues and disruption to routine work programmes.

- Ensure risk assessments are undertaken and that actions are identified in respect of all climate change events,

- Review current policies and ensure adaptation, and the need to provide adaptation measures are addressed when;
    - Planning new developments or investments
    - Assessing sustainability of new projects
    - Developing new strategies/policies
    - Upgrading or refurbishing existing infrastructure.

- Ensure that future climate change related incidents are recorded as such and that all costs – including those which have been hidden in the past or absorbed into routine programmes - related to these incidents are captured.

- Secure budgets and conduct work arising from the review of transport asset resilience to severe weather events.

- Ensure that any relevant emergency plan and related documentation is regularly updated.

Appendix two:

Number of Accident & Emergency Attendances compared to the West Yorkshire Local Climate Impacts Profile

The table below shows the number of attendances at both Calderdale and Huddersfield Hospitals on 13 January 2010, together with the same details for a date in 2009 when there was also bad weather.

The weather related road traffic accidents and falls on ice incidents have then been broken down into number of fracture and other injuries. We have also shown the number of these "bad weather" patients who were admitted to hospital as a result of their injuries.

Huddersfield Royal Infirmary

	02.02.2009	**13.01.2010**	
Other attendances	108	101	
Weather related Road Traffic Accidents	5	20	75% increase
Falls on ice	16	78	79.4% increase
Total	**129**	**199**	35.2% increase
Fractures	8	41	80.4% increase
Other injuries	13	57	77.2% increase
Total	**21**	**98**	78.6% increase
Admitted to hospital	4	6	33.34% increase

Calderdale Royal Hospital

	02.02.2009	**13.01.2010**	
Other attendances	147	142	
Weather related Road Traffic Accidents	7	6	14.2% decrease
Falls on ice	10	50	80% increase
Total	164	198	17.2% increase
Fractures	4	23	82.6% increase
Other injuries	13	33	60.6% incease
	17	56	69.6% increase
Admitted to hospital	0	1	100% increase

Appendix 3.

The table outlines the impacts of severe weather, as identified in the West Yorkshire LCLIP, on the West Yorkshire Fire and Rescue Service's monthly call outs. The call outs have been broken down into different types of calls received.

		Number of calls received to the West Yorkshire Fire & Rescue Service						
Month	**LCLIP incident**	**Primary** - property, houses and cars	**Secondary** - Rubbish and refuse, including grass	**Special Service Calls**, inc Road Traffic Collision, flooding, tile and chimney removal.	**FAAP** - Fire Alarms to commercial and domestic property.	**FAGI** - call were the member of public thinks there is a fire, eg steam from a building mistaken as smoke.	**FAM** - Malicious call, by adult, youth or child.	Total
Jul-03	**Flooding**	**893**	**1236**	**401**	**1208**	**430**	**164**	**4332**
Aug-03	**Super heat**	**878**	**2099**	**372**	**1230**	**569**	**185**	**5333**
Jan-04	**Snow**	**682**	**574**	**308**	**1002**	**303**	**161**	**3030**
Feb-04	**Flooding**	**634**	**982**	**307**	**1031**	**337**	**183**	**3474**
Mar-04	**High Winds**	**693**	**1320**	**382**	**1031**	**402**	**222**	**4050**
Aug-04	**Flooding**	**614**	**854**	**602**	**1450**	**364**	**164**	**4048**
Jan-05	**High Winds**	**563**	**591**	**398**	**1051**	**279**	**143**	**3025**
Feb-05	**Snow**	**560**	**802**	**264**	**972**	**284**	**159**	**3041**
Jul-06	**Super heat**	**548**	**2807**	**408**	**1217**	**686**	**129**	**5795**
Jan-07	**Flooding**	**496**	**482**	**447**	**1060**	**274**	**128**	**2887**
Jun-07	**Flooding**	**436**	**727**	**773**	**1099**	**497**	**100**	**3632**
Jul-07	**Flooding**	**420**	**645**	**336**	**1069**	**457**	**102**	**3029**
Jan-08	**Flooding**	**440**	**447**	**397**	**963**	**430**	**146**	**2823**
May-08	**Super heat**	**488**	**1168**	**315**	**1004**	**503**	**104**	**3582**
Aug-08	**Flooding**	**421**	**691**	**298**	**1113**	**478**	**66**	**3067**
Sep-08	**Flooding**	**448**	**770**	**318**	**1187**	**474**	**80**	**3277**
Dec-08	**Snow**	**376**	**578**	**287**	**920**	**390**	**91**	**2642**
Average		**540**	**1065**	**321**	**1047**	**403**	**132**	**3508**

Appendix four:

Risk assessment methodology

1. **Key activities at risk:**

Please list the key activities that your service/work area currently have responsible for. The matrix has already been partly completed by pulling out actions from relevant Service Performance Plans

2. **Future climatic conditions affecting activities:**

Please use the drop down menu to select the individual climatic condition relevant to the chosen activity. The table below outline these future climatic conditions:

Future Climatic condition	2020	2050	2080
Increased summer temperature	+ 1.3°C	+ 2.3°C	+ 3.3°C
Decreased summer rainfall	- 8%	- 19%	- 23%
Increased winter temperature	+ 1.3°C	+ 1.9°C	+ 2.9°C
Increased winter rainfall	+ 4%	+ 11%	+ 15%
Increased storminess	Increase overtime		
Increased rainfall intensity	Increase overtime		

Source: **Weathering the storm: Yorkshire and Humber regional adaptation study, 2009**

3. **Impact:**

Please list the key impacts that the different climatic conditions (above) would have on the activities e.g. flooding or heatwave.

4. **Consequence:**

What are the results of the impacts? Who or what is impacted? Please list positive & negative consequences e.g.: Increased tourism (+) or road closed (-). If the consequence is positive, then highlight in blue.

5. **How severe is the impact:**

Please rank using the following scores:

1 = Minimal
2 = Minor
3 = Moderate
4 = Serious
5 = Severe

6. **How likely is the risk:**

Please rank using the following scores:

1 = Low
2 = Fairly low
3 = Medium
4 = Fairly high
5 = High

7. **Level of risk:**

This is an automatic calculation (severity x likelihood = risk).
We have followed normal risks assessment protocol by selected scores of:

1-9 to be green
10-15 to be amber
16+ to be red

8. **Action:**

Please list any actions that are currently in place or will soon be out in place to address the risk. If there are none, please propose what would be necessary to deal with the risk. Each action should be colour-coded to represent whether the action is needed, planned or done.

Red = needed
Amber = planned
Green = done

9. **How long before action takes effect:**

Please use the drop down menu to select the relevant timescale for implementation

10. **Cost of impact:**

Please use the drop down menu to score low, medium or high. Monetary values were not used as the cost will be relative to each service or sector & should not be used as a comparable measure.

11. **Cost effectiveness:**

Please use the drop down menu to select relevant criteria

12. **Do current practises stymie future adaptation?**

Are the current actions likely to impact in the future?

