Assessing Flood Risk and Complying with the Requirements of 'The COMAH Competent Authorities Operational Delivery Guide: Flood Preparedness Inspection'

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Within the UK, flooding is the most frequent and impactful natural hazard and with climate change this risk will only increase. It is therefore essential that the potential impacts that flood events can have on the safe operation of hazardous facilities and the significant financial and business interruption exposures are fully understood and planned for.

Flood Preparedness is recognised by both Government and industry as a high priority, with recent flooding events affecting a number of major hazard establishments that are subject to regulation under the Control of Major Accident Hazards Regulations (COMAH) 2015 [1]. Flood preparedness has been designated a strategic topic by the COMAH Strategic Forum. A COMAH Operational Delivery Guide (ODG) [2] has been issued for Competent Authority (CA) inspectors of both upper and lower tier COMAH establishments to review whether flooding could directly initiate a Major Accident to the Environment (MATTE) or may prevent an emergency response to an on-site major accident.

- ABS Consulting Ltd. (ABSC) is a global provider of flood risk management activities across a large range of industry types, including hazardous facilities and this combined with our experience in supporting COMAH facility operators in their Process Safety Management, as such we are well placed to advise and support COMAH operators.
- Within this paper we will present examples of lessons learned from our experience supporting our clients and will provide insights into some gaps that we have found in flood mitigation measures and management plans. Many of the gaps identified were unknown to the client and as a result the facilities often did not have the protection that management thought was in place.

ABSC has extensive experience in risk assessment, mitigation, and emergency response planning. This paper will cover the lessons learned and pitfalls we have experienced in recent years. Specifically, we will cover:

- COMAH ODG principles for inspecting flood preparedness arrangements for at risk COMAH establishments.
- The required flood hazard information, and where to obtain it.
- How to consider the wider impacts of flooding on surrounding infrastructure, especially related to emergency response.
- Secondary flood hazards e.g flow velocities, debris, hydrostatic loads, contamination, water ingress routes into buildings, etc.
- The effects of climate change.
- Flood barriers and how to create layers of flood protection.
- Examples of typical vulnerabilities and case studies from ABSC experience of assessing facility vulnerabilities.

Introduction and Background

Flooding is considered to be the most widespread and impactful of the natural hazards that affect the UK and with climate change effects, flood events will only increase in severity and number. Planning for and the management of these flood events is essential for the safe operation of hazardous facilities and to minimise the significant financial and business interruption exposures they bring. This is a specific hazard that should be considered for high hazard facilities, facilities that are regulated by the Control of Major Accident Hazards Regulations (COMAH) 2015 [1].

The COMAH Strategic Forum, held in 2016, designated Flood Preparedness as a strategic topic and a Chemical and Downstream Oil Industry Forum (CDOIF) Working Group was established to develop, guide and support industry in the development and management of flood resiliency. A study was performed between 2015 and 2017 to increase awareness of flood hazards and to gain an understanding at a national level of the flood risk present at each COMAH establishment. The study determined that there were variations in the levels of adoption of good practices.

The Operational Delivery Guide (ODG) [2] was therefore produced to support the Competent Authorities (CA) regulation of major hazards by presenting a clear and consistent framework for inspecting the flood preparedness arrangements in place for the at risk COMAH establishments.

This paper will outline the framework within the guide and will inform establishments of the measures necessary to demonstrate flood preparedness.

COMAH Competent Authority Operational Delivery Guide

The COMAH CA ODG for the Inspection of COMAH Operator Flood Preparedness was published in June 2018 [2]. It is aimed at upper and lower tier COMAH operations who are deemed to be at risk from flooding, whether a flood can either directly affect the operations at the facility or affect the wider area such that the response to, and management of, a major accident could be compromised. The document is supported by the CDOIF guidance document for preparing for a flood that presents guidance and best practice.

The primary aim of the ODG is to support CA Inspectors and Officers in the planning, inspection, and rating of COMAH establishments with respect to their flood preparedness, assisting the operators in the discharge of their COMAH 2015 duties related to Schedules 2 and 3, plus Regulation 5 [2]:

- Schedule 2 - Requirements and matters to be addressed by safety management systems.
- Schedule 3 - Minimum data and information to be included in a safety report.
    - (5) Identification and accidental risk analysis and prevention methods:
        - (a) a detailed description of the possible major accident scenarios and their probability or the conditions under which they might occur including a summary of the events which may play a role in triggering each of these scenarios, the causes being internal or external to the installation, including in particular.
            - (iii) natural causes, for example earthquakes or floods; operate their sites in a manner consistent with identified best practice, prepared to respond to the flooding incidents.
- Regulation 5 - General duties of operators: Every Operator must take all measures necessary to prevent major accidents and limit their consequences for human health and the environment.

The inspections required to be performed by the CA Inspectors will seek to establish the adequacy of the risk assessments that have been completed and the flood mitigation/reduction measures that the establishment has implemented to measure flood resilience, resistance and the establishments response methods. A flood preparedness inspection route has been devised, with this having five elements beginning with the identification and assessment of the flood risk, through to testing of the measures and responses and the impacts of the postulated flood events. These main areas of inspection are illustrated in Figure 1.

