CIA Chemical Industries Association

Working for chemical and pharmaceutical businesses

Chemical Business Association

nfa non-ferrous alliance

In partnership with CLIMATE READY

Safeguarding chemical businesses in a changing climate

How to prepare a Climate Change Adaptation Plan

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Responsible Care: continuously improving health, safety and environmental performance

Foreword

The chemicals industry has a strategic importance to the UK – chemical products are used in almost all other sectors of manufacturing, and are vital to the products, infrastructure and amenities that are often taken for granted. However, this means that disruptive events, such as the impact of severe weather, could potentially have wide ranging consequences. Planning now for these impacts makes good business sense. It is important for individual companies, for the resilience of the chemicals sector, the economy in the UK and beyond, and ultimately for society at large.

In the chemicals industry we take this resilience seriously, supported through Responsible Care. In recent years CIA has promoted awareness of these issues, for example through our guidance on winterisation[1], and in partnership with others on other risks such as flooding. Severe weather events in recent years have tested company plans and preparedness to their limits, and while they have generally performed well we cannot be complacent. Our climate is changing. The latest scientific research shows that the cause is very likely to be human activity, and the effects will continue well after improved control of greenhouse gas emissions. The impacts are already being observed on every continent and in the oceans[2]. For the UK the projections are that flooding, droughts and heatwaves are likely to become more common[3].

It is this changing frequency that is important and sets climate change apart from one-off disruptive events such as the volcanic ash cloud. It means that the risk profile is changing and weather-related risks may already be greater than we imagine. There may also be threats that we have not yet experienced, such as those arising from combinations of events simultaneously or in quick succession. So we need to review, refresh and redouble our efforts on weather resilience in the context of a changing climate.

This guide was prepared by a partnership between Chemical Business Association (CBA), Chemical Industries Association (CIA), and the Non-Ferrous Alliance (NFA) – led and supported by the Environment Agency's Climate Ready Support Service, which is responsible for delivering the Government's commitments under the National Adaptation Programme[4]. It was developed using an active workshop to bring together climate change adaptation expertise together with technical and industry knowledge, and using Climate Ready's Business Areas Climate Impacts Assessment Tool (BACLIAT)[5]. It also draws on previously published and unpublished material in this area[1,6,7,8].

Until now climate change adaptation advice has been pretty generic in its nature, so I am pleased that CIA and our CBA, NFA and EA partners are able to provide this sector-specific guide, which takes into account specific features of our industries. The advice is aimed at all chemical businesses, large and small, both within and beyond industry association membership. It is intended to give a clear steer on how to prepare a climate change action plan for your business. It contains extensive chemicals-specific advice and examples and should be a valuable information source and framework for businesses looking to manage medium-to-long term risks in this area. I commend the guidance to you in preparing for challenging climate-related disruptive events that threaten future business continuity.

Steve Elliott, Chief Executive
Chemical Industries Association

[1] CIA (2011) Winterisation: Managing process plant through severe and prolonged cold weather

[2] IPCC WG I(2013) The Physical Science Basis and IPCC WG II (2014) Impacts Adaptation and Vulnerability

[3] UK Climate Projections (2009)

[4] HM Government (2013) The National Adaptation Programme: Making the country resilient to a changing climate. The Stationary Office, London

[5] Climate Ready BACLIAT available from http://climateuk.net/resource/bacliat

[6] Environment Agency (2012) Is your business climate change ready?

[7] Chris Dickenson (2014) Climate change adaptation by heavy industry – numbers thinkpiece (unpublished)

[8] Thomas Leslie (2014) Climate change adaptation by heavy industry (unpublished)

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Section 1: Introduction

The climate challenge

Many businesses across all sectors are vulnerable to severe weather. In 2012, 54% of all businesses faced disruption due to severe weather. Those affected by flooding suffered an average of £60,000 worth of setbacks. This included direct damage but also indirect costs, such as through supply chain disruption. It is estimated that over 55% of water and wastewater treatment works and pumping stations, 14% of electricity infrastructure sites, 10% of main roads and 21% of railways in England are at risk of flooding . Other types of severe weather also have implications. The 2003 heatwave, for example, is estimated to have brought forward 2000 deaths and resulted in around £500m costs to the UK economy.

Severe weather is expected to become more common because our climate is changing. Over the next few decades this is unavoidable because of the lag times of greenhouse gases in the atmosphere. Climate projections show that we will face an increased risk of:

- heavy rainfall, leading to more frequent and severe floods
- heatwaves
- drought.

Preparing for these risks is sometimes called 'climate change adaptation' and it makes good business sense in that it will save money in the long term and offers the potential to continue to operate and meet customer orders as weather risks increase.

The chemical context

Weather and climate change resilience are important issues for chemical businesses because:

- They are very reliant on utilities, drainage and water supply infrastructure, which can be compromised by weather events.
- Many major hazard sites store and use significant quantities of hazardous substances. Weather-related events can lead to breaches of environmental permits or trigger major accidents, with potentially serious consequences.
- On-site infrastructure tends to have long lifetimes, increasing their exposure to climate risks (because of exposure to the future as well as the current climate).
- The industry is globalised and therefore exposed to a wide range of impacts internationally.

Chemical businesses need to appreciate that as well as preparing to manage short-term weather-related events that can affect sites, companies need to prepare early for the business risks linked to longer term climate change projections.

Structure of this guide

This guidance aims to help you develop a climate change adaptation plan in order to make your business more resilient to weather and climate change. This section provides some background and context to set the scene while the main guidance is contained within section 2. In order to make your plan robust, the process is broken down into the following steps, which are based on Climate Ready's Adaptation Wizard:

Step 1 Getting started

Step 2 Identifying significant climate risks

Step 3 Managing climate risks

Step 4 Monitoring and review.

Each of these steps will be examined in turn in section 2.

Organisations may choose to develop either a site-based or a business- (or group-) wide adaptation plan. A business-wide adaptation plan will lead to a higher level of resilience, because it is likely to take into account the full range of business risks from weather and climate and present a wider range of possible response measures. However, the narrower coverage of a site-based adaptation plan could make the task more manageable or focussed, if the main objective is to ensure compliance with environmental permit conditions.