Notes

a. For columns 8, 9, 10, 11 & 12, there may not be enough knowledge or information currently available to address the listed risk. In this case, please select 'insufficient data'.
b. The matrix should not be altered, only additional rows can be added

<u>Appendix four:</u> Blank risk assessment template

				How severe is the impact? (5)				How likely is the risk? (6)				level of risk = severity x likelihood (7)								
Receptor (1)	Future climatic conditions affecting receptor (2)	Impacts (3)	Consequence (4)	Now	2020	2050	2080	Now	2020	2050	2080	now	2020	2050	2080	Action done-green/planned-orange/needed-red (8)	How long before action takes effect (9)	Cost of impact (10)	Cost effectiveness (11)	Do current practices stymie future adaptation (12)
												0	0	0	0					
												0	0	0	0					
												0	0	0	0					
												0	0	0	0					
												0	0	0	0					
												0	0	0	0					
												0	0	0	0					
												0	0	0	0					
												0	0	0	0					
												0	0	0	0					
												0	**0**	**0**	**0**					
												0	0	0	0					
												0	0	0	0					
												0	0	0	0					
												0	0	0	0					
												0	0	0	0					
												0	0	0	0					

Natural Environment

				How severe is the impact? (5)				How likely is the risk? (6)				level of risk = severity x likelihood (7)							
Key habitats at risk (1)	**Future climatic conditions affecting habitat (2)**	**Impacts (3)**	**Consequence (4)**	**Now**	**2020**	**2050**	**2080**	**Now**	**2020**	**2050**	**2080**	**now**	**2020**	**2050**	**2080**	**Action done-green/planned-orange/needed-red (8)**	**How long before action takes effect (9)**	**Cost of impact (10)**	**Cost effectiveness (11)**	**Do current practices stymie future adaptation (12)**
Upland Bog	Increased summer temperatures Decreased Summer Rainfall	Drought	Destabilisation of blanket bog	4	4	5	5	1	3	4	4	4	12	20	20	**A. Support for the Moors for the Future partnership and other upland partnerships. B. Delivery of Landscape scale South Pennines project C. Delivery of the Blanket Bog Habitat Action Plan D. Increase public awareness re fire risks E. The introduction of the new Water Framework Directive**	ongoing	high	pays for itself in 20 years	no
	increased winter temperatures		increased risk of fire	3	3	4	4	2	2	3	4	6	6	12	16					
	decreased summer rainfall		loss of biodiversity	2	2	3	3	2	2	3	4	4	4	9	12					
			Reduced water storage capacity leading to down stream flash flooding and decreased water quality	2	2	3	4	2	2	3	4	4	4	9	16					
			Increased erosion	2	2	2	3	2	3	3	3	4	6	6	9					
	increased summer temperature	Heatwave	Decreased species number	3	3	4	4	3	3	4	4	9	9	16	16					
			Loss of stored carbon	4	4	4	4	2	2	3	4	8	8	12	16					
River Corridors & aquatic habitats	Increased Winter rainfall	Flash floods	flooded infrastructure, residential and business areas	4	4	4	4	3	3	4	4	12	12	16	16	**Development of the Surface Water Management Plans**	within a year	high	insufficient data	no
		Fluvial flooding	change in habitat composition	1	1	2	2	3	3	3	3	3	3	6	6	**A. Delivery of landscape scale rivers, riverine corridors and associated habitat projects B. Leeds City Region Green Infrastructure strategy**	insufficient data	medium	insufficient data	no
			spread of non native species	2	2	3	3	2	2	3	4	4	4	9	12	**Increased management intervention (including mapping and spraying)**	Immediate	low	pays for itself in 5 years	no

	increased summer temperature	drought	Reduced water storage capacity leading to down stream flash flooding and decreased water quality	2	2	3	4	2	2	3	4	4	4	9	16	**A. Delivery of landscape scale rivers, riverine corridors and associated habitat projects B. Leeds City Region Green Infrastructure strategy C. Introduction of the Water Framework Directive**				
			loss of seasonal wetland habitat	1	2	2	3	2	3	4	4	2	6	8	12		ongoing	insufficient data	insufficient data	insufficient data
Woodlands and Forests	increased rainfall intensity	Fluvial flooding	Change in species migration patterns	1	1	2	3	1	1	2	3	1	1	4	6	**Regular surveying of area**	five to twenty years	insufficient data	no economic benefit	no
	increased summer temperature	Warmer weather conditions	increased pest and diseases	2	3	3	3	1	2	3	4	2	6	9	12	**Follow best practice guidance re. pests (Nat England, FC, EA)**	insufficient data	insufficient data	insufficient data	no
			increased fires	3	3	4	4	2	2	3	4	6	6	12	16	**A. Awareness of specific weather alerts B. Increase public awareness re fire risks**	five to twenty years	medium	pays for itself in 20 years	insufficient data
Urban Green Spaces (includes parks and open spaces)	Decreased Summer Rainfall Increased Summer Temperatures	Drought	change in habitat composition	2	2	2	3	2	2	3	3	4	4	6	9	**Regular surveying of area**	five to twenty years	insufficient data	no economic benefit	insufficient data
	Increased Winter rainfall Increased winter temperatures		Transmitting of non native plant species from private gardens/ponds	1	1	2	2	1	1	2	2	1	1	4	4	**Identify common examples and manage public areas appropriately**	one to five years	low	no economic benefit	no
	increased rainfall intensity	Urban flooding	Loss of connectivity	1	1	1	1	1	1	2	2	1	1	2	2	**LCR GI Strategy, Landscape scale biodiversity projects, PPS9 Planning apps**	ongoing	medium	insufficient data	insufficient data
			green open spaces flooded	3	3	4	5	3	3	4	4	9	9	16	20	**Identify common examples and manage public areas appropriately**	insufficient data	medium	insufficient data	no
	increased winter rainfall		Increased risk of pests and more pest control needed	1	1	2	2	1	1	2	3	1	1	4	6	**Follow best practice guidance re. pests (Nat England, FC, EA)**	insufficient data	insufficient data	insufficient data	insufficient data
			Increasing use of green spaces leading to more intensive maintenance requirements	1	1	2	2	1	2	3	3	1	2	6	6	**Allow more adaptive naturalistic management of green spaces**	ongoing	low	insufficient data	insufficient data

	Increased Summer Temperatures	Heatwave and drought	Increased growing season	1	1	2	2	2	2	3	3	2	2	6	6	**Allow more adaptive naturalistic management of green spaces**	ongoing	low	insufficient data	insufficient data
			Increasing use of green spaces leading to more intensive maintenance requirements	1	1	1	1	1	1	2	2	1	1	2	2	**Costed maintenance programme for greenways**	one to five years	low	pays for itself in 5 years	no
	Decreased Summer Rainfall		Limited water resources for green space maintenance	1	2	3	3	3	3	4	4	3	6	12	12	**Allow more adaptive naturalistic management of green spaces**	ongoing	low	insufficient data	insufficient data
	increased winter rainfall	Changes in growing seasons	decrease of species richness due to faster growing aggressive species	1	1	2	2	2	3	4	5	2	3	8	10	**Monitor and manage where appropriate by landowners**	ongoing	low	insufficient data	insufficient data
	increased winter temperatures increased summer temperature decreased summer rainfall		Increased mowing regimes in winter/decreased in summer	1	1	2	3	3	3	4	5	3	3	8	15	**Investigate options for meadow creation and Allow more adaptive naturalistic management of green spaces**	Immediate	low	no economic benefit	no
Agricultural land	Increased winter rainfall	Flooding	Potential crop losses	3	3	3	3	1	2	3	3	3	6	9	9	**Investigate a permaculture approach and additional planting**	ongoing	medium	insufficient data	insufficient data
			Soil erosion	1	1	2	3	1	2	3	3	1	2	6	9					
	Increased winter temperatures	Changes in growing seasons	Opportunities for new crop types	1	1	1	1	1	1	2	2	1	1	2	2	**Best practice guidance from the National Farmers Union**	ongoing	low	insufficient data	no
			Loss of traditional crops e.g. Hay making	1	2	3	3	1	2	3	3	1	4	9	9	**Promote Natural England Higher Level Stewardship scheme**	ongoing	low	insufficient data	no
			Longer growing seasons	1	1	2	2	2	2	3	4	2	2	6	8					
	Decreased summer rainfall	Heatwaves and drought	Increased numbers of pests and diseases	1	2	3	3	2	2	3	3	2	4	9	9	**Increased management intervention (including mapping and spraying)**	ongoing	insufficient data	insufficient data	insufficient data
			Impacts on livestock feed and water availability	2	2	3	4	1	1	2	2	2	2	6	8	**Plan for increased arable and livestock farming due to demand for more self sufficient measures in the UK**	insufficient data	insufficient data	insufficient data	insufficient data

