6 Infrastructure: Utilities

To appraise the losses from electricity, gas, water, waste water and telecommunications

Electricity and Gas

Estimating the losses to electricity and gas assets caused by the disruption to supply

OVERVIEW

This sub-section introduces methodologies for the estimation of losses to both electricity and gas assets. This focuses mainly on the losses caused by the disruption to the supply of services as well as some comment on direct damages to these infrastructure types. The impacts of the loss of electricity are particularly significant as the consequences can radiate beyond the immediate vicinity of a flood area and the high number of associated interconnections. Appraisal is primarily based on estimating the amounts that customers are willing to pay to avoid the disruption to service.

There are many assets potentially at flood risk with HR Wallingford (2012) reporting that there are 10,600 electricity and 250 gas assets at significant risk of flooding in England which account for 6.6% or 8.3% of all assets. More recent estimates identify that 22% of electricity and 35% gas infrastructure assets are located in areas at risk from rivers, sea and surface water (Environment Agency, 2024). Furthermore, research by the University of Oxford and Rebalance Earth (Edghill et al, 2026) estimates that 4,000 substations supplying electricity homes and businesses are at risk of flooding. This creates additional vulnerability of disruption to 27,000 businesses which themselves are not themselves at risk of flooding which an estimated £90 million per day financial running costs (Raynor, 2026).

The 2007 floods highlighted the severe consequences and disruption that can occur if electricity infrastructure assets are flooded or threatened and have provided some key lessons for the appraisal of both gas and electricity infrastructure. In total, there were an estimated electricity supply losses of £138-9m which accounted for 20% of all infrastructure losses or over 4% of all economic losses.

LESSONS FROM EXPERIENCE

- Of all the utility assets electricity is the most important to appraise due to the inherent interconnectivity within the system.
- Due to the serious repercussions of severe power outages and high interconnectivity with other essential services, both electricity and gas companies are under a legal duty to ensure security of supply (HM Government 1996; 2002; 2023).
- Since 2007, the need for increasing resilience in utility supply has been highlighted and efforts have begun and more are planned (Pitt, 2008; National Grid Gas, 2010). These measures need to be considered within a project appraisal.

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- The 2007 floods illustrate that the loss of perceived value to users accounted for more than 90% of the total economic costs of flooding in the electricity sector and highlights the importance of assessing the likely value of this disruption of power supplies to large numbers of customers.
- Prioritisation in appraisal is essential with assets on the Protected Site List (PSL) or large populations having higher priority; however, the higher up the distribution chain for electricity the greater the degree of redundancy. Therefore, the risk matrix should be applied.
- Flooding risk to gas infrastructure and/or the continuity of supply is considered to be low with high transferability of service within the gas network. The highest risk is posed by a failure of communications or equipment reliant on electricity supplies.

ESTIMATING DIRECT DAMAGES TO ELECTRICITY AND GAS INFRASTRUCTURE

Depth/damage data are not available for the distribution and grid substations because in these instances damage is potentially highly variable and depends on the configuration and siting of transformers, switch gear and other equipment. Site surveys and further discussions with infrastructure owners would be required to assess the direct damages to grid and distribution substations.

Readers are referred to Chapter 5 for guidance on assessing direct damages to primary substations. In addition to this, we recommend that appraisers discuss the costs of direct damage owing to the flooding of gas assets with National Grid Gas or other distributers.

METHODOLOGY FOR ESTIMATING THE LOSSES DUE TO THE DISRUPTION OF A SERVICE

Step One: Identify the locations and types of substations

Identify with the typology all electricity substations in the floodplain under consideration and for which the National Grid or Distribution Network Operator (DNO) is responsible.

The table below illustrates the different types of electricity substation and permits the prioritisation of assets to consider.

Table 6.4 *Types of electricity substations (ENA, 2009; 2018b)*

Substation type	Typical Voltage transformation levels	Approximate number in UK	Typical size	Typical numbers of customers supplied
Grid (Super grid)	400kV to 132kV	377	250m x 250m	200,000 to 500,000
Grid (Bulk Supply Point)	132kV to 33kV	1,000	75m x 75m	50,000 to 125,000
Primary	33kV to 11kV	4,800	25m x 25m	5,000 to 30,000
Distribution	11/kV to 400/230V	230,000	4m x 5m	1 to 500

NB. This is Table 6.6 in the MCM 2013

Using Table 6.4 above, identify the risk for each substation based on the likelihood and impact of flooding using the following risk matrix (Table 6.5) to prioritise those assets which should be quantified – only those which are categorised as **high** or **very high** risk should be examined further.

Table 6.5 *Risk matrix for electricity substations*

IMPACT	Sig: Grid substations with serving a population of > 125 000	Medium Risk	**High Risk**	**Very High Risk**
	High: Primary substations those with > 10000 *population supplied*	Medium Risk	**High Risk**	**High Risk**
	Mod: Primary substations with 5,000 to 10,000 population supplied	Low Risk	Medium Risk	**High Risk**
	Low: Distribution substations with fewer than 500 people supplied.	Negligible Risk	Low Risk	Medium Risk
		Very Low	*Low*	*Medium/High*
		LIKELIHOOD		

NB. This is Table 6.7 in the MCM 2013

Step Two: Estimation of population served

Estimate the population served based on length of perimeter using the table below and the presence of any "Protected Sites" designated as part of the Protected Sites List (PSL) process (from DNO, see DESNZ, 2026) examples of which are provided in Figure 6.2.

This is a broad estimate. The results from discussions with National Grid or the appropriate DNO will, of course, be more accurate.