While this guidance aims to be standalone, Section 3 provides some sources of further information and advice if a more

[5] Environment Agency (2010) Managing the environment in a changing climate: A report to Defra and the Welsh Assembly Government in response to a direction to report under the Climate Change Act 2008

[6] UK Climate Projections available from http://ukclimateprojections.metoffice.gov.uk/

[7] This is a different activity to climate change mitigation, which refers to tackling the causes of climate change e.g. by reducing emissions or improving energy efficiency

[8] Climate Ready Adaptation Wizard available from http://climateuk.net/resource/adaptation-wizard

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detailed investigation is required and two case studies are given in section 4.

Appendix 1 contains lists of example climate impacts and adaptation measures to support steps 2 and 3 of the guide respectively and some templates are provided in appendix 2.

Section 2: How to prepare an adaptation plan

Step 1: Getting Started

At the outset you should:

- Set broad objectives, such as to avoid potential major accidents or to maintain business continuity or productivity in the face of a changing climate (these can be firmed up later when you have more information). If your adaptation plan is to be business-wide, then these should reflect the objectives in your business plan.
- Ensure management support for the preparation of your adaptation plan.
- Find the right people (internally and externally) to work with.
- Gather information on how your business currently manages weather risks and business continuity and on how severe weather has affected you in the past. This will help you to understand weather-related risks and highlight any vulnerabilities.

Step 2: Identifying significant climate risks

Risks from severe weather and climate change can be assessed by:

- Identifying a wide range of potential impacts, then
- Using a risk based approach to prioritise those that are significant

Identifying potential impacts

Consider how the impacts of heavy rain, flooding, drought, , extremes of temperatures and strong winds could affect your business. At this stage you are brain-storming, aiming for a long list without worrying about whether or not the impacts are likely to happen or would be significant.

Use the prompt questions below to think about impacts across your site or business. Think about things that have happened in the past, including near misses, as well as impacts that could become more frequent or severe as the climate changes. Also consider scenarios arising from the combination of different weather events (such as dry periods followed by heavy rain or a succession of unusually wet seasons), or those leading to widespread or prolonged disruption.

If possible, involve people with a range of experiences and an understanding of operational and business processes. If your adaptation plan is to be site-based then you can miss out the final section on markets and finance.

Tables A1-A5 in Appendix 1 contains a list of examples linked to each question to aid your thinking. Note that this list is not designed to be exhaustive and there may be others specific to your situation. Your resulting list of potential impacts will be specific to your site or business and its unique circumstances. Table A9 in Appendix 2 can be used to record this.

Operations: Some chemical production processes and site management conditions are dependent on specific ambient conditions, which can be affected by the weather. For example, extremes of temperature can affect processes leading to reduced performance and high winds can restrict crane lifts and working at height.

Ask yourself the following questions considering both the normal operating conditions and those associated with an emergency response:

O1 – Do you operate any climate or weather sensitive processes?

O2 – Could any on site activities be affected by weather?

O3 – Could weather events lead to limits set out in regulations, policies, procedures or contracts being exceeded?

O4 – Could a weather event lead to damage to stock or other materials being stored on site?

O5 – Could a weather event have business consequences by preventing access?

Logistics: The chemicals industry relies heavily on utilities and the transport network. It is also characterised by a supply chain that has numerous interdependencies and includes many sole providers of key materials. This leaves the sector particularly vulnerable to supply chain disruption due to severe weather, leading to potential business interruption, loss of productivity or rising costs. For example, weather can disrupt in-coming and outbound deliveries due to blocked roads or difficulties at ports.

In some industries it is possible to reduce vulnerability to disruption caused by travel difficulties or loss of access by using home or remote working. However, this option is likely to be restricted for manufacturing industries since the type of

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work often means that employees need to be on site.

Ask yourself the following questions:

L1 – Would you be affected if weather disrupted or damaged transport infrastructure or services?

L2 – Could there be any issues arising from impacts on key suppliers?

L3 – Would you be affected if weather disrupted or damaged utilities or communications infrastructure and services?

L4 – Are any of the materials you transport temperature or weather sensitive?

Assets: Weather can cause damage, degradation and maintenance implications for your buildings, grounds, plant or machinery and there are sometimes long-lead times for replacing key equipment that is damaged.. For example, flooding can cause erosion of foundations and pipe supports and heavy rain can cause water to collect on stock tanks roofs, possibly causing the roof to sink allowing a loss of containment of the tanks contents.

The chemicals industry uses some plant and machinery that have long lives, meaning that they will be exposed to the future as well as the current climate. Moreover, it is characterised by some ageing infrastructure and the challenges that brings.

Ask yourself the following questions, considering not just potential environmental hazards and disruption but also the implications for maintenance regimes, the design or choice of new buildings and equipment and the costs of repair or replacement:

A1 – Could your buildings be damaged by weather or climate change?

A2 – Could your equipment or other infrastructure be damaged or fail as a result of weather or climate change?

A3 – Could your grounds or the surrounding area be affected by weather or climate change?

People: Weather can affect the comfort, health and safety of employees. For example, hot weather can lead to high indoor temperatures and thermal discomfort and high winds can lead to safety issues on site, such as working at height or damage to buildings, structures and equipment.

People who work around chemicals often need to wear personal protective equipment (PPE), which can exacerbate heat related issues.

Ask yourself the following questions, taking into account those working indoors and outdoors as well as off-site:

P1 – Could severe weather or climate change affect staff comfort?

P2 – Could severe weather or climate change have health and safety implications?

P3 – Could severe weather or climate change affect employees' families, homes or communities?

Markets and Finance: Weather or climate change could affect the demands and requirements of your customers, insurers and investors with implications for your business. For example, there may be an increase in demand for chemicals used in air conditioning or refrigeration and investors' perception of climate risk could increasingly affect the price or availability of capital investment.

Ask yourself the following questions:

M1 – Could climate change mean an increasing, decreasing or changing seasonality of demand for chemical products?

M2 – Could severe weather or climate change disproportionately affect your competitors?

M3 – Could climate change affect your insurance?

M4 – Could climate change influence your investors?

Prioritising risks

Prioritise only potential impacts that pose a significant risk. A simple risk based approach can be used to select these. A simple 'High', 'Medium' or 'Low' for likelihood and magnitude (in light of your objectives) is likely to be sufficient at the outset. Table A10 in Appendix 2 is a template that can be used to record this.