	increased summer temperatures		Increased water management required	2	2	3	4	2	3	4	5	4	6	12	20	**A. LCR GI Strategy, B. Landscape scale biodiversity projects**	within a year	insufficient data	insufficient data	insufficient data

Built Environment

				How severe is the impact? (5)				How likely is the risk? (6)				level of risk = severity x likelihood (7)								
Receptor (1)	**Future climatic conditions affecting habitat (2)**	**Impacts (3)**	**Consequence (4)**	**Now**	**2020**	**2050**	**2080**	**Now**	**2020**	**2050**	**2080**	**now**	**2020**	**2050**	**2080**	**Action done-green/planned-orange/needed-red (8)**	**How long before action takes effect (9)**	**Cost of impact (10)**	**Cost effectiveness (11)**	**Do current practices stymie future adaptation (12)**
Domestic buildings	increased summer temperature	heat wave	Overheating problems	2	2	3	3	2	2	3	3	4	4	9	9	LCR Green Infrastructure strategy - increased planting, shading and use of other materials to reduce the solar heat gain. New and existing buildings painted lighter colours to reflect heat	one to five years	high	insufficient data	no
			reduced comfort in buildings for occupants	3	3	4	5	3	3	4	4	9	9	16	20	Promotion of Passihauv developments. Ensure new builds are built to highest possible Code of Sustainable Homes level . Change orientation of building to ensure reduction is solar gain. Local Development Framework adoption	one to five years	insufficient data	insufficient data	insufficient data
		warmer conditions	Increased condensation and the onset of damp related issues	1	2	2	3	2	2	3	4	2	4	6	12	Allow for adequate ventilation to prevent mould growth	ongoing	low	insufficient data	no
			increased demand for air conditioning	1	2	2	2	1	2	2	2	1	4	4	4	Installation of energy efficient cooling systems	Immediate	low	insufficient data	no
	decreased summer rainfall	drought	water shortages	3	3	4	4	2	2	3	4	6	6	12	16	Increased use of ponds, roadside swales. Install grey water systems and water harvesting system	ongoing	medium	insufficient data	insufficient data

	increased winter rainfall	floods	buildings on low-lying areas at risk of flooding	4	4	4	5	2	2	3	4	8	8	12	20	**LCR Eco-settlement scheme (new builds). Homeowners complete a personal flood plain. New policy on floods as part of the Local Development Framework. Creation of surface water management plans. Install larger soakaways, french drains around buildings to take water away.**	one to five years	high	insufficient data	no
			increased property damage	2	2	3	3	2	3	3	4	4	6	9	12	**Homeowners complete a personal flood plain. Greater community awareness raising needed**	ongoing	medium	insufficient data	no
	increased storminess	more frequent storms	increased cost of repair bills	2	3	4	4	1	2	3	3	2	6	12	12	**Retro existing buildings and carry out routine inspections. Ensure that roof slates are securely fixed and gutters are clear from debris.**	ongoing	medium	no economic benefit	no
Commercial buildings	increased summer temperature	heat wave	Occupant dissatisfaction	1	2	2	3	2	2	3	4	2	4	6	12	LCR Green Infrastructure strategy - increased planting, shading and use of other materials to reduce the solar heat gain	ongoing	low	no economic benefit	no
			Decreased material durability eg UPVS weakening in the sun	1	2	3	4	1	1	2	3	1	2	6	12	**Consider different material use. Timbers treated with oils to reduce them drying out. Use traditional natural materials with tried and tested durability**	insufficient data	insufficient data	insufficient data	insufficient data
			increased energy demand=risk of blackouts	1	1	2	3	1	1	2	3	1	1	4	9	See utilities risk assessment matrix				

	increased winter rainfall	floods	increased damage to buildings	1	2	3	4	2	3	3	4	2	6	9	16	**Install flood resilient measures and retro existing buildings. Carry out routine inspections and manage known 'pinchpoints' .**	ongoing	high	no economic benefit	no
	decreased summer rainfall	drought	Increased subsistence risk	1	1	2	3	1	1	2	3	1	1	4	9	**Allow for monitoring of buildings for possible subsidence. LCR Green Infrastructure strategy**	ongoing	insufficient data	insufficient data	no
			Stress on water supply	1	2	2	4	1	2	3	4	1	4	6	16	**LCR Green Infrastructure strategy. Increase the use of rainwater harvesting and storage. Water efficient fixtures and fittings installed.**	ongoing	medium	insufficient data	no
Building Planning and Design	increased rainfall intensity	flash flooding	Existing flood defences can't cope	2	3	3	4	1	2	3	4	2	6	9	16	Amended parts L, F & G on Building Regulations will cover energy efficiency, water use and ventilation. **Greater promotion of the BREAAM standards**	one to five years	high	insufficient data	insufficient data
	increased storminess	Gales/high winds	increased damage to buildings	2	3	3	4	2	2	4	4	4	6	12	16					
	increased summer temperature	heatwave	failure of current cooling systems	2	3	3	4	1	2	3	3	2	6	9	12					
Building Construction and Management	increased summer temperature	warmer conditions	discomfort/health risk to construction workers	1	2	3	4	1	2	2	3	1	4	6	12	**Introduce flexible working arrangements, Promote the NHS Heatwave Plan**	ongoing	high	no economic benefit	no
	increased summer temperature	increased unsuitable building conditions	Reduced construction time (cementing materials drying faster)	1	2	2	3	1	2	3	4	1	4	6	12	**Consider different material use.**	ongoing	low	insufficient data	no
	increased winter rainfall																			
	increased storminess		Increased stoppage of work	1	2	3	3	1	2	2	3	1	4	6	9	**Change in seasonal construction regimes**	ongoing	low	insufficient data	no
	increased rainfall intensity																			