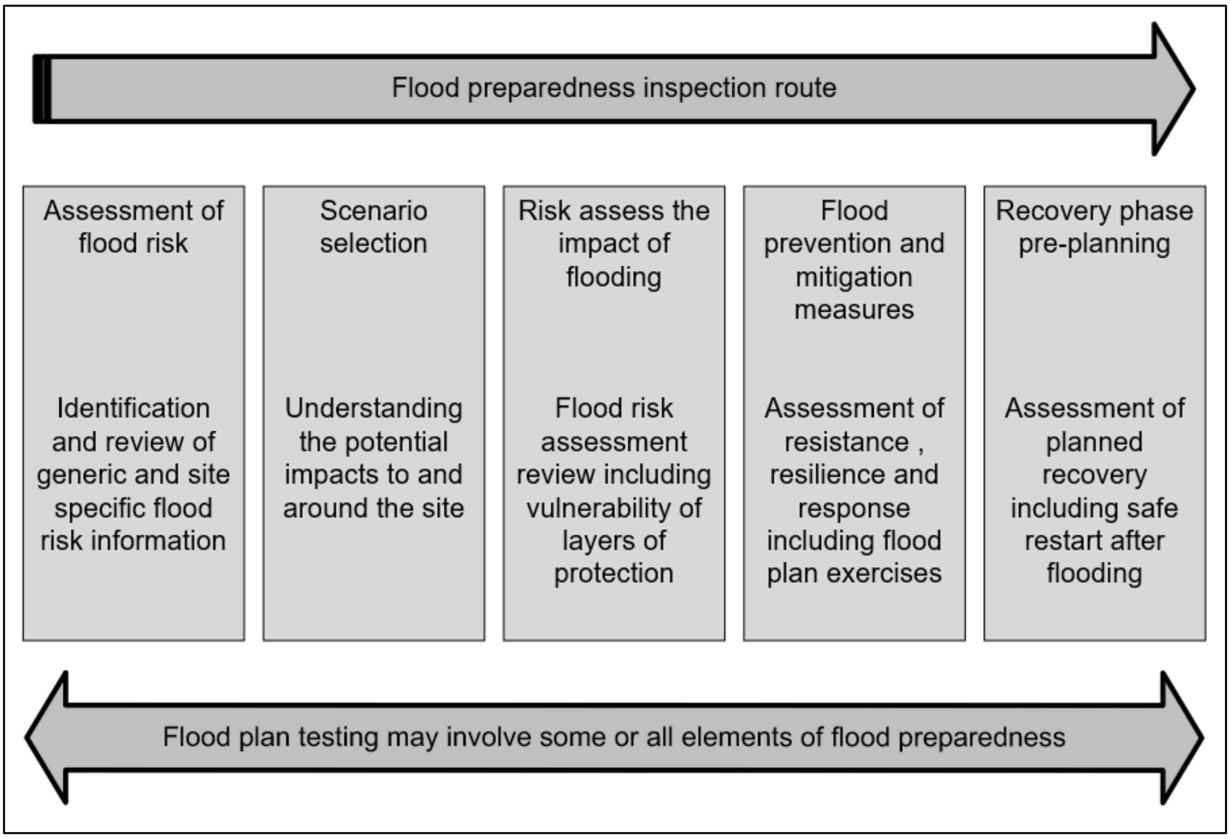

Figure 1. COMAH CA ODG Flood Preparedness Inspection Route [2]

Assessment of Flood Risk

Types of Flooding

The initial element of the process is to first establish if the facility is at risk from flooding. Typically, the primary types of flooding considered are river or coastal, however, it is critical to consider all possible types of flood event that could affect an establishment. Whilst a facility may be deemed to be outside of a river or coastal flood zone, it does not mean that it cannot be significantly impacted by other flood sources. The most common sources of flooding are:

Fluvial Flooding

River flooding or fluvial flooding occurs when watercourses cannot cope with the levels of water entering them from the surrounding catchments and is exacerbated when there are major rainfall events falling on already saturated ground.

Coastal Flooding

Coastal flooding is a result of stormy conditions coinciding with high tides. Additionally, if a low atmospheric pressure system coincides with a high tide, a tidal or storm surge can occur, resulting in significant flooding. When considering coastal flooding it is essential that not only the still water levels are considered but also wave overtopping which can affect operations at facilities that are deemed to be protected from sea inundation.

Pluvial Flooding

Pluvial flooding, or flooding due to significant rainfall events, occurs when heavy rainfall overwhelms the drainage system capacities. Pluvial flooding can come in several forms and can result in surface water accumulations as drainage systems cannot remove water quickly enough. It can result in water entry into buildings, from building roofs where the roof drainage is overwhelmed, and it can also be in the form of sewage flooding when sewer systems become overwhelmed by the volume of rainfall, or simply due to poor maintenance or blockage.

Pluvial flooding often occurs very rapidly and often without warning. Flood waters may be deep and fast flowing depending on the local topography but are likely to subside quickly, usually within minutes rather than hours. This type of flooding is most common in built up areas where large impermeable areas are unable to absorb excess water. However, it can also be a problem in rural areas. This is particularly apparent when catchments are saturated causing water to run-off fields onto roads and into property or where there are rapid response catchments with settlements situated downstream from steep valleys where heavy localised rainfall occurs. Forecasting this type of flooding is difficult, so plans and protection measures are critical to prevent major accidents.

Groundwater Flooding

Groundwater flooding occurs when normal groundwater levels rise above the surface and is most common in locations with an underlying bed of rock or chalk but can also happen with sand and gravel valleys. Groundwater flooding can occur in low lying areas as well as on hillsides where a high rock layer is present. It typically happens following heavy rains and can occur several days to weeks after a heavy rainfall event. Therefore, it is critical to know if this kind of flood source is a possibility.

Reservoir Flooding

Reservoir flooding, whilst less common than the other forms of flooding sources due to the strong safety records of reservoirs, is still a viable flood source that should be considered. When this kind of flooding occurs there would be rapid and significant levels of water released very quickly.

Sources of Information on Flood Risk

Within the UK there are a number of regional sources available to inform the determination of flood hazard exposure. This information can be found from:

- England: Environment Agency (EA) [3]

  https://flood-warning-information.service.gov.uk/long-term-flood-_risk/map?easting=344311&northing=390044&map=RiversOrSeaScotland:

- Scottish Environment Protection Agency (SEPA) / Buidheann Dion Àrainneachd na h-Alba [4]

  https://map.sepa.org.uk/floodmap/map.htm

- Wales: Natural Resources Wales (NRW) / Cyfoeth Naturiol Cymru [5]

  https://naturalresources.wales/flooding/check-your-flood-risk-by-postcode/?lang=en

- Northern Ireland: Department for Infrastructure (DI) / An Roinn Bonneagair [6]

  https://www.infrastructure-ni.gov.uk/rivers-and-flooding/flood-maps-ni

Examples of the flood hazard mapping that is available is presented in Figure 2 and Figure 3, for England and for Wales.