Table 6.6 *Estimations of population served based on the perimeter fence length (after ENA, 2018b)*

Substation type	**Average Perimeter Fence**	**Ratio customers to metres of perimeter**
Grid (Super grid)	1000m	225:1
Grid (Bulk Supply Point)	300m	183:1
Primary	100m	150:1

NB. This is Table 6.8 in the MCM 2013

Step Three: Assess whether an asset is defended against flooding

Much investment and activity has focussed on improving the resiliency of substations and associated infrastructure (National Grid, 2022) so it is likely that some at-risk assets will have protection. The third and fourth round of Climate Change Adaptation Reporting in accordance with the Climate Change Act 2008, provides the updated information on climate resilience for each supplier (Defra, 2023; 2025). Concern following the North Hyde substation fire in March 2025 ,which caused significant disruption to electricity supplies particularly to Heathrow Airport, led to recommendations for the strengthening of resilience of energy supplies (NESO, 2025). The UK Government response to the NESO report (UK Government, 2025a) and its action plan and the associated launch of a new Energy Resilience Strategy (UK Government, 2025b) to be implemented in 2026 may lead to increased attention to substation and other electricity asset's resilience to flooding.

Establish whether the site is within an existing flood-defended area and determine the condition of the defences and their actual standard of protection.

Where defences are below the Environment Agency's set target condition grade and/or the standard of protection is below the resilience levels set by ETR 138 (Issue 3; ENA, 2018a) and Engineering Design Standard (UK Power Networks, 2024) (Table 6.7) establish the flooding threshold for key parts of the substation that will trigger disruption of supply to customers and critical infrastructure.

If an asset is not in an existing flood-defended area move to Step Four.

Table 6.7 *Resilience levels for electricity substations**

Flood type	Protection level			Allowance for climate change rises	Freeboard
	Grid Substation	Primary Substations† > 10,000 unrecoverable connections	Primary Substation† < 10,000 unrecoverable connections		
Fluvial	1:1000 Flood level	1:1000 Flood level	1:100 Flood level	Flood Depth x 20% or use of EA CC factored levels	300mm
Tidal	1:1000 Flood level	1:1000 Flood level	1:200 Flood level	105mm or use of EA CC factored levels	300mm
Surface	1:1000 Flood level	1:1000 Flood level	1:100 Flood level	Flood Depth x 20%	300mm

Source: UK Power Networks (2024, 10); ENA (2018a, 20).

* Please note that critical infrastructure resilience is a priority area following recent floods and storms and the *National Flood Resilience Review* (HM Government, 2016) and so the resilience levels may be subject to change. Furthermore, some DNOs have issued guidance recommending additional safety factors are applied (e.g. Electricity North West, 2017). In particular, the updated ENA (2018a) suggests that Network Operators should ensure that they utilise the most recent guidance available. It is recommended that appraisers also check for updated information from DNOs who own assets in the benefit appraisal area. The third and fourth round of Climate Change Adaptation Reporting in accordance with the Climate Change Act 2008, for each supplier can provide additional information on climate resilience for each supplier (Defra, 2023; 2025).

† ENA (2018a) suggests that network operators should focus on the resilience of service provision to sites supplying significant local communities (SLCs) (which are defined as those comprising at least 10,000 customers/connections) and to the level of the EA's Extreme Flood Outline (i.e. 1/1,000 flood risk). Therefore, those primary substations which are likely to serve a customer population of over 10,000 should have the same protection level (1:1000) as grid substations.

Step Four: Assess presence and importance of resilience measures

If not in an existing flood defended area establish whether the site has been made resilient against flooding with either permanent or temporary locally-installed measures. If the measures are temporary establish whether the site is in receipt of a flood warning (provided by organisations such as the Environment Agency, Natural Resources Wales or SEPA) and that the erection of temporary measures is practical within the lead-time of warnings provided.

If the site is either not in receipt of flood warnings or these are inadequate to secure the site consider the flooding thresholds for key parts of the substation and the potential for transferring other supply to customers and critical infrastructure. If no flood intervention measures are in place or planned imminently by the DNO establish the flooding threshold for key parts of substation likely to disrupt supply to customers and critical infrastructure.

Step Five: Assess the importance of network interconnectivity

Establish the degree of network interconnection to minimise loss of supply to customers and critical infrastructure. Where transferability of supply is 'seamless' losses associated with flooding are only direct damages to the substation.

Step Six: Identify appropriate flood intervention measures

If the project appraisal is specific to the substation, establish the most appropriate flood risk management system, in conjunction with the DNO, to protect the substation. Table 6.8 provides the potential intervention measures for electricity infrastructure with their advantages and disadvantages.

Step Seven: Cost-benefit analysis

Conduct a cost-benefit analysis methodology of preferred solution(s) including an assessment of societal risks. This includes the evaluation of damages by flood depth for critical plant and equipment and the cost of customer supply losses.

'Customer/minutes' loss as a result of flooding during the accounting period including the 2007 floods were only 4.2% of total (with lightning and wind and gales contributing to over 20%). However, the widespread losses of electrical power extend well beyond the obvious consequences and the following should be included where possible as part of the assessment of societal losses.

- Loss of traffic lights can lead to traffic gridlock with knock-on effects on the ability of emergency services to respond.
- Mobile telephony will overload and fail within 6 hours.
- Domestic central heating (even gas fired) will fail and hypothermia is a real threat during winter flooding.
- Disruption of water supplies and sewage treatment and disposal could pose a serious health hazard.
- Petrol pumps, cash tills and cash machines will fail.
- Radio and TV broadcasts will fail to reach the affected population.