Transport

				How severe is the impact?				How likely is the risk?				level of risk = severity x likelihood								
Key transport elements at risk	**Future climatic conditions affecting transport**	**Impacts**	**Consequence**	**Now**	**2020**	**2050**	**2080**	**Now**	**2020**	**2050**	**2080**	**now**	**2020**	**2050**	**2080**	**Action done-green/planned-orange/needed-red**	**How long before action takes effect**	**Cost of impact**	**Cost effectiveness**	**Do current practices stymie future adaptation?**
Road network	increased winter temperatures	Increase in marginal frost nights/flushing of salt & potential for increased use of de-icing agents	Pollution of watercourses near roads & L/B Airport, contamination highway boundaries	2	3	2	1	3	4	3	2	6	12	6	2	Improve spreading of salt , find alternative de-icing agents. Glycol & Acetate based de-icing agent used for aircraft & runways, respectively	ongoing	medium	insufficient data	no
	increased winter temperatures	Chloride damage to concrete highway structures	Structural damage to concrete structures	5	5	5	5	4	4	3	3	20	20	15	15	Consider use of Omex (Potassium Acetate) as de-icing agent for concrete structures, prevents chloride attack. New design standards needed to seal structures & identify alternative steel reinforcement	insufficient data	high	insufficient data	insufficient data
	increased winter temperatures	Increase in marginal frost nights & wet snowfall affecting highway network	Increased risk of vehicular & pedestrian accidents & causalities	3	3	3	3	4	4	4	3	12	12	12	9	Investigate marginal conditions for winter maintenance & actual casualty rates on highway network. (Both vehicular & pedestrian).	insufficient data	insufficient data	insufficient data	no
	increased winter temperatures	Decreased frequency of frost damage & potholes in highway	Reduced highway maintenance costs & damage to vehicles operating on network	4	3	2	1	3	2	1	1	12	6	2	1	A rare opportunity likely with reduced budget spent on repairing frost damage / potholes	five to twenty years	low	insufficient data	no
	increased rainfall intensity	Increased risk of highway flooding resulting from new developments, or highway improvements	Transport disruption & flooding of frontage property	3	3	3	4	3	3	4	4	9	9	12	16	Provision of appropriate sustainable urban drainage, allowing temporary storage & controlled release	ongoing	insufficient data	insufficient data	no
	increased rainfall intensity	Aqua-planning & poor visibility on derestricted highways & motorways, during periods of heavy rainfall	Increased risk of highway accidents & casualties	2	3	3	3	2	3	4	4	4	9	12	12	Use of porous asphalt in vulnerable areas to allow free draining highway surface. (Need to consider affects of skid resistance, water scour & tyre noise)	over twenty years	insufficient data	insufficient data	no

	increased storminess	Buffeting/toppling of vehicles in high winds. (Motorways mainly at risk)	Traffic disruption, potential closure of highways, especially on motorways & derestricted roads	4	4	4	5	3	3	4	5	12	12	16	25	Consider use of natural shelter belts or wind diffusers in vulnerable areas. Appropriate use of highway warnings (VMS) , improved enforcement of speed restrictions & vehicle bans when dangerous	insufficient data	medium	insufficient data	insufficient data
	increased storminess	Trees, frontage property or street furniture damaged, or blown on to road network	Traffic disruption, potential closure of highways	3	3	4	4	3	4	4	5	9	12	16	20	Select robust highway trees in exposed locations and ensure careful pruning of trees in vulnerable areas. Consider new design standards for resilience of street furniture & building fabric. A Severe Weather Plan for High Winds has been developed by P&E P	ongoing	insufficient data	insufficient data	no
	increased summer temperature	Melting, 'fatting up' or rutting of highway surfaces, due to high surface temperatures	Damage to road surfaces in exposed locations . Melting bitumen can soil vehicle paintwork pedestrian footwear. Overheating of paths can also cause discomfort to pedestrians.	2	2	3	3	2	3	3	4	4	6	9	12	Select appropriate road surface materials for application in vulnerable (exposed) locations & on high load bearing sections of highway. Prepare appropriate contingency plans - e.g. deployment of gritters to apply sand during heatwave conditions	over twenty years	high	no economic benefit	yes
	increased rainfall intensity	Road surface scouring & separation of carriageway surfaces, caused by flooding events & suction effect	Road surface damage, local traffic disruption and increased maintenance burden	2	2	3	3	2	2	3	4	4	4	9	12	Identify vulnerable locations & seek actions to reduce risk of highway flooding. Improve bonding of highway surfaces.	over twenty years	insufficient data	insufficient data	no
	increased rainfall intensity increased winter rainfall	Localised flooding of road network, resulting from flash flooding , minor fluvial or overland flooding events	Highway flooding causing traffic disruption, potential closure of highways. Most vulnerable after dry or very wet period, leading to rapid runoff	3	3	4	4	3	4	4	5	9	12	16	20	Use of VMS / CCTV / UTC Intranet Service to direct traffic away from affected areas. Emergency planning procedures to help coordinate flood response. Develop bespoke actions to reduce vulnerability to flash & overland flooding .	insufficient data	insufficient data	insufficient data	no
Road network (& damage to frontage property)	increased rainfall intensity	Blocked Highway gulleys & culverts, due to intense or prolonged heavy rainfall events.	Local flash flooding, disruption to transport, damage to frontage property. Most vulnerable after dry period, with rapid runoff & first flush debris blocking drainage, or when ground is saturated	4	4	4	4	3	4	4	5	12	16	16	20	Identify vulnerability of gully/culvert to flooding. Fortnightly cleansing of vulnerable culvert grids, improved gully cleansing procedures	Immediate	high	pays for itself in 5 years	no

Road network Rail infrastructure	increased winter rainfall	Fluvial flooding of highways or rail lines, normally caused by heavy & prolonged winter rainfall	Serious flooding of highway network & rail lines adjacent to major rivers	5	5	5	5	3	4	4	5	15	20	20	25	Identify vulnerable locations & design appropriate flood alleviation measures & supporting emergency procedures	insufficient data	insufficient data	insufficient data	insufficient data
Road network Rail infrastructure	increased rainfall intensity increased winter rainfall	Increased risk of landslips during of heavy rainfall & saturated ground	Can cause local serious disruption or closure of highways or rail lines	3	3	4	5	2	3	3	4	6	9	12	20	Identify vulnerable locations & stabilise embankments using appropriate geotechnical solutions, or tree planting.	insufficient data	insufficient data	insufficient data	insufficient data
Road network Rail infrastructure	increased summer temperature decreased summer rainfall	Subsidence of roads/rail lines during prolonged hot dry spells.	Surface and structural damage to the road and rail networks resulting in the need for increased maintenance or repair, and disruption to travel.	2	3	3	4	2	3	4	4	4	9	12	16	Identify vulnerable locations, use of appropriate raft foundations resilient to soil heave.	insufficient data	high	insufficient data	no
Road network	increased summer temperature	Damage to bridge expansion joints	increased risk of salt penetration & chloride damage to structures & problems with joint tyre noise	2	2	3	3	2	3	3	4	4	6	9	12	Investigate use of alternative design of structures, or improved expansion joint & bonding within structure (Reduced salt application)	insufficient data	insufficient data	insufficient data	insufficient data
Road network	increased storminess	Bridge structures are vulnerable to high winds. Vehicles and pedestrians using bridges may be subjected to high levels of buffeting during storms.	Risk to safety of bridge users and to the stability of some bridge structures.	2	2	3	3	2	3	3	4	4	6	9	12	Raising of parapets for bridges in particularly vulnerable locations. Potential need to review structure maintenance regimes, again particularly for the most vulnerable bridges.	insufficient data	insufficient data	insufficient data	insufficient data
Rail infrastructure	increased summer temperature	Vulnerability of rails buckling during heatwave, or possible subsidence in drought	Speed resictions & increased risk of rail accident	2	2	3	3	2	3	3	4	4	6	9	12	Amend pre-tension of continuously welded rail line, strengthen foundation of rail line to prevent possible subsidence	insufficient data	high	insufficient data	insufficient data
Road network	increased rainfall intensity	Structural damage to bridges caused by increased river scour & debris blockage	Potentially high costs of repair and disruption to travel.	3	4	4	5	3	3	4	4	9	12	16	20	Increased frequency of bridge scour inspections from annual to 6 monthly . Debris clearance following flood events. New design standards to improve bridge resilience to high river flows	insufficient data	insufficient data	insufficient data	insufficient data
Rail infrastructure	increased winter rainfall																			
Rail infrastructure	increased rainfall intensity	Localised flooding of rail network , scouring & erosion of ballast	Disruption or closure of rail line, and potential damage to infrastructure.	3	3	4	4	3	4	4	5	9	12	16	20	Improve drainage, use of SUDS, and re-direct source of overland flooding.	insufficient data	high	insufficient data	insufficient data