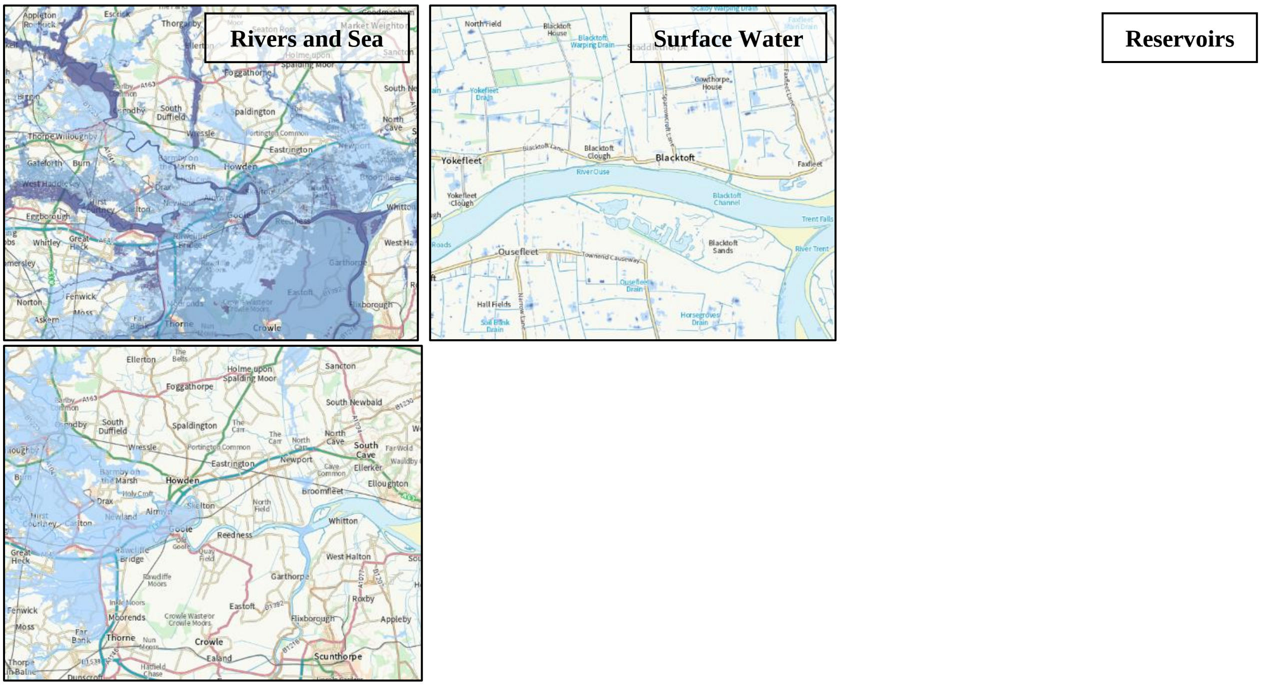

Figure 2. Flood Hazard Maps for England showing Rivers and Sea, Surface Water and Reservoir Flood Hazard, Source: EA [3]

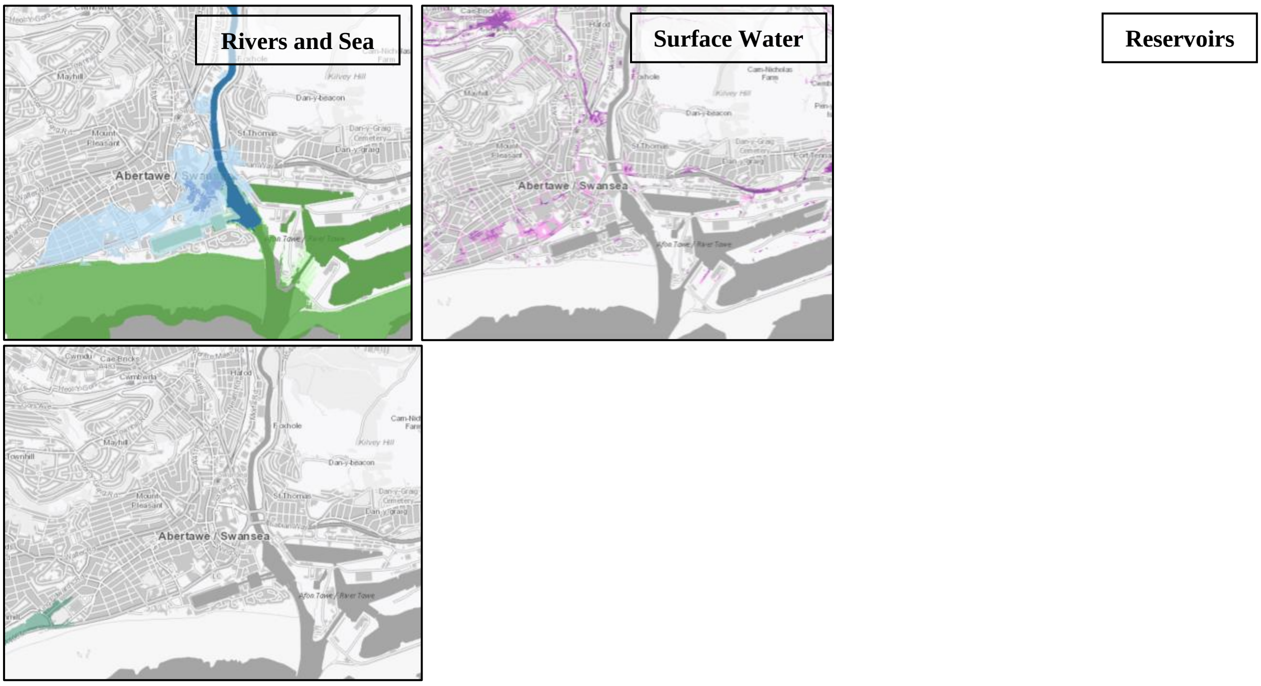

Figure 3. Flood Hazard Maps for Wales showing Rivers and Sea, Surface Water and Reservoir Flood Hazard, Source: NRW [5]

In addition to the basic mapping information, further documentation related to the modelling that has been performed can be sourced for some locations. The EA, for example, can provide packages of information to support flood risk assessments, with products [7] available including:

- Product 1: Flood Map, including flood zones, defences and storage areas and areas benefiting from flood defences.
- Product 3: Basic Flood Risk Assessment Map, including flood zones, defences and storage areas, areas benefiting from defences, statutory main river designations and some key modelled flood levels.
- Product 4: Detailed Flood Risk Assessment Map, including flood zones, defences and storage areas, areas benefiting from defences, statutory main river designations, historic flood event outlines and more detailed information from computer river models (including model extent, information on one or more specific points,

flood levels, flood flows).