- Use of candles and alternative cooking practices could pose potentially serious fire hazard and dangers of asphyxiation.

The appraiser should create a template about when each of the above benefits is worthy of further analysis. The ratio of property within the floodplain to those outside the floodplain serviced by a distribution substation subject to flooding (within Flood Zone 3) may determine whether induced losses should be assessed. Appraisal is probably only worthwhile if more than 50% of the properties served by a flooded distribution substation are largely flood free (i.e. in Flood Zones 1 and 2).

Step Eight: Quantify the potential costs due to the disruption of services (using the equation below).

Equation 6I.1

CD = P * EC * WTP * D

where:
CD is Estimated total cost of disruption as a consequence of the flooding (£)
P is Number of properties affected by power outage[1]
EC is Hourly electricity consumption (kWh)
WTP is Willingness-to-pay value to avoid power outage (£/kwh)
D is Estimated duration of disruption to supply (hours)

Some indicative values of average energy consumption and willingness to pay to avoid a disruption in service are provided in Figure 6.3.

DURATION OF ELECTRICITY DISRUPTION

In general, most repairs to distribution substations would be achieved within a 24-hour period and therefore power restored to properties relatively quickly. However, those properties and businesses which are themselves flooded will suffer electricity outages for longer, because the property-level electrical fittings will also need repair. The specific impacts of these outages will depend upon whether residents are in temporary accommodation (and therefore may be less impacted by the lack of supply) or whether they are remaining in the affected property. Therefore, in some situations it may be appropriate to estimate the number of households that might be flooded within the area served by a distribution substation and remove these from the total number of properties affected by the power outage.

DISRUPTION TO GAS SUPPLIES

Overall, the pressurised gas network is far more resilient than electricity distribution. National Grid Gas have been working to increase the resilience of its assets to flooding including activities such as reinforcing river banks and further research about what the impacts of flooding are on pipelines and other equipment (National Grid Gas, 2010). As part of this process risks have been categorised (on a four point scale) according to the degree of material risk they pose to different assets and how robust business process and/or action plans are to deal with these risks. For flooding, the majority of risks are considered either to be low in terms of the damage likely to be sustained or that the continuity of supply would not be threatened. National Grid Gas (2016; 2021) and National Gas (2024) reports on the progress of resilience efforts and the Climate Change Adaptation Reporting (under the Climate

[1] i.e. total number of properties served by the substation or infrastructure affected

Change Act, 2008), third and fourth round reports highlight the progress on climate resilience by each supplier (Defra, 2023; 2025). However, the following should be considered for appraisal:

- A gas compressor station was considered to be at risk of flooding, but supply was not thought to be threatened if it was inundated.
- National Transmission Pipe work (~70 barg). These were considered to be at risk as there is the potential for these pipes to float if the ground around and above them is flooded. However, the main concern is that there is insufficient information about these risks and therefore further research is required to be able to quantify fully their susceptibility to flood water
- The main concern remains the pipework and their pressure gauges where the ingress of flood water may necessitate a mass purge of the affected pipeline.

Should a gas installation be located in a floodplain under investigation then discussions with the National Grid Gas or other distributers may be appropriate on the lines of the step-by-step guide above for electricity. In those situations where further analysis of a loss of gas supply is required the calculation provided for electricity may also be adopted. An estimation of the annual gas energy consumption for the average UK home is provided in Figure 6.3.

KEY ELECTRICITY ASSETS FOR APPRAISAL FROM EXPERIENCE

A summary of the relative importance of all utility and infrastructure measures adopting the risk matrix approach (with the addition of scale) can be found in Table 6.1. Although not an exhaustive list (and appraisers should undertake their own filtering approach) we suggest a full monetary quantification of utility damages/losses is required (i.e. proportional) and will contribute significantly to the present value of benefits in the following situations:

- Tidal inundation of electricity transmission lines greater than 132 kV unless flooding thresholds are less frequent than 1 in 75 years (1.3%).
- Tidal inundation of electricity transmission lines of less than 132 kV but only if flooding is more frequent than 1 in 25 years (4%).
- Flooding of electricity grid substations (including super grid and bulk supply point installations) when the risk of flooding is moderate (i.e. more frequent than 1 in 200 years; 0.5%) as these serve greater than 125,000 and up to 500,000 customers.
- Flooding of primary and grid substations where when the risk of flooding is more frequent than 1 in 75 years (1.3%); thereby serving a dependent population of greater than 5,000.

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Water and Waste Water

Estimation of potential losses due to the flooding of water infrastructure

OVERVIEW

This sub-section provides a methodology for estimating the potential losses due to the flooding of water infrastructure. Appraisal in this sub-section is based on the Ofwat (2008) guidance on the costs imposed on households when water is cut-off and on willingness-to-pay valuation of customers to avoid a disruption to either water supply or waste water services. In addition to this, the Security and Emergency Measures Direction (SEMD) 1998 provision about the minimum requirement of water which should be provided (per person) when water supply is cut-off is also utilised.

HR Wallingford (2012) has reported that there are 970 sewerage and 290 assets located in areas at moderate or significant risk of flooding in England; with the Environment Agency (2024) estimating that 34% of water pumping stations and treatment plants are located at risk of flooding from multiple sources. The floods in 2007 served to highlight the susceptibility of the water supply network and the potential large-scale disruption that can occur when only one major single source of water supply serving a large number of users is flooded. The overall costs to Severn Trent Water alone were in the order of £30 million with supply being interrupted for approximately 350, 000 customers (Chatterton et al., 2010).