If there are no long term considerations, then only the current climate risk may be relevant. However, be aware that climate change that has already occurred could mean that your perception of the risk is out of date. For any areas where longer timescales are relevant make sure you should consider future climate change.

Climate change may mean thresholds are breached in the future, even if this hasn't happened before. These thresholds can be identified from past experience, company policies, procedures or operating standards for machinery.

For each impact you have identified, ask yourself the following questions in order to assess their risk.

Likelihood

Has the impact already been experienced?

Have there been any near misses? Or are there any thresholds that are close to being breached?

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Does the business area affected by the risk involve making any decisions with long term consequences (beyond 10 years)?

Magnitude

How has this impact affected you in the past?

How do the things specific to your business (e.g. the types of processes and activities, products, services, market features and available resources) influence the magnitude of the consequences?

If you are considering a future time period: are there any business or industry trends that could make you more or less vulnerable in the future?

In some cases (where the consequence could be serious or the cost of adapting high) a more detailed risk assessment may be required as a second iteration. Boxes 2.1-2.4 provide some further guidance on assessing risk, specific to each weather hazard.

BOX 2.1: Assessing flood risk

Flooding is the most frequently occurring natural disaster in the UK. Regulated businesses are required to prepare for flooding as part of their systems for environmental protection.

As the first step in assessing flood risk consider the following questions:

- Is your site in an area susceptible to flooding from rivers or the sea?
- Is your site susceptible to surface water flooding?
- Has your site been flooded before?
- Will climate change affect the risk of future flooding?

Use the following to help answer these questions:

- the resources listed in section 3 below
- your local Strategic Flood Risk Assessment – available from your local authority.
- your Environment Agency regulatory officer.
- flood modelling information from the Environment Agency where appropriate;
- a bespoke/detailed flood risk assessment where appropriate.

BOX 2.2: Assessing drought risk

Droughts occur periodically in the UK: in April 2012 drought was declared in a large proportion of England after two consecutive dry summers and winters. In England, climate change could contribute to reduced water availability in summer by reducing the amount of summer precipitation. The biggest changes in precipitation, with a reduction of about 40% by the end of the century, may be in parts of the far south of England[9].

To assess your risk:

- Explore your sensitivity to water availability. How would you cope if, hypothetically, the amount of water available was reduced by 5, 10, 25 or 50%?
- Use the resources listed in section 3 to explore the water availability issues in your catchment
- Check any available historical data on drought.

BOX 2.3: Assessing temperature risk

Hot summers, such as in 2003 and 2006 will become more likely as the climate changes. On average winters are expected to become milder. However, very cold winters with heavy snow, such as we have had in recent years, will still occur.

To assess your risks:

- Identify temperature thresholds which could affect your business (staff and processes).
- Check that suppliers have adaptation measures in place for extremes of temperature – would their ability to deliver/collect supplies and goods be affected?
- Check the UKCP09 climate change projections to see how temperatures could change. You can use UKCP09's weather generator to explore how often temperature threshold may be exceeded in future (http://ukclimateprojections.metoffice.gov.uk/). If you need help using the Weather Generator, contact climatechange@environment-agency.gov.uk
- Use the resources listed in Section 3 to further explore extremes of temperatures in the current and future climates of relevant locations.

[9] Watts G and Anderson M (eds.) (2013) A climate change report card for water. LWEC report card.

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BOX 2.4: Assessing storm risk

Storms and high winds can affect businesses and the services on which they rely. At the moment we do not have high confidence in future projections of changes in the frequency and severity of storms and high winds. However you can assess your risk to this hazard by:

- assessing your site to see if any areas could be vulnerable to strong winds
- checking if your business has been affected by storm damage in the past.
- using the resources listed in Section 3 to further explore the potential for storms in the current and future climates of relevant locations.

Step 3: Managing climate risks

Once significant climate risks are known, they can be managed through an adaptation plan, which is developed through a process of:

- Identifying a range of potential resilience options
- Selecting preferred measures, then
- Building these up into a plan

Identifying resilience options

For your priority risks, brainstorm potential ways that you could minimise the threat or maximise any benefit, if possible involving others from across the business.

Ask yourself the following five questions, drawing on: experience of dealing with similar risks; from what you know about how others manage similar risks; existing related plans such as business continuity plans and accident management plans, as these may already contain suitable resilience measures. Consider both permanent and temporary arrangements as well as measures which would benefit from working in partnership (such as with other companies on the same industrial park) to share costs, other resources, information or learning.

How could you improve resilience generally by targeting the business consequences of incidents (e.g. disruption, costs or reputation)? See page 5 of Appendix 1 for examples.

What information, awareness or skills would improve your resilience to your priority risks? See table A6 in Appendix 1 for examples.

What operational changes could you make to manage your priority risks? See table A7 in Appendix 1 for examples.

What physical changes or technology could you invest in to manage your priority risks? See table A8 in Appendix 1 for examples.

Due to the nature or size of the risk or opportunity are there any strategic responses that should be considered, such as by relocating, developing a new product, exploiting a new market or creating a strategic partnership to manage shared risks?

Selecting preferred measures

Once you have identified a list of potential options, you should evaluate these in order to choose preferred measures by asking yourself the following questions.

Will it work?

How much will it cost?

Will there be any unintended consequences for you and/ or others?

Is it flexible enough to allow for adjustments later on? For example you might choose to build a flood wall now, but build larger foundations to allow it to be raised at a later date if necessary.

Is it practical to implement within relevant timescales?

Making a plan

Your adaptation plan should set out what you intend to do before during and after a weather event and when it is appropriate to implement any pre-emptive measures and those aimed at exploiting opportunities. It should be clear who is responsible for implementing actions and for monitoring and reviewing the plan.

Take note of links to other plans and procedures, such as, business continuity management, risk management, health and safety arrangements, emergency plan and/ or flood plan. You might choose to have a standalone adaptation plan which references other appropriate plans, or you might find that all measures can be more effectively implemented through other plans. Either way, ask yourself the following questions in order to build your selected resilience measures into a coherent plan.