- Product 5: Reports, including flood modelling and hydrology reports and modelling guidelines.
- Product 6: Model Output Data, including product 5.
- Product 7: Calibrated and Verified Model Input Data (CaVMID), including product 5.
- Product 8: Flood Defence Breach Hazard Map including, maximum flood depth, maximum flood velocity, maximum flood hazard.

The selection of appropriate products will depend upon the type and size of the establishment. The following guidance can be used to choose the correct product, and is applicable depending upon site size and flood zone; for example the products applicable to sites with areas greater than 1 hectare are:

- Flood Zone 1 - Product 3
- Flood Zones 2 and 3 - Products 4, 5, 6 or 7
- Flood Zone 3 (behind raised flood defences) - Product 8

Information Required for Establishments

The following covers the typical information that establishments should have for the identification of the hazard, determination of vulnerability and consequences, through to the management of the response.

Flood extent and sources of flooding:

- Flood data should include; Flood Probability (Return Periods), Flood Depth, Flood Velocity, Rate of Onset of Flooding, Flood Duration, etc.
- It is critical that all potential flood sources are considered as part of a comprehensive flood study including the impacts of localised flooding on plant and equipment. For example, water entry into electrical systems from roof drainage can result in loss of power, etc.
- Up-to-date information is a necessity, such as site layout drawings that detail facility ground elevations, building floor levels, equipment levels and the presence of basement areas to assess flood potential as any available existing flood maps would not have been produced with this level of data.

Vulnerability Review:

- Assess the impact of flood waters, addressing not just water immersion but also considering the effects from fast flowing water, debris within the water and the potential for failure of structural elements from hydrostatic pressures. These reviews need to consider all systems and utility lifelines, covering the primary, backup and emergency systems.
- Assess the impact on utilities and safety critical equipment for both on and off site, where response would be necessary from off-site emergency services, plus the vulnerability of critical access routes, considering that primary access routes could be cut-off (See Figure 4) [5]. In a major accident, communication with internal safety systems and external emergency services will be essential, therefore, it is important to understand the impacts on communication and safety systems, and the knowledge of potential vulnerabilities within these systems is essential.

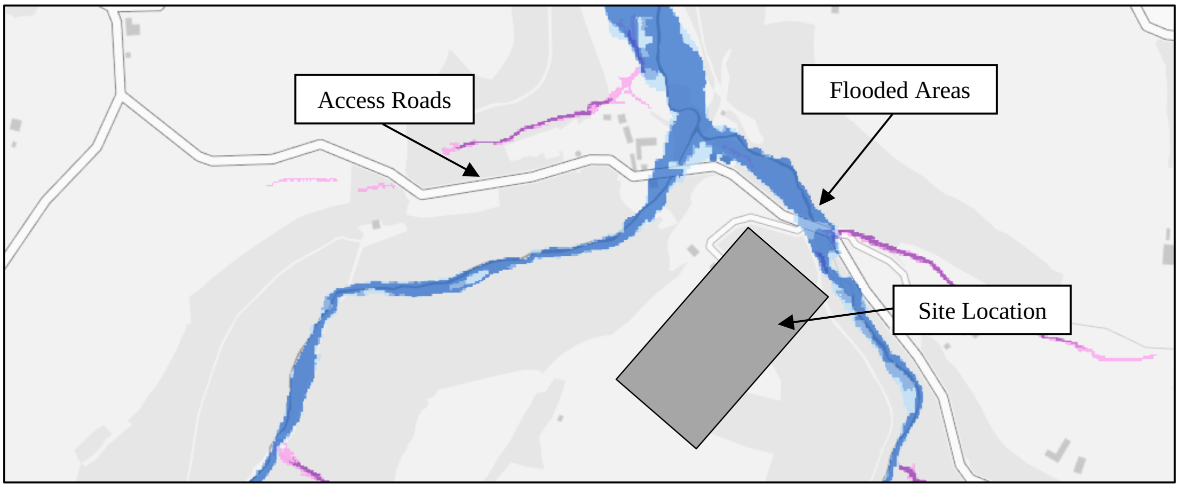

Figure 4. Example of Potential for Facility Access Impediment by Flood Waters, Flood Extent Map Source: NRW [5]

- It would be a recommendation that once the flood extent is established and the vulnerabilities are known that a Hazard and Operability (HAZOP) study is undertaken to consider potential problems through a review of the safety systems.