LESSONS FROM EXPERIENCE

- Generally, sewage treatment and pumping facilities are not as susceptible to flooding as water supply facilities.
- In 2004, the Water UK Council established a mutual aid protocol for all members to ensure delivery of water by companies during an emergency. The protocol (amended after 2007) includes agreements to share emergency equipment and to support affected member companies during incidents and enhances the resilience and contingency options of the sector.
- Regulators have a key role in supporting the UK's resilience agenda, and the Pitt Review recommended that this was recognised by "placing a duty on economic regulator to build resilience". These resilience activities (and future planned activities) need to be included within project appraisal. Of particular use to appraisers are the indicators some companies have used for defining and measuring resilience.
- Similar to electricity the interconnectivity of water infrastructure means that losses can extend widely beyond the flooded area.

ESTIMATING DIRECT DAMAGE TO WATER INFRASTRUCTURE

Readers are referred to Chapter 5 for guidance on assessing direct damages to sewage treatment works. The data contained on MCM-Online provide sector average indicative values only and therefore site surveys or discussions with the infrastructure owner are recommended to verify these estimations and to appraise the potential damages to water supply infrastructure which are not included as depth/damage curves in Chapter 5.

APPRAISAL FOR WATER RELATED ASSETS AT FLOOD RISK

The Cabinet Office (2011, 28) suggests a benchmark that "as a minimum essential services provided by Critical National Infrastructure (CNI) in the UK should not be disrupted by a flood event with an annual likelihood of 1 in 200 (0.5%)". The guide goes on to indicate that the costs and benefits of individual projects should be considered when deciding which projects to fund and whether the benchmark can be achieved. The benchmark does not apply to other infrastructure that is not designated as Critical National Infrastructure. The Climate Change Adaptation Reporting (under the Climate Change Act, 2008), third and fourth round reports highlight the progress on climate resilience by each supplier (Defra, 2023; 2025).

There is a fundamental difficulty in creating a definitive listing of water supply and sewerage infrastructure at risk from flooding (or any critical infrastructure, e.g. electricity substations, for that matter). Any reference to sites/assets being critical infrastructure indicates that the asset is important and could provide useful targeting information for those with a 'terrorist' intent. Such information may require a protective marking (e.g. "RESTRICTED"). Consequently, an appraiser must rely on the often incomplete data provided by the Environment Agency's National Receptor Dataset as a starting point and follow up the results with direct contact with the water supply and sewage treatment providers.

The process of evaluating the contribution of a water supply or water treatment works to the total flood losses of a community is similar to the step-by-step procedure outlined for electricity installations (Section 6b) but with different impact filters to account for.

Step One: Apply the relevant risk matrix

Identify the risk based on likelihood and impact of flooding using the appropriate risk matrices for sewage treatment and water supply works below. Using this as a decision filter – only consider steps 2 onwards for **High** and **Very High Risk** assets.

Table 6.9 *Risk matrix for sewage treatment works*

IMPACT	*Sig: > 30,000 cumecs effluent dry weather flow*	Medium Risk	**High Risk**	**Very High Risk**
	Mod: 5,000 to 30,000 cumecs effluent dry weather flow	Low Risk	Medium Risk	**High Risk**
	Low: < 5,000 cumecs effluent dry weather flow	Negligible Risk	Low Risk	Medium Risk
		Very Low	*Low*	*Medium/High*
		LIKELIHOOD		

NB. This is Table 6.12 in the MCM 2013

Table 6.10 *Risk matrix for water supply*

IMPACT	*Sig: > 20,000 population supplied or PSL customers*	Medium Risk	**High Risk**	**Very High Risk**
	Mod: 5,000 to 20,000 population supplied	Low Risk	Medium Risk	**High Risk**
	Low: < 5,000 population supplied	Negligible Risk	Low Risk	Medium Risk
		Very Low	*Low*	*Medium/High*
		LIKELIHOOD		

NB. This is Table 6.13 in the MCM 2013

Step Two: Assess whether an asset is defended against flooding

Establish whether the site is within an existing flood defended area and determine the condition of the defences and their actual standard of protection. Where defences are below the Environment Agency's set target condition grade and/or the standard of protection is below the optimum design standard proposed by the Environment Agency establish the flooding threshold for key parts of the works likely to disrupt supply to customers and critical infrastructure (see Protected Site List established for electricity in Figure 6.2).

Step Three: Assess the presence and importance of resilience measures

If not in an area already benefiting from flood risk management measures, establish whether the site has been made resilient against flooding by the Water Company with either permanent or temporary locally installed measures. If the measures are temporary establish whether the site is in receipt of flood warnings and that erection of temporary measures is practical within the lead-time of warnings offered.

If the site is either not in receipt of flood warnings or these are inadequate to secure the site consider the flooding thresholds for key parts of the works and the potential for transferring other supply/treatment capacity to customers and critical infrastructure. If no flood intervention measures are in place or planned imminently by the water company establish the flooding threshold for key parts of works likely to disrupt supply to customers and critical infrastructure.

Step Four: Assess the importance of network interconnectivity

Establish the degree of network interconnection to minimise loss of supply/treatment to customers and critical infrastructure. Where transferability of supply is 'seamless', losses associated with flooding are only direct damages to the works.

Step Five: Identify appropriate flood intervention measures

Establish the most appropriate flood risk management system in conjunction with the water company (see Table 6.8 for examples established for electricity which provides a starting point for these)

Step Six: Cost-benefit analysis

Apply a conventional cost-benefit analysis of preferred solution(s) including societal and environmental risks. This includes the evaluation of damages by flood depth for critical plant and equipment and the cost of customer supply losses using cost of water under Security and Emergency Measures Direction (SEMD) (as amended) (Defra, 2022; 2024a) provision as a minimum cost, supplemented with willingness to pay data/surveys as appropriate. MCM (2005) (Penning-Rowsell et al., 2005) provides an example of appraisal for the Newport Waste Water Improvement Scheme which highlights the process that could be applied.