What are the timescales of associated business decisions? For example, the lead in times involved in contingency arrangements when supply of key ingredients is disrupted.

For any future risks, can you estimate when it is likely to become significant?

Are there any points in time that represent an opportunity to put in place physical resilience measures that have a

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cost associated with them in a cost effective way? For example, within replacement cycles, maintenance regimes or management system review schedules.

What barriers to action are there likely to be? And what capacity building could help overcome these? See table A6 in Appendix 1 for examples.

Do you need to do any external engagement to make sure that your plan connects with the arrangements of neighbours, suppliers or others as appropriate?

Step 4: Monitoring and Review

Making sure an adaptation plan works requires

- Monitoring weather impacts and the effectiveness of measures
- Exercising the plan and
- Reviewing it regularly

Monitoring weather impacts and effectiveness of measures

You should record weather impacts that have an effect on your business noting the effectiveness of your planned measures (see appendix for template). This will give an indication of the extent to which your plan is achieving the objectives set out at the beginning and managing your priority risks. The information gathered can also be used to check assumptions made in your assessment of risk.

Exercising

Make sure plans for dealing with incidents are regularly exercised. It is worth exercising scenarios that involve a combination of different events at the same time or in quick succession or scenarios related to widespread disruption.

Regular review

The output of monitoring and exercising should feed into a review of your plan. You will need to decide how often the plan will be reviewed and who will be responsible. These reviews could coincide with scheduled reviews of the other business systems. We recommend you review your plan annually or sooner if a factor that has influenced your objectives or assessment changes significantly, for example, if new information becomes available either in the form of published climate information or your own experience of a severe weather event.

Section 3: Sources of further information and advice

Climate projections

- UK Climate Projections can be found here: http://ukclimateprojections.metoffice.gov.uk/).

Weather extremes

- For information on weather extremes in the current climate see http://www.torro.org.uk/site/extreme_info.php
- For information on future weather extremes see http://ipcc-wg2.gov/SREX/

Flooding

- General information on preparing for flooding, including access to the Environment Agency's flood maps can be found here: https://www.gov.uk/prepare-for-a-flood
- the relevant Catchment Flood Management Plan – https://www.gov.uk/government/collections/catchment-flood-management-plans
- To register for flood alerts – Floodline – 0345 988 1188 or visit https://www.gov.uk/sign-up-for-flood-warnings
- Preparing for flooding: a guide for regulated sites can be found here: https://www.gov.uk/government/publications/preparing-for-flooding-a-guide-for-regulated-sites
- Pollution prevention guidance can be found here: https://www.gov.uk/government/collections/pollution-prevention-guidance-ppg
- Living On The Edge explains the rights and responsibilities of riverside ownership and can be found here: https://www.gov.uk/government/publications/riverside-ownership-rights-and-responsibilities
- CIRIA Report 736 'Containment systems for the prevention of pollution', is available from CIRIA.

Drought

- The Catchment Abstraction Management Strategy (CAMS) for your area, which show water availability for each river catchment, can be found here: https://www.gov.uk/government/collections/water-abstraction-licensing-strategies-cams-process
- The latest River Basin Management Plan for your area to find out if catchments in your area are over-abstracted

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from the point of view of the water environment – https://www.gov.uk/government/collections/river-basin-management-plans

- Further information on drought can be found here: https://www.gov.uk/government/policies/maintaining-secure-water-supplies-high-standards-of-drinking-water-and-effective-sewerage-services/supporting-pages/water-resource-management#drought and http://www.lwec.org.uk/resources/report-cards/water
- Cefic's 'Water Matters' initiative aims is to define sustainable water management metrics indicators. http://www.cefic.org/Documents/Learn%20and%20Share/Flagship-Initiatives/Factsheet/Cefic-Flagship-initiatives-Water-Management-in-Chemical-Production-Plants-factsheet.pdf. Look out for these in future 'Responsible Care' and 'Cefic Sustainability' reports. A self assessment tool for companies is coming soon.

Temperatures

- See the Health and Safety Executive's information on work place temperature requirements: http://www.hse.gov.uk/temperature/index.htm

Further resilience/adaptation/emergency planning resources:

- See page 21 of the guidance on 'How to comply with your environmental permit', which describes the requirements of an accident management plan, including taking into account extreme weather https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/298102/LIT_7123_79744e.pdf
- HSE's Emergency Planning for Major Accidents: COMAH http://www.hse.gov.uk/pubns/books/hsg191.htm
- The business resilience healthcheck is an online questionnaire that results in a report recommending actions. Looks at resilience more broadly than climate risks: www.businessresiliencehealthcheck.co.uk
- 'Assessing and managing climate change risks in supply chains' provides information on climate risks and opportunities, and guidance on how it can be integrated into established business practices for addressing risk across supply chains. Includes five case studies. http://climateuk.net/resource/supply-chains-adaptation-guidance
- 'Adapting to Climate Change through your business continuity management system' is aimed at business continuity professionals and is compatible with the current ISO standard on business continuity management http://www.bsigroup.com/en-GB/forms/Adapting-to-Climate-Change-using-your-Business-Continuity-Management-System/
- The 'Adaptation Wizard' is a generic and comprehensive guide to the adaptation process presented in five steps with signposts and templates for each: http://climateuk.net/resource/adaptation-wizard
- The Institute of Environmental Management and Assessment have produced guidance on building support for climate change adaptation in an organisation http://www.iema.net/system/files/iema_guidance_report_v5.pdf
- The Ofqual accredited 'Get Resilient' training course involves developing a resilience plan for your own business http://sfediawards.com/qualifications/level-3-award-in-understanding-and-planning-business-resilience/

Section 4: Case studies

Chemicals facilities in the US Gulf Coast[10]

The American Chemistry Council (ACC) reported that during hurricanes Katrina and IKE, not a single employee was injured and there were no significant chemical releases from any of their members' facilities. In fact, most chemical facilities returned to full operational status in a matter of days, which is a tribute to their planning.