Mitigation and Management:

- Mitigation in the form of physical barriers to prevent water ingress, pumping systems to remove water as it enters an establishment, replacement of equipment that is vulnerable to water exposure with resilient flood proof equipment, and equipment relocations should all form part of a structured mitigation plan. This should consider the effects from the flood hazard but also consider the potential for failure of primary flood defences. It should not simply be assumed that flood measures will not fail. The degree of flooding considered could be exceeded and as such the consideration of cliff edge effects should form an element of the process to determine what would happen. Options for protection should include:
    - Protection levels to be considered, i.e. 100-year or 500-year Return Period.
    - Extent of protection: Facility-wide perimeter flood walls or key areas only.
    - Facility-wide entry point flood gate, walls, embankments, etc.
    - Individual building waterproofing, covering: Perimeter walls, doorways, openings and drainage systems.
    - Equipment location optimisation, i.e. on a cost/benefit basis to relocate operations from highly exposed buildings or areas to lower exposed buildings or areas at a facility.
    - Equipment elevation changes, i.e. raising equipment onto higher floor levels, mezzanine floors, concrete plinths, etc.
- Flood Management Plans (FMP) that details the response strategies and plans to deal with specific scenarios, with the following contents:
    - Organisational chart for plan ownership.
    - Partner and Stakeholders identification.
    - Potential flooding sources.
    - Flood assessment study results.
    - Historic and current flood history.
    - Discussion on influences around future conditions (climate change and land use).
    - Documentation of current laws and regulations that do or could influence plans.
    - Process is continuous (Prevent, Before, During, and After).
    - Warning system to define level of action needed – linked back to flood warning information provided, such as that by the EA within https://flood-warning-information.service.gov.uk [8]

Flood Protection – Multiple Layers

When considering flood protection, hard defences along rivers or coastal areas are often assumed to provide protection that cannot fail. But this is wrong. Hard defences do fail, due to a lack of proper maintenance, river channels becoming blocked by debris through poor vegetation management, or an event that is larger than the design levels for the defence.

In the case of hazardous facilities, the consequences of failure can be great and as such it is essential that cliff edge reviews of the designs are considered. When planning flood defences it is vital that several layers of protection are incorporated, be that physical barriers, pumping systems or redundancy in the power supply systems to emergency systems. Figure 5 presents an example of how multiple layers of physical defences can be incorporated, with these devised on the assumption that the first layer could be breached or exceeded. The scale of the second line of defence could need to be higher than the initial layer to account for longer return periods and events exceeding the design basis.

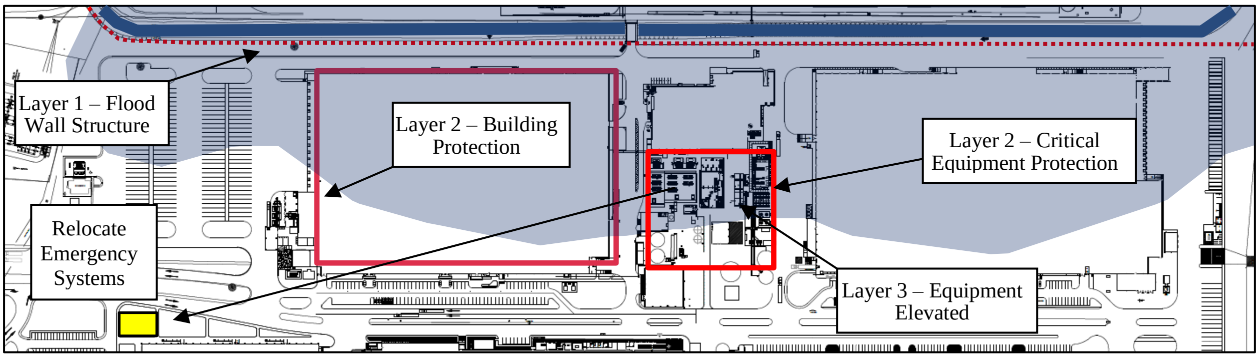

Figure 5. Building in Physical Layers of Protection – Primary Flood Walls, Secondary Building and Equipment Protection

The key to this element is to never assume that defences cannot fail.

Flood Emergency Response Drill Considerations

During the response to a flood event the planning should consider that responders are likely to encounter additional hazards. These hazards should be considered when developing response plans and drills, to make sure that these are as representative as possible to a real-life event. Hazards that are likely to be encountered should be included within a drill, including:

Driving during flood conditions

It is important to be careful when driving during flood conditions. Nearly half of flood fatalities are vehicle-related and shallow depths of standing water can be enough to stall some cars, with the risk of vehicles floating or being swept away if depths are great. If the water level is rising around your vehicle, it should be abandoned and flooded roads should not be crossed if water depths are not known. This level of information with respect to access routes should be considered, for off-site access route planning and on-site movements. The flood risk assessment should include details of flow velocities such that this can be planned for in emergency management planning operations.

Electrical hazards

Standing water will be present throughout a flood zone and when this has been anywhere near electrical circuits and electrical equipment, it is essential that the facility is able to turn off the power at the main breaker, which should remain accessible in flood conditions. Personnel should not enter flooded areas or touch electrical equipment if the ground is wet and they should stay clear of any downed or damaged power lines.

Debris

This is either from trees or materials on site and this can block access roads to site and those on site and damage power lines.

Chemical and biological hazards

These hazards will be present at COMAH facilities in varying quantities; underground storage tanks, along with other chemical containers, may break away and float downstream, causing hazards from their released contents. Floodwaters may also contain biohazards due to direct contamination by untreated raw sewage, etc.

Fire

Floods can damage fire protection systems and result in delays to response times of emergency services. These factors lead to increased dangers from fire and decreasing firefighter capabilities.

Drowning

Obviously responding during flood conditions exposes personnel to moving water, their chances for accidental drowning increase. This should be considered within planning and drills to realistically simulate the potential extra difficulties in responding to an event.

Hypothermia

It is probable that response to a flood event will occur during poor weather and potential exposure to cold water. Standing or working in cold water will remove body heat more rapidly than it can be replaced, resulting in hypothermia.

Exhaustion

Personnel responding to an event may be required to do so at any time day or night and would be required to work extended hours under stressful conditions. This environment can increase the risk of injury due to fatigue and emergency response procedures should consider human factors.