	increased winter rainfall		Disruption to power supply on electrified lines.												Contingency plans to enable efficient pumping of water from affected sites.					
	increased summer temperature	Rail lines buckling	Speed restrictions, disruption or closure of rail line, and potential damage to infrastructure.	4	4	5	5	1	2	3	4	4	8	15	20	Plant trees and shrubs along vulnerable exposed lengths of track to provide shading. Adjust pre-tensioning of rail line.	insufficient data	insufficient data	insufficient data	insufficient data
	increased storminess	Trees, etc blown on to rail network	Disruption to travel, speed restrictions, potential risk to trains and passenger safety in the event of a collision.	2	3	3	4	3	4	4	4	6	12	12	16	Regular maintenance checks of structure stability. & condition of trees, pruning of vulnerable trees	Immediate	medium	insufficient data	insufficient data
		Rail power lines affected by high winds and lightning strikes	Disruption to travel & speed restrictions on network.	2	3	4	4	2	3	3	4	4	9	12	16	Regular maintenance checks. Design guidance for overhead lines/gantries may need to be amended to account for potential future changes.	ongoing	medium	insufficient data	no
Air infrastructure	Increased storminess	Risk of increasing gales/cross winds at LBIA	Short period airport closures, difficulty in aircraft landing, LBIA runway perpendicular to prevailing winds	3	4	4	4	3	3	4	4	9	12	16	16	Inappropriate to shelter, must wait for winds to subside, wind direction to change, or divert to appropriate Airport	insufficient data	insufficient data	insufficient data	no
	Increased winter rainfall	Increased risk of low cloud & aqua-planning on runway	Short period airport closures due to difficulty in take-off & landing	2	3	3	4	2	2	3	3	4	6	9	12	Wait for conditions to improve, or divert older aircraft to appropriate Airport. During conditions of radiation or valley fog, LBIA often accepts flights from other Airports, due to its high altitude.	insufficient data	medium	insufficient data	no
	increased rainfall intensity	Potential increased risk associated with thunderstorm downdrafts, lightning strikes	As above, plus risk of damage from lightning strike	2	2	3	3	2	2	3	4	4	4	9	12	Wait for conditions to improve, or divert to appropriate Airport.	insufficient data	insufficient data	insufficient data	insufficient data
Highway maintenance (verges)	increased winter temperatures	Continued growth of grass/ landscaping, during mild winters	Untidy verges & landscaping, potential loss of sight-lines & Signage by drivers	1	2	2	3	2	3	3	4	2	6	6	12	Develop more versatile highway verge management throughout the year	over twenty years	low	no economic benefit	no
Highway maintenance (pest control)	increased winter temperatures	Mild winters allow rodents & other pests to thrive & even breed during the winter	Increased pest nuisance within highway drainage systems & adjacent landscaping	2	2	3	3	2	3	3	4	4	6	9	12	Ensure new drainage systems are less accessible to rodents. Reduced use of low growing landscaping, which provide shelter for pests	over twenty years	low	no economic benefit	no
Highway maintenance (verges & landscaping)	decreased summer rainfall	Drought conditions, coupled with heatwave, causing low soil moisture	Vulnerable trees & landscaped areas die, or become weakened & at risk from pest attack	2	2	3	3	2	3	3	4	4	6	9	12	Amend verge & landscape management, irrigate vulnerable areas, consider drought tolerate species	insufficient data	insufficient data	insufficient data	insufficient data

Street furniture	increased storminess	Street lighting, road signs and other street furniture damaged	Cost of removal and repair or replacement. Also risk to public if struck by falling objects. Transport diversions and disruption to travel.	2	3	3	3	3	3	4	4	6	9	12	12	Consider use of VMS to control speed of traffic on vulnerable stretches of road.	insufficient data	low	insufficient data	no
																Ensure highway infrastructure and street furniture is resilient to the effects of high winds	insufficient data	medium	insufficient data	no
Public comfort and safety	increased storminess	Risk to pedestrians and cyclists of being blown into carriageway.	Increased risk of accidents & casualties, posing a risk to safety.	2	3	3	4	3	4	4	4	6	12	12	16	Identify vulnerable crossings/stretches of highway and erect guard rails, etc where necessary. Consider use of wind diffusers, or natural shelterbelts in exposed locations	insufficient data	medium	insufficient data	no
	increased storminess	Gales and storms - falling signs, trees, lighting columns etc pose danger to public	Increased risk of accidents & casualties, posing a risk to safety.	2	3	3	3	3	3	4	4	6	9	12	12	Make sure new street furniture and lighting columns are resilient to high winds and that existing structures are maintained for sufficient resilience.	insufficient data	medium	insufficient data	no
																Regular maintenance checks of structure stability.	ongoing	medium	insufficient data	no
																Emergency response plans prepared.	ongoing	insufficient data	insufficient data	no
	increased storminess	Gales and storms - lack of sheltered waiting facilities for public transport users .	Passenger discomfort and potential reduction in uptake of public transport during severe weather events (e.g. vulnerable people or those choosing to drive by car in preference).	1	2	2	3	3	3	4	4	3	6	8	12	Ensure adequate provision of sheltered waiting facilities.	one to five years	medium	insufficient data	no
																Real time travel info to avoid people having to wait too long in adverse weather conditions.	ongoing	low	pays for itself in 5 years	no
	increased storminess	Bus services cancelled due to route restrictions or road closures.	Reduced services and resulting travel disruption and lost revenue.	1	1	2	2	2	2	3	3	2	2	6	6	Diversions through less vulnerable areas.	ongoing	medium	pays for itself in 5 years	no
	increased summer temperature	Heatwaves - lack of shaded waiting facilities with seating for public transport users.	Passenger discomfort and potential reduction in uptake of public transport during severe weather events.	2	3	3	4	3	3	4	4	6	9	12	16	Ensure shaded and seated waiting facilities are available at exposed locations.	one to five years	medium	insufficient data	no
																Real time bus information systems to avoid people having to wait in the heat for an unnecessarily long time.	ongoing	low	pays for itself in 5 years	no
	increased summer temperature	Overheating in bus and local rail stations	Heat stress problems, especially for very young & old persons	2	3	3	4	3	3	4	4	6	9	12	16	Design in adequate natural ventilation systems, without resorting to use of air conditioning . Provide water during periods of heatwave.	five to twenty years	medium	insufficient data	no

	increased summer temperature	Poor thermal comfort within mass transit systems / public transport.	Heat stress problems, especially for very young & old persons	3	4	4	5	3	3	4	4	9	12	16	20	Include specifications for adequate ventilation and/or air conditioning, tinted windows, etc. in tender specifications.	one to five years	high	insufficient data	no
	increased summer temperature	Heatwaves - increased risk of photochemical pollution episodes & resultant poor air quality	Increased risk of health problems & morbidity for vulnerable groups of the population	2	3	3	4	3	3	4	4	6	9	12	16	Raise priority of air quality issues in local decision-making and implement schemes to reduce levels of air pollution.	Immediate	medium	pays for itself in 5 years	no
																Implement text alert scheme for people with respiratory illness during pollution episodes.	Immediate	high	pays for itself in 5 years	no
																Use real time information for public transport to avoid vulnerable passengers having to wait at the roadside/rail stations during pollution episodes.	one to five years	low	insufficient data	no
Information	increased summer temperature increased winter rainfall increased storminess increased rainfall intensity	Poor communication of travel information during service disruptions during severe weather events.	Confusion and dissatisfaction of customers. Potential for people to be left stranded.	2	2	2	2	2	3	4	5	4	6	8	10	Contingency plans to be drawn up to ensure effective communication is provided for all passengers, and in particular for vulnerable passenger groups.	within a year	medium	insufficient data	no