Planning and preparation

Like the CIA and CBA in the UK, the ACC runs a Responsible Care® programme, covering issues of health, safety, environment and security. All ACC members have long-established emergency plans, which are activated in close

[10] Sources

http://www.americanchemistry.com/Media/PressReleasesTranscripts/ACC-news-releases/Chemical-Industry-Prepared-for-Hurricane-Season.html

http://www1.eere.energy.gov/manufacturing/pdfs/40324.pdf

http://www.chemalliance.org/featured/?sec=5&id=7017

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coordination with local, state and national authorities, other businesses and transportation systems, along the path of the storms. When a storm is forecast, these well-rehearsed emergency plans are enacted with the actions depending on the severity of the storm range from removal of vehicles and other unnecessary equipment and activating generators to complete shutdown of facility and evacuation of personnel.

In the USA companies are also taking hurricanes into account when designing and building chemical facilities to be safe, such as by including hardened equipment, dikes and levees.

Beyond the site boundaries

In addition to thinking about their own resilience, many contributed to the wider relief effort, donating tens of millions of dollars for relief assistance, volunteering time and providing much-needed supplies. Some of this was coordinated by the ACC, the state chemistry councils, the Red Cross, Salvation Army and other organisations. For example, one facility was able to assist the recovery efforts of a nearby town since it was the only local institution with emergency power and communications.

While most facilities recovered themselves quickly, many were unable to resume normal production because of other external consequences of the storms. Extensive damage to the local infrastructure blocked the flow of key supplies, like electricity and natural gas, necessary to manufacture chemicals, while damaged roads and rail lines prevented the delivery of products to consumers. Ultimately, this led to higher natural gas costs for everyone and curtailed the delivery of chemicals essential to producing important everyday items like clean drinking water and life-saving medicines.

Some lessons learned:

The experiences from recent storms in the USA are being used to further improve resilience of chemical facilities. The following lessons learned were identified by the Louisiana Chemicals Association:

- Establish several ways to maintain critical communications with managers, suppliers, and customers both during and after the emergency; consider creating a mobile emergency operations centre.
- Focus on flood resistance and resilience as flood waters are usually the most serious obstacle to restarting operations.
- Prepare to quickly shut down key utility supplies like air, oxygen, nitrogen, steam, natural gas, and other raw material feeds.
- Establish plant evacuation routes, know the evacuation routes for your city or region, and communicate them to employees.
- Maintain internal contact lists so you can locate employees quickly.
- Maintain current contact information for emergency response groups.
- Investigate how to provide temporary housing, basic amenities, and medical services to employees, if necessary
- Carefully assess the makeup of ‘ride out’ teams that stay in place during a storm so that they include enough skilled craftsmen such as electricians, maintenance staff, and operators to get plants up and running again.
- Plants that are sole suppliers of specialty materials will come under pressure to safely begin producing as soon as possible. These companies in particular must have good communication links with their suppliers and contractors to ensure that everyone feels the same level of urgency. The best approach is to establish this in advance of the storm.
- Because secondary containment systems are designed to prevent releases of materials, they also prevented release of the corrosive sea water after the flood waters receded
- For facilities flooded by seawater, many pipes, vessels, and electrical systems have been damaged, and companies will be spending a long time and significant expense to repair or replace them. For the future, companies prone to storm flooding should design secondary containment systems with a dewatering capability
- The authorities only have limited resources available for infrastructure restoration and they must balance the needs of private industry and the public sector when establishing priorities, such as for restoring power. Therefore, the onus is also on chemical companies to make certain state and local authorities are aware of the interrelationships between individual plant sites and how plant closures can affect the economy and the ability of the country to meet the basic needs of its citizens.

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Responsible Care and legislation in the UK

In the UK, major hazard facilities subject to COMAH Regulations are required to have emergency plans and to exercise them. It is important that site operators ensure that climate-related risks are included in the scenarios for which plans may be activated.

CIA's Responsible Care programme covers 12 regional Cells for industry across the UK, open to CIA members and non-members. The Cell meetings, facilitated by CIA staff, take place approximately 3- or 4-monthly, and are an excellent forum for businesses to share and exchange information on a range of health, safety and environment topics – including risks from severe weather-related events.

Teesside Flooding December 2013

Due to a combination of high tide and storm surge, December 2013 saw record breaking flooding on the East Coast. In Teesside, two separate flood defences failed, one of which was an operator's own defences at the head of the River and the other was the Environment Agency (EA) maintained flood defence on Greatham Creek. Many more flood defences were overtopped and flood waters were recorded as high as 4.08m affecting several industrial sites, including chemical facilities.

There was no loss of process containment, however, the flood led to millions of pounds worth of damage and disruption. Initial confusion over the ownership of one of the flood defences, took up valuable time at the early stages of the incident. When there are only 12 hours between high tides and with facilities requiring up to two hours to be shut down properly, time is of the essence.

During the flood, the EA were able to take action to help the operators to mitigate the consequences of the flood, including: mobilising resources the day after to start work at Greatham Creek; allowing the Riverside Terminal to over pump flood water back into the River and providing advice on where to find clay. Afterwards, the EA and the Health and Safety Executive took a pragmatic approach to their role as the Competent Authority, relying on inspection to ensure safe systems were being adopted rather than formal modification reports and assessments.

Below outlines how the flood affected three facilities in the area. All of these sites had flood plans, which were enacted and the experience suggests that the costs would have been far greater had they not.

Facility 1: A chemical storage terminal

This storage site was completely flooded to the point where eight of their ten bunds were overtopped and with empty stock tanks floating in water. In response, the site had to be shut down with product still in tanks and transfer lines.

This shut down meant that their principle customer was restricted to 30% of capacity, representing a real financial loss at a time when demand was not a limiting factor.

Since the flood level was above the electrical switch house roof, all electrical and control systems were lost and the main switchgear and control PLC needed to be replaced. This meant that although limited manual operations were able to start a week later, it will be months before the terminal is back to normal.

Whilst the recovery was ongoing there was also the issue of protecting the site from the next spring tide in January (in the face of seriously compromised defences), which was only just achieved.

Facility 2: A large petrochemical plant

As the plant flooded, all field instruments and 415V electrical systems were taken out, however, 11 kV and central instrument function were not affected. Underground storage facilities at the site were flooded. Product storage systems had to be shut down, again with product in transfer lines, as did a natural gas processing plant due to condensate lines being under water. The storage facilities only came back into service fully in April 2014, 4 months later.