Climate Change Effects

The application and consideration of Climate Change effects to external hazards and implications for future flood events is essential to ensure that any flood management plans are maintained and comprehensive. In the UK, Climate Change Projections were updated in 2018 by the publication of UKCP18 [10]. This publication was accompanied by a series of guidance documents with the following published by the Met Office:

- Met Office: UKCP18 Guidance: UKCP18 for UKCP09 users, 2018 [11]
- Met Office: UKCP18 Science Overview Report, Mar-19 [12]
- Met Office: UKCP18 Guidance: Caveats and limitations, 2018 [13]
- Met Office: UKCP18 Guidance: Representative Concentration Pathways, 2018 [14]
- Met Office: UKCP18 Fact Sheet - Temperature, Feb-19 [15]
- Met Office: UKCP18 Factsheet: Derived projections, 2018 [16]

The fundamental difference between UKCP18 [10] and the previous guidance UKCP09 [9] is the projected treatment of greenhouse gas emissions. The UK Met Office considers the potential changes in climate for the UK over time based on different projections of emissions of greenhouse gasses.

UKCP09 used a set of three alternative views of future greenhouse gas emissions drawn from a set called ‘Special Report on Emission Scenarios’ (SRES). The SRES scenarios did not consider recent developments in climate change mitigation and many of the assumptions on the evolution of technologies, such as renewable energy generation, are now considered to be out of date.

UKCP18 uses scenarios for future greenhouse gases called the Representative Concentration Pathways (RCPs) that were designed to cover a more up to date range of assumptions around future population, economic development and to explicitly include the possibility of mitigation of greenhouse gas emissions towards international targets.

RCPs specify the concentrations of greenhouse gases that would result in target amounts of radiative forcing at the top of the atmosphere by 2100, relative to pre-industrial levels. Four forcing levels have been set: 2.6, 4.5, 6.0 and 8.5 W/m^2, which create the four RCPs used in UKCP18 [10], namely, RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5 which are based on the Paris Climate Change Agreement (Paris-Agreement) [17] being implemented world-wide.

The key aim of the Paris Agreement is [17]:

> *“…to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius”.*

The RCPs defined in UKCP18 [10] can be summarised as:

- RCP 2.6: represents a future in which the world aims for, and is able to implement, sizeable reductions in emissions of greenhouse gases.
- RCP 4.5: assumes that following 2030, the Paris-Agreement is implemented world-wide, and no further emission reductions are achieved but emissions do not rise.
- RCP 6.0: applies the same basis as RCP4.5 but allows for some future increases in emissions.
- RCP 8.5: represents a world in which global greenhouse gas emissions continue to rise.

Each RCP results in a different range of global mean temperature increases until 2100. Each RCP can be met by a combination of different socioeconomic assumptions, which includes population growth, economic development, technological innovation, and attitudes to social and environmental sustainability.

As a result of the different methods used to construct the RCPs and SRES it is not possible to directly compare the two data sets. However, Table 1 of UKCP18 Guidance: UKCP18 for UKCP09 users [11] presents a mapped equivalency, replicated as Table 1, below:

RCP	Most similar SRES scenario (in terms of temperature) UKCP09
RCP2.6	None
RCP4.5	SRES B1 (low emissions scenario in UKCP09)
RCP6.0	SRES B2 (between the low and medium emission scenarios in UKCP09)
RCP8.5	SRES A1F1 (high emissions scenario in UKCP09)

Table 1. Comparison of UKCP18 RCP and UKCP09 SRES Scenarios - Source Table 1 of [11]

A summary of the projections for sea level rise and precipitation changes are presented in Figure 6 and Figure 7, utilising data from the Met Office documentation for the RCP8.5 worst case scenarios.

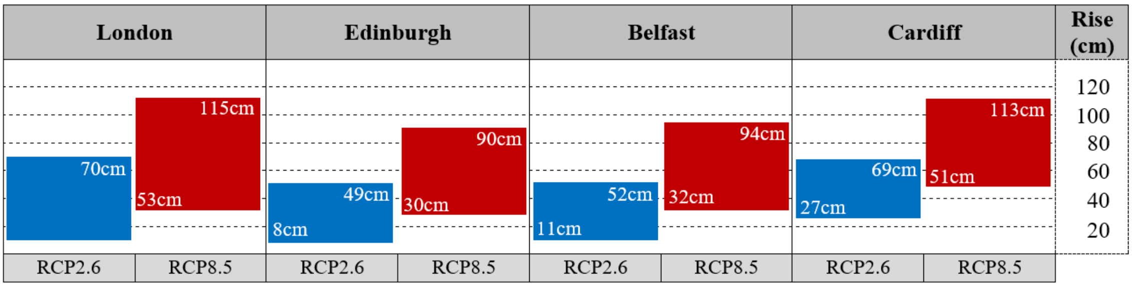

Figure 6. Projected Sea Level Rises by 2100 relative to 1981-2000, Source: Met Office [10]

As a result of the sea level rise, the risk of coastal flooding from storm surges and high tides will increase over time. Sea defences that are in place will likely require modifications to maintain the same levels of protection as present day. It is critical that the long-term projections are considered when determining the flood exposure from coastal flooding due to climate change. Beyond 2100 the sea levels will continue to rise. However, there is uncertainty at this time as to the degree of increase in these levels from 2100 onwards.

Precipitation levels will have a significant impact on future flood events and understanding how rainfall patterns are going to change will allow long-term flood management plans to be developed. The precipitation levels within the UK are predicted to be lower for summer months and to increase for the winter months, with patterns of shorter periods of rainfall but with higher intensities. Figure 7 presents the projected change in precipitation levels from 2061-2080 for the UK considering the RCP8.5 scenario.