Under the Guaranteed Standards Scheme (GSS) customers are entitled to financial recompense when water is disconnected without prior warning (Ofwat, 2008; 2025; HM Government, 2028; 2025). In October 2025 new standards came into force which for English water customers increased the payments homeowners and businesses are entitled to for emergency disruptions to service (HM Government, 2025). Please note that the new standards have been adopted in England and the standards for Wales remain unchanged as of April 2026[2]. Appraisers therefore should consider where an affected property is located and the water and sewerage service supplier.

For customers with a disrupted supply in England the GSS (Ofwat, 2026; p25) provides a minimum amount that companies must provide; £50 for domestic customers plus an additional £50 for each subsequent 12 hours (up to cap of twice customer's annual water supply charge) the supply remains cut-off. For non-domestic customers suppliers should provide minimum payments of £100 plus an additional and £100 for each subsequent 12 hours (up to cap of twice customer's annual water supply charge) the supply remains unrestored.

For customers with a disrupted supply in Wales the GSS (Ofwat, 2026; p10-11) provides a minimum amount that companies must provide; £20 for domestic customers plus an additional £10 for each subsequent 24 hours the supply remains cut off. For non-domestic customers suppliers should provide minimum payments of £50 plus an additional £25 for each subsequent 24 hours the supply remains cut off.

This compensation agreement is often waived in extreme weather conditions or exceptional circumstances; however, it may be used to estimate the potential costs of disruption of supply. Water UK (2017) provides a Technical Guidance Note detailing operational principles to be considered by water undertakers when fulfilling their responsibilities under licensing requirements (Defra, 2022 as per Section 208 of the Water Industry Act 1991) which requires all water companies to provide 10 litres of water per person per day or 20 litres per person per day in incidents lasting more than 5 days.

[2] Welsh Government has indicated that similar changes will be pursued separately in Wales. Appraisers should consider whether there are any similar regulations in the country where they are undertaking analysis.

KEY WATER ASSETS FOR APPRAISAL FROM EXPERIENCE

A summary of the relative importance of all utility and infrastructure measures adopting the risk matrix approach (with the addition of scale) can be found in Table 6.3. Although not an exhaustive list (and appraisers should undertake their own filtering approach) we suggest a full monetary quantification of utility damages/losses is required (i.e. proportional) and will contribute significantly to the present value of benefits in the following situations:

- Flooding of sewage treatment works when the risk of flooding is more frequent than 1 in 75 years (1.3%) and the effluent dry weather flow is greater than 5,000 cumecs.
- Flooding of sewage treatment works when the risk of flooding is moderate (i.e. more frequent than 1 in 200 years; 0.5%) and the effluent dry weather flow is greater than 30,000 cumecs.
- Flooding of water treatment works when the risk of flooding is more frequent than 1 in 75 years (1.3%) and the population affected is greater than 5,000.
- Flooding of water treatment works when the risk of flooding is moderate (i.e. more frequent than 1 in 200 years; 0.5%) and where the dependent population is significantly large (i.e. >20,000).

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Information and communication technology

Appraising potential losses owing to the flooding of information and communication technology infrastructure

OVERVIEW

This sub-section explores the potential losses caused by the flooding of information and communication assets. Modern communication network infrastructure plays a pivotal role in contemporary society, enabling seamless information exchange, economic activity, and emergency response. CIRIA (2010) report that British Telecom has approximately 8,000 sites including telephone exchanges, with 500 major assets located within floodplain areas. The 2007 floods highlighted that "the interconnected nature of the network provided a degree of resilience and helped prevent significant failures" (Pitt Review interim report, 2007; 97). Chatterton et al. (2010) reported that during the 2007 floods there were few reports of failures or damages to the telephone network or exchanges and that damages were estimated to be lower than £1 million; although data to provide estimates was limited.

It is necessary to consider a wide view of ICT which incorporates fibre optics, cloud storage, data centres, and the widespread adoption of 4G/5G mobile networks. Indeed, this sector is also highly dynamic and through increasing the accessibility of broadband coverage is undertaking one of the largest infrastructure projects in the UK (ISPA/INCA, 2024). It is essential to evaluate the resilience, recoverability, and redundancy of these networks in times of flooding, consistent with the MCM methodology for appraising networks and other flood losses. Despite the importance of the ICT sector to societal and economic resilience, the fourth-round adaptation reporting associated with the Climate Change Act (2008) indicates high consideration of flooding and the prevention of associated losses. Both ISPA/INCA (2024) and Ofcom (2024) highlight the requirement to avoid locating assets at risk of flooding and the integration of mitigation measures for high-risk sites, as well as the integration of planning for network recovery. Importantly, Ofcom (2024) also highlight that fibre networks remain broadly unaffected by flooding and services remain unaffected as long as electricity is retained; thereby illustrating the interconnectivity between utilities and potential losses.

Consistent with MCM principles, the appraisal of flood impacts on communication networks requires a structured approach:

1. *Infrastructure vulnerability assessment:* Identifying key assets at risk during flood events.
2. *Risk quantification*: Determining probabilities of network failure based on flood models.
3. *Economic impact evaluation:* Estimating economic losses related to customer communication downtime.
4. *Resilience measures*: Assessing mitigation strategies, such as flood barriers for data centres or backup mobile towers.
5. *Redundancy analysis*: Evaluating multi-site networks and failover mechanisms.