Since interplant buffer storage of hydrocarbons was not available, dependant plants were operating 'just in time' for most raw materials. Due to the size of the plant, national gas supply integrity was affected.

The cost of the flood to the business, including restorative work, ran into millions of pounds. The operator used established major overhaul management systems to manage the restoration work in a systematic way.

Facility 3: A third 'Top Tier' COMAH site

The operator of this facility had not registered the site address for flood warnings from the EA and therefore they only had about half an hour's warning, given by the Local Authority Emergency Planning Unit. They shut down all operations involving gas and the site boilers and took a roll call but were not able to evacuate the site before the flood cut off normal access to the establishment.

Subsequent site evacuation was 'Ad Hoc' and all site based employee's domestic cars were written off. Due to water ingress into an old PLC control system, one workshop was rendered inoperative. However, limited operations restarted two weeks after flood.

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Lessons learned

- Flood defences can fail
- Putting in place a flood plan is essential
- Operators should register at their actual address for flood warning purposes, not the communication address or head office
- Operators must know who owns and maintains flood defences that they rely upon
- Early communication with the EA during flood events can help both parties in a number of ways, even where there are no regulatory issues

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Appendix 1: Examples to support steps 2 and 3 of the guide

Table A1: Example impacts to operations

Prompt question	Example impacts
O1	• Lack of process water during drought causes disruption.
	• Heavy rain or flooding means effluent system overloads with dilution water or other problems such as wash out of biomass. Effluent treatment plants are often gravity fed and therefore at the lowest, most vulnerable part of the site.
	• High temperatures lead to poor cooling meaning that throughputs need to be limited or processes shut down if their cooling systems can't cope.
	• Temperature impacts on catalytic processes leading to reduced performance e.g. effluent treatment where poor nitrification, reduced oxygen levels and increased odour present environmental issues.
	• Maximum process relief rates are reduced due to high inlet temperatures and high flashing ratios.
	• Extreme temperatures affect the operation of effluent treatment plant.
	• Low temperatures lead to freezing of coolant lines to a chemical reaction vessel resulting in rising reaction temperature and pressure.
	• Flooding compromises emergency relief systems that are designed for an atmospheric discharge pressure (not against a static head of water).
	• Lack of water for fire-fighting, caused by either drought and poor availability of water, or prolonged severe cold temperature and freezing of lines.
O2	• High winds restrict crane lifts and working at height.
	• Outdoor operations may need to be restricted during severe weather.
	• Flooding prevents access so that facility cannot operate properly.
O3	• Reduced river flow means the quality of incoming water deteriorates, reduced dilution of effluent and greater pollution.
	• Process contamination by flood waters leading to large quantities of liquid effluent that require treatment e.g. from oil/water separators, sumps, drains, ground stocks of products or maintenance materials.
	• Change in expectations in relation to how to comply with regulation where compliance is affected by weather leading to increased costs.
	• Chemical release or venting during emergency shutdown causes breach in permit conditions.
	• A switch to back up fuel due to weather related disruption leads to operating outside permit conditions on a temporary basis.
O4	• Flood causes stored materials to react with water or be contaminated.
	• Flooding causes floatation of empty/part full stock tanks, product or waste containers with subsequent loss of containment.
	• Evaporation rates of volatile material increase with higher temperature, placing increased demand on cooling systems.
	• High costs of storing water on site for managed disposal following heavy rain, especially if containment systems overloaded.
	• Lightning strike causes process disruption that could lead to loss of containment.
O5	• Flooding prevents access by staff, customers or vehicles, compromising business continuity and the ability to keep the site in a safe condition.
	• Due to flooding or snow, land banks are not available for sludge spreading. Stock piles of sludge may lead to odour issues.
	• Inclement weather restricts the movement of key staff around the site.
	• Severe weather including snow and ice prevent key staff travelling to/from work.

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A2: Examples of impacts to logistics

Prompt question	Example impacts
L1	• Disrupted in-coming and outbound deliveries due to blocked roads or difficulties at ports.
	• Emergency services unable to access the site or are not available because of all the demands that are being placed upon them.
	• Key staff not able to get to work.
	• Increased road accidents due to bad weather.
L2	• Weather or climate impacts on supplier affect the price, availability or quality of materials. Business interruption can result, particularly if there is only a single source of a key material.
	• Increased risk provides an opportunity to strengthen supplier relationships and increase oversight of the supply chain.
L3	• Severe weather causes loss of utilities (e.g. power, communications, steam, compressed gasses).
	• Costs/ operational difficulties caused by underground pipelines being damaged due to expansion.
	• Disposal of hazardous waste difficult due to impacts on sewage works or other waste services. Associated legislative issues of holding waste on site.
	• Electrical storm causes power surge taking out power supplies, control systems and communications systems.
L4	• The temperature range of volatile chemicals is exceeded during transport.
	• More refrigerated distribution is required, increasing costs.
	• Loss or hazard due to loss of containment during transport, such as of materials that are reactive or require refrigeration.

A3: Examples of impacts to assets

Prompt question	Examples impacts
A1	• Severe weather or flooding damages buildings fabric leading to disruption, repair and maintenance costs.
	• Flooding or drought causes erosion of foundations and pipe supports.
	• Snow and ice loading on tank roofs leads to loss of containment.
	• Following heavy rain, water collects on tank roofs causing collapse and loss of containment.
A2	• Extreme weather or flooding causes mechanical damage to process equipment, particularly equipment running hot subject to sudden thermal stress when inundated with water.
	• Flooding causes equipment or machinery to be made unserviceable. For example, electrical equipment, switchgear, cabling, rotating mechanical equipment, control equipment and effluent treatment plants (because the biomass has been washed out).
	• Bunds cracked by 'heave' from freezing ground.
	• Water and other 'wet' lines freeze, leading to flanges, valve bonnets and other joints failing. This can lead to loss of boiler feed water lines, frozen cooling towers and frozen sprinkler systems.
	• Repaired burst joints refreezing before effective lagging could be applied.
	• Pneumatic control systems failing because instrument air is not dry enough.
	• Lightning causes fire due to direct action or provision of an ignition source.
	• Heavy rain overloads inlet air filters and causes damage to downstream equipment.
	• Heavy rain causes water to collect on stock tanks roofs. For floating roof tanks this could possibly cause the roof to sink allowing a loss of containment of the tanks contents.