Utilities

				How severe is the impact?				How likely is the risk...				level of risk (severity x likelihood)							
Receptor	**Future climatic conditions affecting receptor**	**Impacts**	**Consequence (who or what is impacted)**	**now**	**2020**	**2050**	**2080**	**Now**	**2020**	**2050**	**2080**	**now**	**2020**	**Now**	**2080**	**Action(s)**	**How long before action takes effect**	**Cost effectiveness**	**Do current practices stymie future adaptation**
Reservoirs	increased summer temperature	Drought	Increased demand for water and declining water stocks	2	2	3	4	2	3	3	4	4	6	9	16	1. build new reservoirs; 2. invest in water efficiency in homes and businesses			
	decreased summer rainfall	Drought	Reduced water availability (impact on people, gardens, agriculture	2	2	3	4	2	3	4	4	4	6	12	16	1. invest in water efficiency in homes and businesses; 2. develop/plant drought resilient species			
	increased winter rainfall	Flooding	Overtopping and erosion of dams leading to catastrophic collapse and flooding	5	5	5	5	1	2	3	3	5	10	15	15	1. Risk assessments for specific dams; 2. ongoing monitoring of structural integrity; 3. remedial works (Yorkshire Water)			
	increased rainfall intensity	Flooding	Overtopping and erosion of dams leading to catastrophic collapse and flooding	5	5	5	5	1	1	2	2	5	5	10	10				
Water treatment works	increased winter rainfall	Flooding	Washout of sewage to watercourses	2	2	3	3	3	3	4	4	6	6	12	12				
	increased rainfall intensity	Flooding	Washout of sewage to watercourses	3	3	4	4	2	3	4	5	6	9	16	20	? Sewage traps?			
Rivers	decreased summer rainfall	Drought	combined with risk below									0	0	0	0				
	increased summer temperature	Enhanced evaporation	Decreased river water levels leading to poor water quality and slower reservoir recharge	2	2	4	5	2	3	3	4	4	6	12	20	? Ecology link			
Groundwater		Prolonged drought	Insufficient recharge of groundwater leading to water shortages	3	3	3	3					0	0	0	0	(need to check overall rainfall figs)			
Electricity grid	increased summer temperature	Heatwave	Surge in energy demand for A/C leads to brownouts	2	3	4	4	1	2	3	4	2	6	12	16	1. cultural change to wear fewer clothes in summer and expect to be hot; 2. provide specific public A/C shelters; 3. new buildings built to remain cooler in summer; 4. older buildings retrofitted with solar shades etc			
	increased winter temperatures	Reduced heating demand	Lower gas demand									0	0	0	0				

Electricity pylons	increased storminess	Gales	Potential for pylons/cables to be damaged, leading to blackouts	4	4	4	4	3	3	3	3	12	12	12	12			
	increased rainfall intensity	Landslides	Potential for pylons/cables to be damaged, leading to blackouts	4	4	4	4	1	2	3	3	4	8	12	12			
Electricity sub-stations	increased rainfall intensity	Flooding	Inundation of sub-stations leading to blackouts	2	3	3	4	2	2	3	3	4	6	9	12			
	increased winter rainfall	Flooding	Inundation of sub-stations leading to blackouts	3	3	4	5	3	3	4	4	9	9	16	20	1. Risk assessments for specific data centres; 2. flood resilience measures implemented or data centres relocated.			
Nuclear power stations	increased summer temperature	Heatwave	Emergency shutdown to avoid overheating leading to brownouts	3	3	4	4	1	2	3	4	3	6	12	16	1. n/a for Yorkshire but may need to deal with consequences			
Conventional power stations	increased winter rainfall	Flooding	Inundation of power stations leading to brownouts	3	3	3	3	1	1	2	3	3	3	6	9				
Wind farms	increased storminess	Gales	Damage to wind turbines	4	4	4	4	2	2	2	2	8	8	8	8				
Wind farms	increased storminess	Higher average wind speed	potential to generate more electricity																
Telephone poles and mobile phone masts	increased storminess	Gales	Potential for pylons/cables to be damaged, leading to loss of communications	3	3	3	3	2	2	2	2	6	6	6	6				
	increased rainfall intensity	Landslides	Potential for pylons/cables to be damaged, leading to loss of communications	3	3	3	3	1	2	3	3	3	6	9	9				
Data centres	increased rainfall intensity	Flooding	Inundation of data centres leading to loss of critical information or internet access	3	3	3	3	3	3	4	4	9	9	12	12				
	increased summer temperature	overheating	Need to switch off data centres	2	3	4	4	1	2	3	3	2	6	12	12				
Urban drainage network	increased rainfall intensity	Flooding	Overwhelmed urban drainage network (impacts on ecology and urban flooding)	5	5	5	5	3	3	4	5	15	15	20	25	1. Reduce runoff rates by intercepting water through enhanced use of SUDS. 2. Improve capacity of drainage network. 3. Protect properties/infrastructure at greatest risk of inundation			

Utilities staff	increased winter rainfall	Flooding	Difficulties carrying out ongoing maintenance and repairs	3	3	3	3	2	3	3	4	6	9	9	12				
Gas supply	increased winter temperatures	Higher average wind speed	Reduced demand for heating									0	0	0	0				