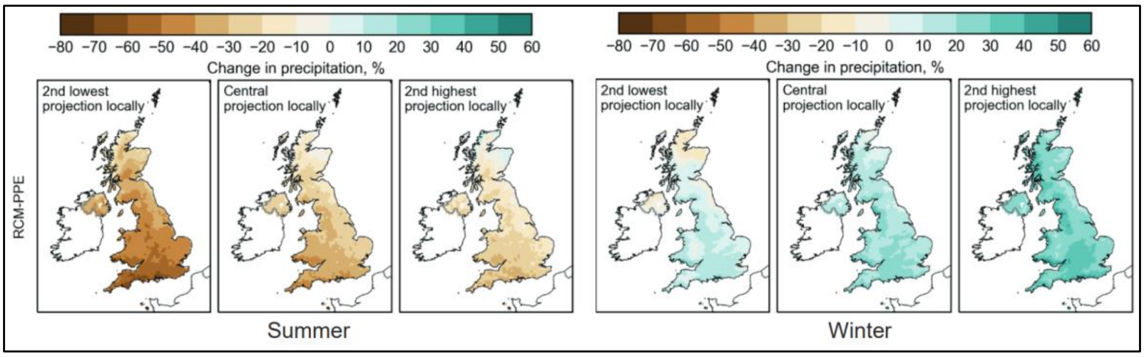

Figure 7. Patterns of Precipitation Change to 2061-2080 for UK (RCP8.5) – Source: Met Office [10]

When considering climate change effects, the flooding from fluvial and pluvial sources would be affected by the changes in the predicted rainfall levels. In the cases where the precipitation levels are predicted to increase the effects could be that on-site drainage systems become overwhelmed by the rainfall or building roof drainage systems cannot cope with the volumes of rainfall and result in water ingress into buildings and critical operational areas. This could affect electrical systems and result in a loss of power at a facility.

Effectiveness of Flood Protection – Case Studies

Often, a facility or enterprise that has a degree of flood protection in place will fail to ensure the ongoing effectiveness of that protection, be that to the whole establishments in the form of embankments or concrete protection walls, or to individual components of a facility, such as building flood protection or installing protection systems and implementing procedures.

The following examples are based on our experience of performing facility risk audits. We regularly identify issues that can undermine existing flood protection measures. It is often the issues that have a perceived small impact that are most often overlooked but have the potential to fundamentally impact protection.

Case One: Controlling Facility Alterations

A facility, located within a riverine flood zone installed a series of concrete blockwork flood barriers to the perimeter of their production area buildings. The facility was around 30 years old, and the protection was installed shortly after the commencement of operations.

Alterations over time to the operations and the installation of new equipment resulted in the compromise of the flood protection, as illustrated in Figure 8. In several locations equipment was installed at the protection boundary that resulted in the creation of flood ingress routes. When this was pointed out to the facility operators, it was established that the personnel who removed the sections of the wall were not aware that the wall formed part of the flood protection boundary. Therefore, this concern was not identified until an audit of the flood risk was undertaken.

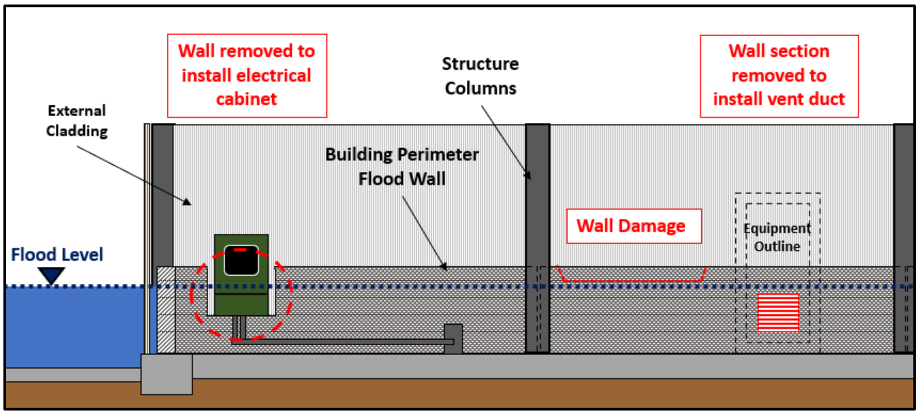

Figure 8. Examples of Facility Actions that Undermine Flood Protection Measures

A lesson learned from this audit was for the flood protection measures in place to be explicitly shown on building drawings and emergency plans, and for the protection to have an identifier in the form of signage or paining to make personnel aware of the protection.

This is particularly important where the installation forms part of a secondary layer of protection. Even if a facility is protected off-site or at the site boundary by embankments, etc. it should not be assumed that this is the only protection in place and any additional on-site layers must also be considered.

Case Two: Maintaining Monitoring Equipment

Pluvial flooding can create issues with facilities, particularly when failure of drainage systems can result in water build-up on roofs, such as that behind a parapet shown in Figure 9. At this location the operators recognised this risk and installed water gauges in the drainage system. This monitoring system would sound an alarm if the drainage system became blocked and also at roof level a depth gauge was installed to notify operators if water accumulations occurred.

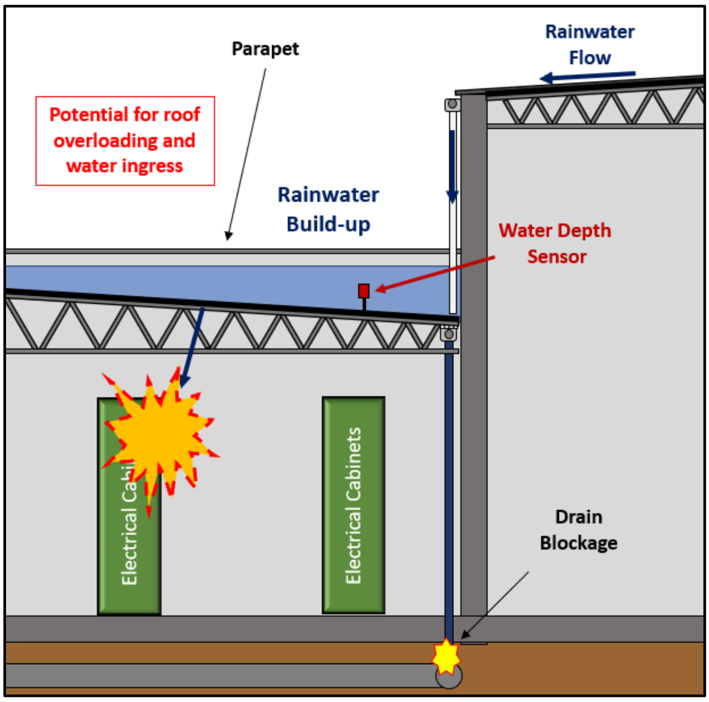

Figure 9. Examples of Facility Rainfall Sensors and Drainage Monitoring

When a review was undertaken for the facility for flood risk, fluvial and pluvial flooding was the concern and on inspection of the drainage monitoring system it was clear that the system did not function, as it had not been maintained, plus the operators at the location were not aware that the system was in place as it was not covered within the flood management plan. An alarm panel was installed on site, but the current staff were not aware of the function.