This sub-section describes those situations where an appraisal might be appropriate and proportional and local and up-to-date knowledge is generally recommended to react to the changing nature of areas.

LESSONS FROM EXPERIENCE

- There is considered to be a great deal of redundancy in the system, in particular, in relation to telephone systems and the transfer of services to mobile communications. Furthermore, providers are undertaking adaptation and resilience measures to avoid flood losses and disruption.

- Flooding of communication assets in flood plains cannot be fully avoided by resistance strategies but with the advent of cloud storage data resilience is significantly enhanced during floods by offering off-site, decentralized storage, ensuring critical information remains accessible and protected even if local infrastructure is flooded.

- The roll out of fibre broadband services nationally and the implementation of glass fibre cables (rather than copper cabling) which is more resilient to water damage is likely to lead to increased resilience in the future.

- Despite the advanced technology, improved resilience to assets located in the floodplain and increased redundancy, if assets are affected by flooding there is still the need to engage with network providers, especially Openreach, to evaluate the costs, properties affected and lengths of downtime for vulnerable cabinets and chambers.

- The largest potential danger from flooding is often the knock-on impact of a loss of electricity supply on telecommunications, rather than flooding directly impacting the telecommunication assets.

ROLES AND RESPONSIBILITIES OF TELECOMMUNICATION PROVIDERS

Communication Network Providers have responsibilities as part of the Civil Contingencies Act 2004[3] and as Category 2 responders to include any person who provides a public electronic communications network which makes telephone services available (whether for spoken communication or for the transmission of data) (HM Government, 2004; 25). Additionally, the Communications Act 2003 permits the regulator Ofcom the scope to impose specific requirements regarding the availability and use of the communications network and services during an emergency situation (HM Government, 2003). There are also standard requirements as part of licensing conditions to maintain services and restore services as quickly as possible, where practicable.

COMMUNICATION NETWORKS: ASSETS AT RISK IN THE UK

Ofgem provided a case study in 2014 based on UK Flooding and Implications for Openreach (an organisation which maintains telephone cables, ducts, cabinets and exchanges and runs digital networks in the UK) (Ofgem, 2014). This was in response to expectation of more severe weather in future control periods. The extremes of weather cause extreme fault intakes raising overall levels of faults experienced by Openreach.

Openreach infrastructure[4] is extensive, and all major asset classes (ducting, poles, copper, fibre and street cabinets and chambers) are predominantly externally located (approximately two-thirds of the access infrastructure is underground). Moreover, Openreach has substantial infrastructure in the 1% probability floodplain in the UK:

- 7,178 (7.8% of total)[5]
- 9,198 T-codes (8.1%)
- 1,569,247 lines (6.0%)
- 502,272 jointing chambers (8.4%)[6]

Flooding not only affects Openreach equipment but also their ability to respond by reaching fault locations or in diagnosing faults and accessing plant.

The pattern of exposure to flooding can be substantial. At the height of the 2013/2014 flooding, 2,383 faults were recorded in Openreach's Wessex area alone. During flooding, Openreach's ability to service end-users and access its infrastructure is severely disrupted, and extensive damage is caused to infrastructure both over and underground, causing very high fault intake rates, increases contractual agreements, increased costs, longer travel times and significant health and safety concerns for engineering teams; all directly raising costs for the business.

During the period 2013 September to August 2014 the frequency of outages reported to Ofcom, by location indicated that faults are more correlated with centres of population (especially London) than locations experiencing severe winter weather. Overall, the average duration of an incident for a given

[3] Although the UK Government has been consulting on its effectiveness (https://www.gov.uk/government/consultations/strengthening-partnerships-consultation/outcome/outcome-report-html). It is expected that any regulatory changes will be taken as part of the post-implementation review of the Civil Contingencies Act in 2027.

[4] Openreach serves the vast majority of the UK's residential and business customers and delivers the infrastructure element of the UK telephony Universal Service Obligation (USO).

[5] An Openreach T code refers to a specific identifier used in their systems to track orders, faults, or equipment.

[6] An Openreach jointing chamber is an underground structure used to house and protect telecommunications cables and joints. These chambers are essential for maintaining and managing Openreach's network infrastructure. They provide access points for engineers to perform tasks such as splicing, repairing, or upgrading cables.

month increased during the winter months. This is consistent with providers' incident response operations and the challenges their engineers face during severe weather (Chatterton et al., 2015).

INCREASING RESILIENCE THROUGH THE IMPLEMENTATION OF CLOUD STORAGE

Flooding of communication assets in flood plains cannot be fully avoided by resistance strategies but with the advent of Cloud storage data resilience is significantly enhanced during floods by offering off-site, decentralized storage, ensuring critical information remains accessible and protected even if local infrastructure is flooded:

1. Off-Site and Distributed Data Storage
Cloud storage providers maintain multiple data centres across various geographical locations, reducing the risk of total data loss due to localized flooding. If one facility is affected, data remains accessible from backup servers elsewhere**.**

2. Backups and Redundant Systems
Most cloud services employ redundancy strategies, meaning data is copied across multiple locations. This ensures that if one data Centre experiences flooding, mirrored data remains intact, minimizing downtime and preventing permanent loss.

3. Accessibility from Anywhere
Cloud storage allows users to access their files remotely via the internet, meaning businesses, government agencies, and individuals can retrieve critical data even if local servers are damaged by floodwaters.