Waste management

				How severe is the impact?				How likely is the risk...				level of risk (severity x likelihood)							
Receptor	**Future climatic conditions affecting receptor**	**Impacts**	**Consequence (who or what is impacted)**	**Now**	**2020**	**2050**	**2080**	**Now**	**2020**	**2050**	**2080**	**now**	**2020**	**2050**	**2080**	**Action done-green/planned-orange/needed-red**	**Lead Partners**	**Financing**	**Monitoring and Review**
Landfilled waste																			
& increased winter rainfall	increased summer temperature	Changes to decomposition rate	Increased or decreased lifespan of site	1	1	3	1	1	1	1	1	1	1	3	1	1) Monitor leachate and landfill gas production 2) Revise site lifespan	Local authorities, waste contractors,	Insufficient data	one to five years
& decreased rainfall & increased rainfall intensity	increased summer temperature	Changes to decomposition rate	Altered volume and composition of leachate and landfill gas production and concentration	1	1	2	2	1	1	2	2	1	1	4	4	1) Monitor leachate and landfill gas production 2) Upgrade collection treatment methods	Local authorities, external waste contractors, environment agency	Insufficient data	one to five years
& increased rainfall intensity	increased winter rainfall	Waste becomes saturated, groundwater levels rise	Greater risk of off-site leachate pollution and landfill gas migration	3	3	4	4	1	1	2	2	3	3	8	8	Ensure facilities have good surface water management plans in place such as larger gutters for increased rainfall and SUDS	Local authorities, waste contractors,	Insufficient data	one to five years
	increased rainfall intensity	Waste becomes saturated	Landfill slopes become unstable, potential for slippage	4	4	4	4	2	2	1	1	8	8	4	4	Enforcement of regulations on steepness of slopes.	Local authorities, environment agency	Insufficient data	one to five years
Refuse workers	increased summer temperature	Outdoor based staff exposed to more intense heat and sunlight	Workers suffer from sunburn, dehydration or other conditions associated with over-exposure	2	3	3	3	1	2	3	4	2	6	9	12	1) Ensure staff are aware of risks of over-exposure; 2) Ensure staff have adequate access to drinking water and sunblock	local authorities, external waste contractors,	Insufficient data	one to five years
	increased winter rainfall	Flooded roads	Staff unable to get to work	4	4	4	4	3	4	4	5	12	16	16	20	1) Conduct staff travel surveys to asses vulnerability; 2) Ensure facilities are accessible by multiple transport modes	local authorities, Metro	Insufficient data	one to five years
Putrescible waste	increased summer temperature	Higher incidence of vermin	More complaints from residents and lower satisfaction levels with service.	2	3	3	3	3	4	5	5	6	12	15	15	Inform residents how to store waste so that it doesn't attract vermin	local authorities, external waste contractors,	Insufficient data	one to five years
	increased summer temperature	Higher incidence of vermin	More demand on pest control services	3	4	4	4	3	4	5	5	9	16	20	20	Inform residents how to store waste so that it doesn't attract vermin	local authorities, external waste contractors,	Insufficient data	one to five years
	increased summer temperature	Higher incidence of vermin	Greater risk of pest borne diseases to staff and residents	3	3	4	4	2	3	3	4	6	9	12	16	1) Make staff aware of potential symptoms of vermin borne diseases and actions to take; 2) Ensure waste is stored in ways less likely to encourage vermin	local authorities, external waste contractors,	Insufficient data	one to five years

	increased summer temperature	Higher incidence of odour and bioaerosol nuisance	Nuisance to residents, lower satisfaction levels with service	1	1	2	2	4	5	5	5	4	5	10	10	1) Ensure residents advised of how to store waste to minimise odours 2) Procurement of receptacles that mitigate decomposition process	local authorities, external waste contractors,	Insufficient data	one to five years
	increased summer temperature	Waste decomposes at a higher rate	Reduced potential storage time for waste at transfer loading stations.	3	3	3	3	1	2	3	3	3	6	9	9	Revise transfer loading operations schedules	local authorities, external waste contractors,	Insufficient data	one to five years
Road infrastructure	increased rainfall intensity	Localised flash flooding	Waste collections missed	3	3	3	3	3	4	4	5	9	12	12	15	1) Identify areas most at risk, 2) Enhance catch up capacity within collection route design	local authorities	Insufficient data	one to five years
	increased rainfall intensity	Localised flash flooding	Sites have operations disrupted or suffer closure.	4	4	4	4	3	4	4	5	12	16	16	20	Identify sites at risk; 2) design appropriate contingency measures for these sites; 3) Ensure that new facilities are built in areas with low flooding risk; 4) Allow sufficient capacity at other sites to enable continued waste management operations	local, emergency planning teams,	Insufficient data	one to five years
	increased winter rainfall	Serious fluvial flooding	Waste collections missed over prolonged period	4	4	4	4	3	4	4	5	12	16	16	20	1) Identify areas at risk, 2) Ensure catch up capacity is built into collection route design	local authorities, external waste contractors,	Insufficient data	one to five years
	increased winter rainfall	Flooded roads	Sites have operations disrupted or suffer closure for a prolonged period.	5	5	5	5	3	4	4	5	15	20	20	25	Identify sites at risk; 2) design appropriate contingency measures for these sites; 3) Ensure that new facilities are built in areas with low flooding risk; 4) Allow sufficient capacity at other sites to enable continued waste management operations	local authorities, external waste contractors, emergency planning teams, highways authorities	Insufficient data	one to five years
Waste processing sites	increased rainfall intensity	Water content of waste increases	Mechanical recovery equipment affected and may need to be changed	4	4	4	4	1	1	2	2	4	4	8	8	1) Use receptacles that prevent ingress of water into waste, 2) undertake processing indoors whenever possible	local authorities, external waste contractors,	Insufficient data	one to five years
	increased rainfall intensity	Water content of waste increases	Waste becomes less combustible (for EfW purposes)	2	2	2	2	1	1	2	2	2	2	4	4	1) Use receptacles that prevent ingress of water into waste, 2) undertake processing indoors whenever possible	local authorities, external waste contractors,	Insufficient data	one to five years
	increased summer temperature	Dust produced at greater volumes	Increased disamenity of site	3	3	3	3	1	2	2	3	3	6	6	9	Upgrade dust suppression systems	local authorities, external waste contractors,	Insufficient data	one to five years

&increased intensity	increased winter rainfall	Flooding of site	operations disrupted or site closes	5	5	5	5	2	3	3	4	10	15	15	20	Identify sites at risk; 2) design appropriate contingency measures for these sites; 3) Ensure that new facilities are built in areas with low flooding risk; 4) Build in sustainable drainage at sites; 5) Allow sufficient capacity at other sites to enable continued waste management operations	local authorities, external waste contractors,	Insufficient data	one to five years
&increased intensity	increased winter rainfall	Flooding of site	insurance premiums increase	2	2	3	3	2	3	4	4	4	6	12	12	1) Survey regularly for leaks 2) Use more resilient liners	local authorities, external waste contractors,	Insufficient data	one to five years
Waste collection containers	increased summer temperature	Solar exposure leads to brittleness	Lifespan of containers reduced	3	3	3	3	2	3	3	4	6	9	9	12	1) Survey regularly for leaks 2) Use more resilient liners	local authorities, external waste contractors,	Insufficient data	one to five years
Landfill sites	increased summer temperature	Solar exposure shortens lifespan of landfill liners	Greater risk of off-site leachate pollution	3	3	3	2	1	1	1	1	3	3	3	2	1) Survey regularly for leaks 2) Use more resilient liners	local authorities, external waste contractors,	Insufficient data	one to five years
	increased summer temperature	Increased dust at site	Increased disamenity	3	2	2	1	2	3	2	2	6	6	4	2	Upgrade dust suppression systems	local authorities, external waste contractors,	Insufficient data	one to five years
	decreased summer rainfall	Shrinkage of clay lining and capping layers	Greater risk of off-site leachate and landfill gas pollution	3	3	2	2	1	2	3	4	3	6	6	8	1) Monitor caps for cracks and gas / leachate emissions, 2) Repair degraded caps, 3) Use capping techniques less prone to shrinkage for currently uncapped sites	local authorities, external waste contractors,	Insufficient data	one to five years
	increased winter rainfall	increase erosion of landfill bunds and capping layers	Greater risk of off-site leachate and landfill gas pollution	3	3	2	2	1	1	2	3	3	3	4	6	1) Monitor caps / bunds erosion 2) Repair degraded bunds / caps, 3) Use techniques more resilient to erosion	local authorities, external waste contractors,	Insufficient data	one to five years
	increased winter rainfall	ground saturated	certain types of equipment can't be used or require modifying - e.g. different tyres needed.	3	2	2	1	2	3	3	3	6	6	6	3	1) Modify affected equipment 2)Adjust procurement practice to take account of risk	local authorities, external waste contractors,	Insufficient data	one to five years
Civic amenity sites	increased storminess	Wind blown litter and debris	Customer satisfaction reduced,	2	2	2	2	3	3	3	3	6	6	6	6	Ensure waste stored in covered receptacles, 2) keep sites tidy	local authorities, external waste contractors,	Insufficient data	one to five years
	increased storminess	Wind blown litter and debris	Risks of site damage and to health from wind blown objects .	4	4	4	4	2	2	2	2	8	8	8	8	Ensure waste stored in covered receptacles, 2) keep sites tidy	local authorities, external waste contractors,	Insufficient data	one to five years