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	• High winds cause structural damage to process plant.
	• High winds cause problems with floating roof tanks, partially lifting the roof and causing it to stick or at worst sink.
	• Freezing weather leads to burst pipes or failures of primary containment including potentially simultaneous failure of multiple layers of protection.
	• Loss of containment due to direct lightning strikes.
	• Pipeline damage by cold weather, hot weather or subsidence.
	• Electrical storm causes build up of static in insulated objects.
A3	• High winds blow site litter or contaminated debris off-site.
	• Flooding, heavy rain or drought causes landslide, subsidence.

A4 Examples of impacts to people

Prompt question	Examples
P1	• High indoor temperatures lead to thermal discomfort and related building services issues.
	• People's performance drops due to conditions of thermal discomfort, especially those in PPE.
	• More complaints from staff.
	• Inclement weather makes working outdoors unpleasant.
P2	• Working in high temperatures can lead to heat stress and time off.
	• High winds cause safety issues on site (too dangerous to work at height)
	• Drivers are more at risk during bad weather.
	• Unmanaged health risks could lead to industrial action.
	• Lightning strike to a person causes injury or death.
	• Lightning strike contributes to a fire.
P3	• Staff absence due to school closures.
	• Impacts on staff well-being and disruption to work attendance due to flooding or damage to own properties.

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A5: Examples of impacts to market or finance

Prompt question	Examples
M1	• Increasing/ decreasing demand for some products, such as de-icers, protective equipment, sun-cream ingredients, chemicals used in air conditioning or refrigeration.
	• If more storage of hazardous substances is required there may be an impact on the site's COMAH status.
	• New market for existing product.
	• Potential to develop new product.
M2	• Market advantage can be gained by being more resilient to severe weather and climate change.
M3	• Climate risks affect price or availability of buildings or business continuity insurance.
	• Resilience or adaptation measures reduce premiums or increase availability.
M4	• Investors' perception of climate risks affect the price or availability of capital investment.
	• Resilience or adaptation measures attract investors.

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Examples of resilience and adaptation measures

Note: these are intended as illustrative examples only. The list is in no way designed to be exhaustive and there may be other options that should be considered. Equally, some of the measures below will not be appropriate to all businesses dependent on the complexity, processes, and range of hazards and vulnerabilities.

Examples of potential generic resilience measures

Capacity building

- Research to identify where on site or which sites are a priority for protection.
- Update list of contacts for before, during, and after an emergency including utility contact information for power outages.
- Improved interaction with Environment Agency.
- Interaction with Government or trade bodies to influence national strategy.
- Awareness raising with staff e.g. promoting dynamic risk assessments.
- Promoting an attitude that puts health, safety and wellbeing first and then prioritises business continuity above getting to work and being at work.
- Adequate on site communications.
- Train all shift personnel so that there are sufficient personnel available to operate the essential safety systems at all times or establish a plan and identify the resources required to get the extra personnel needed on site.

Operational

- Arrangements to ramp up/down production at short notice.
- Review the established procedures for safe shutdown, recovery, and restart of utilities and process operations.
- Ensure there is an evacuation plan, including support for employees.
- Increase stocks of fuel or consider alternative fuels.
- Alternative sources of key ingredients/ raw materials.
- Increase stockpiling.
- Arrangements for getting people to work or providing accommodation at times of disruption, and identification of where homeworking may be possible for some staff.
- Stop operations that require external intervention if a disruption compromises the ability of emergency services to access the site.
- Back up of electronic records.
- Offsite storage of products or third party manufacture.
- Ensure production trips to a safe condition in the event of loss of electricity.
- Real time liaison with the Local Authorities Silver Command to ensure that the requirements of 'Basis of Safety' can still be met during an incident.
- Ensure all safety critical systems have the appropriate safety intergrity, to reduce where necessary the risks from human factors failures.
- Ensure inspection and maintenance regimes are comprehensive and at an appropriately high level.
- Restrict access where there is a risk to health and safety
- Explore alternatives to roads for supply network.

Physical/technical

- Have emergency onsite backup power – e.g. a generator, battery storage, or combined heat and power (CHP) system with adequate fuel storage.
- Update emergency power and supply options.
- Establish emergency communication systems and backup.

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The examples given in tables A6-A8 are categorised by a) weather type or impact of relevance and b) business area where the corresponding impact is felt. This will enable examples to be linked to priority risks that have been identified in step 2.

Table A6: Capacity building measures aimed at specific impacts

	Weather/impact type							Business area				
Measure	Flooding	Drought	High temps	Low temps	Wind storm	Electrical storm	Humidity	Operations	Logistics	Assets	People	Markets/ finance
Warnings and awareness raising for staff on the increased risks during inclement weather	×	×	×	×	×	×					×	
Look at international analogues	×	×	×	×	×	×	×	×	×	×	×	
Further research to assess risk using external experts	×	×	×	×	×	×	×	×	×	×	×	
Use design limits to explore whether measures for heating, cooling, insulating or drying are required.			×	×			×	×	×	×	×	
Review pipework to identify which parts of plant or equipment may be vulnerable to heat or cold			×	×				×		×		
Provide specific information/ guidance on working in extreme temperatures or windy weather			×	×	×						×	
Use specialist techniques such as HAZOP or SIL to identify safety critical plant that may be susceptible			×	×				×		×	×	
Identify temperature thresholds where the risks associated with plant failure outweigh those of shutting down			×	×				×	×	×	×	
Talk to regulatory officer to discuss options if there could be the need to operate outside permit conditions	×	×	×	×	×	×	×	×				
Stress test control systems to rapid cooling of surfaces and modify if necessary	×							×		×		
Civil engineering checks of foundations	×	×			×					×		
Check capacity of existing systems for heating, cooling, drying			×	×			×					
Train staff in minimising the risk of lightning strikes to their person						×					×	
Factor lightning strikes of combustible materials into risk assessments						×				×	×	

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Table A7: Operational measures aimed at specific impacts (related to prompt question R3)