4 Hardware failures.
Cloud storage eliminates the need for localized servers, significantly improving resilience.

5 Disaster Recovery and Failover Mechanisms
Many cloud providers have disaster recovery (DR) solutions that quickly restore data and services following a natural disaster. Failover mechanisms automatically redirect operations to unaffected servers, ensuring continuity.

6. Reduced Dependence on Physical Infrastructure
Traditional on-premise data storage is vulnerable to flood damage, power outages, and physical hardware failures. Cloud storage eliminates the need for localized servers, significantly improving resilience.

7. Scalable and Real-Time Protection
Cloud providers frequently update security protocols, monitor threats in real time, and offer scalable solutions tailored to different risk levels, ensuring ongoing protection against environmental disruptions.

In conclusion, by leveraging cloud storage, organizations and individuals can mitigate the risks posed by flooding to their data hardware, ensuring uninterrupted access to vital data and its swift recovery.

MITIGATING POTENTIAL DAMAGE AND SERVICE LOSS

Flooding can pose significant challenges for underground telecom infrastructure, including Openreach access chambers, though in recent times traditional modular systems such as Stakkaboxes[7] made from lightweight yet durable materials, for example, Glass Reinforced Polyester (GRP)[8] are providing increased resilience. Even though these chambers to protect cables and joints are engineered to be water-resistant and incorporate drainage features, extreme flood events can sometimes overwhelm these defences. While Stakkabox-style chambers systems (known for their strength, scalability, and cost-effectiveness compared to traditional concrete chambers) are designed with tight seals and sometimes even self-draining properties, heavy or prolonged flooding can force water and extraneous debris into the chamber. This may lead to damage of the internal wiring, fibre optic cables, and any electronic components housed within. Once water enters the chamber, even after the flood subsides, residual moisture can cause corrosion and functional degradation over time, reducing performance.

Flooding may also hinder routine inspection and maintenance. When water covers large areas, detecting early signs of damage becomes more challenging, potentially delaying repairs. This delay increases the risk of further degradation or additional water ingress if issues aren’t promptly addressed.

Openreach and other network providers generally mitigate flood risks to chambers and cabinets by:

- Installing chambers in less flood-prone areas and using enhanced waterproof seals to minimize ingress.
- Designing the chambers with built-in drainage pathways to quickly expel any water that might seep in during heavy rains.
- After significant flooding events undertaking dedicated inspections and rapid repairs to restore full functionality and prevent long-term deterioration.

COSTS OF REPAIRS TO CHAMBERS AND CABINETS AFTER FLOODING

Repairing flood-damaged chambers involves water extraction, drying, and replacing damaged components like cables or seals. Costs can range from hundreds to thousands of pounds per chamber, depending on the extent of the damage.

Prolonged outages due to flooding can lead to financial losses for telecom providers and inconvenience for customers. Emergency repairs often require additional resources, increasing costs. Repeated flood damage can lead to higher insurance premiums for telecom providers, adding to long-term expenses.

Innovative resilience methods are being introduced such as Portadam’s modular barrier Flood protection systems[9] and remote sensing technologies with historical data analytics to produce real-time flood alerts in high-risk areas (Bukhari et al., 2025). The cost trade-off between investments in preventative technology and event repair costs is justified through improved resilience and reliability of telecom networks, ensuring service continuity in the face of increasingly frequent flood events.

[7] e.g. https://elliotts.uk/product/cubis-stakkabox-jmf-104-915x445x150mm; https://www.castingsdrainage.co.uk/product/bt-quadbox-stakkabox/
[8] Modular units can cost as little as £100 each
[9] https://portadam.com/whats-new/blog/telecom-infrastructure-flood-protection/

The cost of repairing Openreach chambers or cabinets after flooding can vary significantly depending on the extent of the damage and the specific components affected.

1. Chamber Repairs

- Minor repairs, such as resealing joints or replacing small components, might cost a few hundred pounds per chamber.
- Major repairs, including structural damage or complete replacement of a chamber, could escalate to thousands of pounds.

2. Cabinet Repairs

Flood-damaged cabinets often require water extraction, drying, and replacement of electronic components like DSLAMs (Digital Subscriber Line Access Multiplexers). These repairs can range from £1,000 to £5,000 or more, depending on the cabinet's size, complexity and duration of flooding.

3. Network Downtime Costs

Beyond physical repairs, service disruptions can lead to additional costs, including customer compensation and emergency response measures. Ofgem compensation for disruption of landline or loss of broadband services is £9.98 (2025) for each calendar day that the service is not repaired *after an elapsed 2 day*s. Most communication providers (Virgin, EE, Talk Talk etc) have signed up to this scheme and provide a customer charter concerning continuity of service[10]. Openreach are limited to the extent that they can site assets within the network such that floodplain exposure is reduced. The ability to move such network assets (cabinets) etc. further away might either not be possible, result in poorer service or be a significant additional investment.

A substantial portion of the millions of broadband customers in the UK rely on these street cabinets for their internet and telephone services. Indicative customer numbers are as follows:

- **Urban Areas**: In high-density urban settings, a single cabinet can often serve anywhere from 300 to 500 or more customers due to the tighter clustering of premises.
- **Rural/Suburban Areas**: In less dense regions, the same cabinet might be responsible for connecting closer to 200–300 customers.

IMPLICATIONS FOR MODERN COMMUNICATION NETWORKS

By integrating fibre optics, cloud storage, data centres, and advanced mobile networks into the appraisal framework, resilience and redundancy strategies can be optimized, mitigating losses and improving post-flood recoverability.