Health and Social Care

				How severe is the impact?				How likely is the risk...				level of risk (severity x likelihood)							
Receptor	**Future climatic conditions affecting receptor**	**Impacts**	**Consequence (who or what is impacted)**	**Now**	**2020**	**2050**	**2080**	**Now**	**2020**	**2050**	**2080**	**now**	**2020**	**2050**	**2080**	**Action(s)**	**How long before action takes effect**	**Cost effectiveness**	**Do current practices stymie future adaptation**
Care staff	increased winter rainfall	Widespread flooding of transport infrastructure	Unable to get to work; increased workload with fewer staff	3	3	4	4	2	2	3	4	6	6	12	16				
	increased rainfall intensity	Localised flooding of transport infrastructure	Unable to get to work; increased workload with fewer staff	2	2	2	2	2	3	4	5	4	6	8	10				
	increased summer temperature	Overheated premises	Less effective patient care and need for more water/breaks	1	2	3	4	2	2	3	4	2	4	9	16	1. analyse risk in existing stock and retrofit measures to reduce summer overheating. 2. ensure new build is able to cope with higher temperatures.			
	increased winter rainfall	Widespread flooding of transport infrastructure	If roads flood, more difficult to attend emergencies	3	3	4	4	2	3	4	4	6	9	16	16	1. Invest in boats/helicopters			
	increased rainfall intensity	Localised flooding of transport infrastructure	If roads flood, more difficult to attend emergencies	2	2	3	3	2	3	4	5	4	6	12	15	1. Invest in boats/helicopters			
	increased storminess	Broken communication links	Access to services reduced through poor communications	3	3	3	3	3	3	3	3	9	9	9	9				
	increased storminess	Roads blocked by debris	Access to services reduced through poor communications or inability attend emergencies	2	2	2	2	2	2	2	2	4	4	4	4				
	increased storminess	Roads blocked by debris	Unable to get to work; increased workload with fewer staff	2	2	2	2	2	2	2	2	4	4	4	4				
Vulnerable people (elderly, mental health patients, drug users etc)	increased summer temperature	Overheating of domestic properties	Uncomfortable and even dangerously hot homes increase pressure on health services	4	4	5	5	2	3	4	5	8	12	20	25	1. investigate and promote measures to reduce summer overheating. 2. ensure new build is able to cope with enhanced temperatures. 3. Create a register of vulnerable people			

																who may need extra visits in event of heatwave.			
	increased summer temperature	Heatwave and poor air quality	Increased risk of respiratory related illness	3	3	4	4	2	3	4	5	6	9	16	20				
	increased winter temperatures	Warmer homes	Lower incidence of fuel poverty and cold-related ill-health									0	0	0	0				
	increased winter temperatures	Less snow and ice	Reduced trips and falls and fewer broken hips									0	0	0	0				
	increased winter rainfall	Increased severe flooding of residential areas	Most vulnerable people marooned in their homes	5	5	5	5	2	3	3	4	10	15	15	20	1. Create a GIS enabled register of vulnerable people who may need priority rescuing/services in event of a flood.			
	increased winter rainfall	Increased severe flooding of residential areas	Housing inequalities exacerbated as many of most deprived areas in flood plains	3	3	4	4	2	3	3	4	6	9	12	16				
	increased storminess	Unsteady people!	Increased likelihood of falls	3	3	3	3	2	2	2	2	6	6	6	6				
Young people	increased summer temperature	Sunburn/heatstroke	Additional short-term burden and possible long-term increase in skin cancers	3	3	3	4	2	3	3	4	6	9	9	16				
	increased summer temperature	More time spent outside	healthier lifestyle and reduced obesity									0	0	0	0				
Care facilities and buildings	increased summer temperature	Overheating of care premises	Buildings become uncomfortable for staff and patients and in extreme cases dangerous	3	3	3	4	2	3	4	5	6	9	12	20	1. ensure new care facilities are built to cope with higher temperatures. 2. retrofit measures into existing care facilities to reduce overheating when carrying out planned maintenance. 3. increase green infrastructure to reduce temperatures			
	increased summer temperature	Conditions conducive to bacterial growth etc	Higher temperatures encourage pests and associated diseases in hospital and care environments	3	3	4	4	2	3	3	4	6	9	12	16				

increased intensity	increased winter rainfall	Drainage overwhelmed and more leaks	Parts of the building suffer structural damage or become unusable	2	2	3	3	3	3	3	4	6	6	9	12	Need for larger gutters and drains and need for better roofing (*is this an action*?)			
increased intensity	increased winter rainfall	Flooding: interruption to electricity, water, other utilities	May need to close some health/social care facilities	5	5	5	5	3	3	4	4	15	15	20	20				
increased intensity	increased winter rainfall	Flooding of premises	May need to close some health/social care facilities	5	5	5	5	3	3	4	4	15	15	20	20				
	increased storminess	High winds damage premises	May need to close some health/social care facilities	5	5	5	5	2	2	2	2	10	10	10	10				
All people	increased summer temperature	Increased sweating!	Dehydration	2	2	2	2	2	3	4	5	4	6	8	10				
	increased summer temperature	Conditions conducive to pests	Increased incidence of food poisoning possible	3	3	3	3	2	3	4	5	6	9	12	15				
(milder wetter winters)	increased winter temperatures	Longer growing season	More potential for locally grown seasonal food									0	0	0	0				
	increased winter temperatures	Less experience of snow and ice	When harsh winters do arrive, much more serious consequences (e.g. road accidents, slips, hypothermia etc)	3	4	4	5	3	3	2	2	9	12	8	10				
	increased winter rainfall	Increased severe flooding of residential areas	Minor and major flooding will impact on individual households and communities and lead to displacement, social isolation and mental health issues.	5	5	5	5	2	3	3	4	10	15	15	20				
	increased rainfall intensity	Localised flooding	may lead to mobilisation of dangerous chemicals from storage or remobilisation of chemicals already in the environment, e.g. pesticides	4	4	4	4	2	3	3	4	8	12	12	16				
Disease vectors	increased winter temperatures	Less prolonged cold therefore no die-back of disease vectors	More incidence of disease	2	3	3	4	3	3	4	5	6	9	12	20				
	increased summer temperature	New diseases more commonplace	More alien ailments (eg West Nile Virus)	4	4	4	4	2	3	3	4	8	12	12	16				

storminess	increased winter rainfall	Increased flooding of waste water treatment works	Sewage runoff will lead to lower water quality and possible outbreaks of diseases such as cholera etc	3	3	3	3	2	2	3	4	6	6	9	12			