	Weather/impact type							Business area				
Measure	Flooding	Drought	High temps	Low temps	Wind storm	Electrical storm	Humidity	Operations	Logistics	Assets	People	Markets/ finance
Regime for regularly unblocking drains and drainage routes.	X											
Remove loose objects from site.	X				X							
Securing IBCs, drums and other containers.	X				X							
Raising IBCs, drums and other containers.	X											
Locate records, materials and inventory away from potential flood waters.	X							X				
Working for shorter periods with more breaks and providing drinks during hot weather.			X								X	
Improve storage of paper litter.					X							
Extra site gritting and snow clearance during cold weather				X				X		X	X	
An evacuation meeting point that is above potential flood levels	X							X			X	
At times of high risk amend shipping plans to ensure high stocks of raw materials and low stocks of product	X				X				X			
Shut down any vulnerable equipment in advance of a flood allowing enough time for cool down	X							X		X		
Shut down process and pumping operations to minimise process contamination in advance of a flood	X							X		X		
Shut down and isolate both the inlet and the outlet of the effluent treatment plant during the flood	X							X				
Following a flood, take care not to suddenly re-establish effluent flows on restart	X							X				
Ensure all vehicle movements are on hard standing	X	X						X		X	X	
Maintenance regime for air conditioning system			X					X			X	

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Measure	Weather/impact type							Business area				
	Flooding	Drought	High temps	Low temps	Wind storm	Electrical storm	Humidity	Operations	Logistics	Assets	People	Markets/ finance
Phase production to avoid hotter or drier periods			X	X				X	X		X	
Minimise stocks of products that deteriorate over time during hot weather			X						X			
Fire security measures: improved housekeeping, removal or cutting of vegetation			X			X		X		X	X	
Report and clear any very large icicles				X							X	
clear the snow from and grit roads and walkways				X				X			X	
Pipe in emergency sources of heat into the effluent system, e.g. boiler blowdown, hot condensate or even warm cooling waste return				X				X				
Minimise cold water flows and maximise strength of effluent (for biological treatment)												
Minimise cooling demand at times of water shortage by switching out marginal cooling requirements		X						X				
Alternative sources of cooling (other than with water)		X						X				
Tighten up control of recirculation and purge systems		X						X				

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Table A8: Physical/Technical resilience measures aimed at specific impacts (related to prompt question R4)

	Weather/impact type							**Business area**				
Measure	Flooding	Drought	High temps	Low temps	Wind storm	Electrical storm	Humidity	Operations	Logistics	Assets	People	Markets/ finance
Use flood-resistant building materials.	X							X		X		
Erect/ fit flood barriers or have temporary measures available.	X							X		X		
Build storm drains.	X							X		X	X	
Reinforce roof and siding panels.					X	X				X		
Install water storage systems such as rainwater harvesting		X						X	X			
Install odour control systems.			X					X			X	
Fit insulation to pipes or building			X	X				X		X	X	
Install blinds or shading			X					X	X	X	X	
Improve/ install ventilation			X					X	X	X	X	
Install/ improve systems for cooling			X					X	X	X	X	
Use building materials with high thermal mass			X					X		X	X	
Provide staff with more/ better PPE e.g. air-flow suits/ helmets for hot weather, insect repellent	X		X	X	X	X	X				X	
Fit trace heating for pipes.				X				X		X		
Cover windows and doors to prevent storm damage.					X					X		
Securing IBCs, drums and other containers.	X				X			X		X	X	
Anchoring tanks and other structures								X		X	X	
Scaffolding and sheeting of pipetracks and some process plants as a precaution in advance of severe cold				X				X		X	X	
Provision of warm clothing and PPE during cold weather				X							X	
Site cabling and electrical equipment above likely flood levels	X							X		X		

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Measure	Weather/impact type							Business area				
	Flooding	Drought	High temps	Low temps	Wind storm	Electrical storm	Humidity	Operations	Logistics	Assets	People	Markets/ finance
Specify power systems for operation in submerged conditions	X							X		X		
Segregation of effluents on site with closed pumping and storage systems during a flood	X							X				
Relocate discharge points above maximum predicted flood levels	X							X		X		
Improve site drainage and roof drainage	X							X		X		
Civil engineering measures to combat landslide, subsidence, heave or wind damage	X	X		X	X					X		
Improve site/ building design to combat landslide, subsidence, heave or wind damage	X	X		X	X					X		
Choice of building materials for higher level of protection	X	X	X	X	X	X	X			X	X	
Tertiary containment with overflows directing potentially contaminated waters to where they will cause the least harm to people or the environment	X							X			X	
extra hardening of surrounds of foundations of susceptible structures	X	X		X	X					X		
Change blends in summertime to reduce volatility			X					X				
Ensure process relief devices are adequately sized			X					X				
Improved filtration and anti-algal growth systems			X					X				
Strengthen buildings and process plant					X					X	X	

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Table A8: Physical/Technical resilience measures aimed at specific impacts (related to prompt question R4) – continued

Measure	Weather/impact type: Flooding	Drought	High temps	Low temps	Wind storm	Electrical storm	Humidity	Business area: Operations	Logistics	Assets	People	Markets/finance
Provide buildings and other structures with suitable protection against lightning						X				X	X	
Stock tank vents from flammable stock tanks may be provided with flame arrestors						X				X	X	
Amend process to reduce cooling demand		X						X				
Recirculate treated effluent at times of low water availability		X						X				
Reduce water demand of effluent plant by minimising sources of contaminants		X						X				
Introduce recirculation of scrubbing water on once through systems												
Import water		X						X				
Design Effluent Treatment system such that the final effluent will not cause harm to the receiving environment even if released undiluted		X						X				

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Appendix 2: Templates

Table A9: Identifying potential impacts (in support of step 2 of the guide)

Business area	Responsibility	Weather-related hazard that could affect business area or cause environmental harm	Describe past or potential effects on business area or environment	Adaptation action already taken
Operations				
Logistics				
Assets				
People				
Markets				
Finance				

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Table A10: Risk Assessment (in support of step 2 of the guide)

Potential impact	Critical threshold (if relevant)	Likelihood *	Magnitude *	Priority

* A rating of high, medium or low with a note of any assumptions.

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Table A11: Monitoring Weather Event Log (in support of step 4 of the guide)

Business area:

Date	Weather event	Extent of incident	Damage/effect to the business or environment

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