1. ***Fibre Optic Networks***: Fibre optic technology revolutionised data transmission by replacing traditional copper-based networks with high-speed optical fibres, offering:

- *High bandwidth* - Enabling rapid data transfer
- *Low latency* - Enhancing real-time communication applications, including financial transactions and emergency response
- *Flood resilience*- Compared to copper networks, fibre optics are less prone to electromagnetic interference and degradation from water exposure, though underground fibre routes may still be affected by floodwaters.

2. Cloud Storage and Data Centres have shifted digital infrastructure away from local servers, enabling decentralized data management:

[10] Ofgem does however indicate that specific exceptions may apply to the receipt (and level) of compensation. One of these exceptions is for disruption caused by extreme weather (https://www.ofcom.org.uk/phones-and-broadband/service-quality/automatic-compensation-need-know). Therefore, some customers may not receive compensation following disruptions from flooding.

- Organisations store critical data in cloud environments managed by providers such as Amazon Web Services (AWS), Microsoft Azure, and Google Cloud.
- Data centres house vast digital infrastructure which can be vulnerable to physical threats including flooding
- However, multi-site cloud solutions allow for seamless failover systems (a measure of redundancy) in case one data centre is compromised by flooding.

3. Mobile Networks and 4G/5G Technology: The widespread adoption of 4G and 5G networks has dramatically enhanced wireless connectivity providing reliable mobile broadband, supporting digital commerce and communication, though Cellular infrastructure (e.g., base stations and towers) can be affected by flood-related power outages and equipment damage. Mobile networks often have backup generators remote recovery and capabilities, though physical damage to infrastructure may necessitate post-flood restoration efforts.

EXAMPLES OF FLOOD DAMAGE ON COMMUNICATIONS ASSETS

The Climate Risks Study for Telecommunications and Data Center Services prepared for the US General Services Administration (GSA) reviews selected case studies where extreme weather—including floods—led to operational disruptions (Adams et al., 2014). These studies highlight how water ingress, whether affecting above-ground sites (like cell towers and microwave links) or underground assets (such as fibre cables), compromises both the integrity of physical devices and the continuous delivery of digital services.

In the UK, assessments reveal that similar risks are emerging domestically (UK Climate Risk, 2021). Heavy rainfall, which can result in localised flooding, has been linked to issues such as power failures at mobile base stations and degraded performance of radio systems. While these incidents might not always receive the same headline attention as severe storms, they nonetheless illustrate an ongoing vulnerability—especially when existing infrastructure was not originally engineered to handle the increased intensity and frequency of such weather events.

Storm Eowyn in early 2025 tested the resilience of communications Infrastructure in the UK and Ireland with performance heavily compromised especially in Northern Ireland and Scotland. In early 2022 three storms in succession resulted in nationwide power cuts severing broadband connectivity. In Shrewsbury alone dozens of roadside cabinets were sealed by emergency Openreach teams to prevent failure (Openreach, 2025). More recently in January 2026, Storm Goretti severely damaged communication infrastructure, particularly poles in South West England (Openreach, 2026) with reports of 28,000 households in Cornwall remaining without broadband for extended periods some for up to a month (BBC, 2026).

These examples demonstrate the importance of resilience measures, such as backup power systems, network redundancy, and improved infrastructure protection (water proofing sensitive equipment) and elevating installations away from flood-prone areas to mitigate the impact of flooding on communication networks.

APPRAISING THE POTENTIAL FOR DISRUPTION TO TELECOMMUNICATIONS

Chatterton et al. (2010) describe the origin of the additional costs due to flooding in this sector as including:

- Repair costs due to direct damage of the infrastructure asset.
- Additional maintenance costs.
- Extra operating costs during an emergency.

As discussed previously, communication assets are generally considered to be quite resilient to the effects of flooding. Proportionally, damages to this sector will be lower than to other utility and transport networks and indeed the communication providers argue that a power failure will be more problematic than direct flooding of their network. Therefore, it is suggested that appraisers need to identify if there are major information and communication technology assets located within the benefit area (e.g. major exchanges) or assets are in areas at high probabilities of flooding. In these situations, for improved accuracy, we strongly propose speaking with infrastructure owners to understand the vulnerability of the asset from flooding and potential damage and losses accruing.

The following process provides an approach for analysing damages and losses to network assets.

Step One: Risk Evaluation

Assess the flooding probability of assets exposed to flooding. If the probability is very high (bands 1 and 2)[11] trigger flooding consequences. If the probability is in bands 3 and 4 ignore the potential consequences.

Step Two: Enumerate the assets

Estimate the number of telecommunication assets in probability bands 1 and 2 for the floodplain in question.

Step Three: Area Type Determination

If the assets are in an urban area assume 400 properties linked to each asset. If assets are in a suburban area assume 300 properties, and if in a rural area assume 200 properties.

Step Four: Identify the likely duration of disruption

If the duration of the flood is determined to be long (a prolonged or severe event), and/or the depth of flooding in the vicinity of the assets greater than 0.5m, compensation to customers is triggered[12] at a rate of £9.98 per property per calendar day after outages of more than 2 days.

Step Five: Consider any redundancies in the system

Compensation is removed from the consequences of flooding if the asset is resistant to flooding or customer networks can be transferred seamlessly.

Step Six: Costs of operational repairs

If the asset is not resilient to flooding then costs involved in resuming service are £1,000 where duration is short and flood depths low and £3,000 if duration to repair is extensive and or depth of flooding is significant.

[11] Band 1 - greater than 3.3% chance of flooding in any year; Band 2 - between 3.3% and 1% chance of flooding in any year (see https://www.gov.uk/check-long-term-flood-risk)
[12] Unless the service provider indicates that the extreme weather experienced is a specific exception for providing compensation for disrupted service.

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