This is an example of how facilities should ensure that any protection equipment is contained within the management systems and to ensure that this equipment is maintained. Management of change policies were updated at this location to ensure that as personnel changed the new personnel were adequately briefed with respect to such systems. Fortunately, the system was not required for a pluvial flood event, however, had the flooding occurred then loss of site power would have been likely as the system was installed on the roof of the main facility sub-station.

Case Three: Not considering all ingress routes

Flood protection provided at a building level is potentially vulnerable to small ingress routes that may not be fully captured during a flood assessment which could result in water entry to critical areas. A cable ducting that was installed had not been fully sealed and as such when the service trench filled with water the ducting provided a route into the pit beneath a back-up power generator during heavy rains that went undetected until the following morning when personnel entered the building.

It is therefore critical that all potential entry points are identified when flood proofing is performed and that this is documented on a survey plan. Other ingress routes that can be overlooked are internal building drains that are connected to external systems.

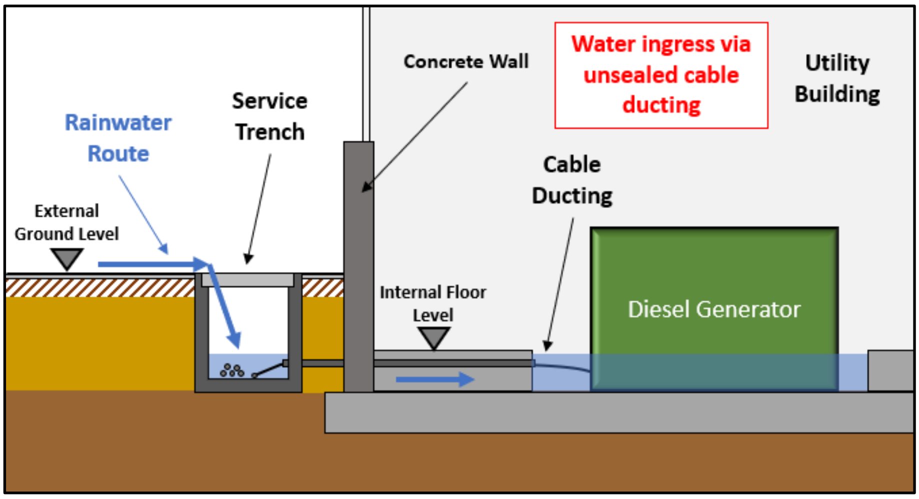

Figure 10. Examples of Flood Water Entry Route into Building

Case Four: Flood Management Plan and Management of Change

A facility, located within an area having high levels of rainfall had several buildings with basement areas and pathways to these basements. Within the basement there was various electrical equipment supporting the IT systems and communications systems. The entrance areas had demountable flood barriers to prevent water entry into the building, however, the installation of these was not properly covered within the Flood Management Plan, nor within work instructions at the facility.

During a heavy rainfall event the basement was flooded, and equipment was damaged as the barriers were not installed ahead of the event. The reason for this was that there had been personnel changes at the facility and the new personnel responsible for erecting the barriers had not been fully briefed. To address this, the facility incorporated this action within the flood management plan and added the task to the work instructions of the on-site security team.

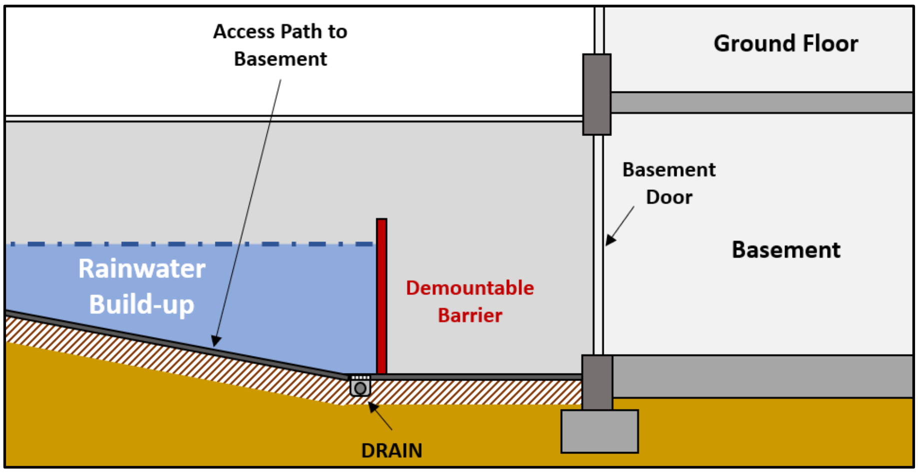

Figure 11. Examples of Facility Flood Protection Measures – Demountable Barrier

Conclusions

Flooding is the most frequent and impactful natural hazard in the UK that is set to increase because of climate change. Identifying the present-day flood risk and future flood risk is essential for a facility to begin the process of Flood Risk Management and the process of demonstrating that the systems in place meet the needs of a COMAH facility in line with what the ODG will seek to establish. It is key that all potential flood sources are considered, particularly as the potential flood events from heavy rainfall can have major impacts on the safe operation of hazardous facilities.

Often when facilities are managing flood risk, the major elements of physical flood barriers are well considered, however, actions of changes to site personnel or poorly written management plans can undermine the systems in place. What can be seen as small issues on site can result in loss of power systems and therefore it is key that any flood risk and vulnerability assessments undertaken are thorough and well documented, along with well written and robust flood management plans.

With climate change effects, the flood systems that are in place today may no longer be fit for purpose in 20- or 30-years' time, so the periodic review of the flood management of a facility is essential to ensure that the levels of protection are maintained, with the ODG being a key tool in that process.

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