IMP/001/012 – Code of Practice for Flood Mitigation at Operational Premises

1. Purpose

The purpose of this document is to provide guidance on the process of establishing the risk of flooding at operational premises within Northern Powergrid and guidance on the appropriate level of mitigation to be applied.

This code of practice contributes towards the company's (Northern Powergrid) obligations under The Electricity Safety, Quality and Continuity Regulations (ESQCR) 2002, regulation 3(1)(b) and the Energy Networks Association (ENA) Engineering Technical Report (ETR) 138 – Resilience to Flooding of Grid and Primary Substations Issue 3 2018. ESQCR regulation 3(1)(b) requires the company to prevent interruptions of supply so far as reasonably practicable and ETR 138 presents a risk-based methodology to improve the resilience of electricity substations to flooding.

This document supersedes the following documents, all copies of which should be destroyed;

Document Reference	Document Title	Version	Published Date
IMP/001/012	Code of Practice for Flood Mitigation at Operational Premises	3.0	March 2015

2. Scope

This document applies to all ground mounted operational substation premises in Northern Powergrid. Those premises being distribution substations, primary substations, supply points and grid supply points in the Northeast and Yorkshire licence areas. For the purpose of this code of practice a 'major substation' is defined as any primary, supply or grid type substation, see section 5 Definitions.

The document provides specific guidance in relation to fluvial (river), coastal and pluvial (surface water) flood risk.

This document does not cover non-operational premises under the ownership or control of the company.

2.1. Table of Contents

3. Code of Practice for Flood Mitigation at Operational Premises

3.1. Introduction

A significant flooding event at a substation site has the potential to cause damage to company owned property and to cause significant disruption to customers' supplies. The Electricity Safety, Quality and Continuity Regulations (ESQCR) 2002, regulation 3(1)(b) requires the company to prevent interruptions of supply, so far as reasonably practicable.

Northern Powergrid owns and operates 781 132kV and primary substation sites (RRP return March 2022). In November 2000, major flooding in the Yorkshire operational area directly affected eight of these sites. One site, Osgodby Supply Point (North Yorkshire), had to be taken out of service for six months whilst major rectification works were carried out. The total cost of rectification work at this one site was £1.25m and additional costs were incurred for the use of mobile generators connected to the local network, and for the use of local company generation. The final cost of recovery from this incident was approximately £4m.

The severe flooding during the summer of 2007 resulted in widespread and sustained power interruptions across the Yorkshire license area. Supplies to around 130,000 customers were interrupted and flooding occurred at four major substations, with substantial damage occurring at 55 distribution substations. The control centre in Leeds had to be evacuated and the National Grid substation at Neepsend was flooded, and ceased to provide an in-feed to our network, which resulted in a rota disconnection process being implemented. The final cost of recovery from this incident was approximately £6m.

Following the flood event of the summer of 2007, Sir Michael Pitt was tasked by ministers to carry out a review of the flood-related emergencies. The findings of his review were captured in the 'Learning lessons from the 2007 floods' report, which contained a series of recommendations. The ones relevant to Northern Powergrid entailed developing a systematic programme and introducing defined standards, these aimed at reducing the known risk to critical infrastructure.

In parallel, an industry wide task group was established and facilitated by the Energy Networks Association and to which Northern Powergrid actively participated. The aim was to develop an Engineering Technical Report (ETR) on flooding, to determine a risk-based methodology, providing guidance on how to improve the resilience of electricity substations to flooding. October 2009 saw the approval and publication of ETR 138 – 'Resilience to Flooding of Grid and Primary Substations' covering fluvial (river) and coastal flood risk.

Since 2009 Northern Powergrid has experienced a number of further flood events most notably in 2012 when a series of intense thunderstorms brought exceptionally severe weather to the North East with two major substations subjected to flash flooding (Ravensworth and Tanfield).

The ENA working group re-formed following the 2012 floods to undertake a review of ETR 138, this resulted in a revised scope that included a requirement to assess the risks posed by Pluvial (surface water) flood risk.

More recently in 2015 storm Eva brought torrential rain to North and West Yorkshire. This resulted in significant flooding in the Calder Valley, Leeds, West Yorkshire and the City of York. The flooding affected one 132/33kV bulk supply point (Kirkstall C), 35 distribution substations and 3,500 premises needed post flood inspections.

The floods of 2015 prompted the government to initiate a National Flood Resilience Review published in 2016 following from which a further review of ETR138 brought another revised scope with primary substations feeding over 10,000 customers being treated with the same criticality as 132kV substations.

3.2. Key Requirements

The objectives of this code of practice are to provide guidance to ensure resilience levels to flooding for Northern Powergrid substations are in line with the table below:

Substation type	Level of resilience
Grid supply points and bulk supply points	Protection against the level of flooding that may occur within a 1:1000 year flood contour for fluvial, pluvial and coastal flooding.
Primary substation with over 10,000 connected customers	Protection against the level of flooding that may occur within a 1:1000 year flood contour for fluvial, pluvial and coastal flooding.
Primary substation with fewer than 10,000 connected customers	Protection against the level of flooding that may occur within a 1:100 year fluvial and pluvial flooding contour and within the 1:200 year contour for coastal flooding.
Existing distribution substation sites	See 3.4.2 below
New and replacement distribution substation sites	See 3.4.2 below

It should be noted that because of the difficulty in identifying and protecting against flood risks in the form of reservoir failure, canal bank bursts and water pipe bursts it is expected that mitigating action will normally focus on effective recovery plans to ensure that services can be restored as quickly as possible rather than physical protection.

3.3. Systematic Approach to Flood Risk Assessment and Mitigation

ETR 138 identifies a number of steps in a systematic approach to ensure the resilience of major substations against flood risk. This approach can be summarised as follows:

- Identity all major substations located in a flood plain
- Establish the flood risk for each substation
- Identify societal impacts for identified ‘at risk’ substations
- Investigate options for flood protection
- Propose appropriate solution based flood mitigation

3.3.1. Identify All Major Substations Located in a Flood Plain

In order that a consistent approach to flood modelling is applied it is recommended that the services of a specialist flood consultant be utilised. The consultant should identify if sites are in an area that could be affected by fluvial, pluvial and coastal flood using best available current data.

The consultant should also identify whether the sites benefit from a flood defence scheme provided by the Environment Agency, site owner or any other party.

Flood modelling is subject to change for example as a result of release of new data from the Environment Agency, increased accuracy of digital terrain mapping or indeed following changes to national standards or policies. Therefore it will be necessary to review and update flood risks periodically.

3.3.2. Establish the Flood Risk for Each Substation

The specialist flood consultants should confirm the predicted flood depth for identified ’at risk’ sites. The basis for calculating flood depths used by the specialist consultants should be consistent with the methodology used by the Environment Agency.

3.3.3. Identify Societal Impacts for Identified 'at risk' Substations

Having assessed the flood risk as described above it is necessary to consider the flooding impact on each major substation identified as 'at risk'. This is achieved by comparing the predicted flood level with the level of the critical equipment that if flooded will cause supplies to be interrupted.

Critical equipment may be high–voltage apparatus, but is equally likely to be auxiliary equipment such as outdoor kiosks or indoor protection, control or battery equipment.

The potential impact on society resulting from loss of any substation should be assessed taking into account relevant factors including:

- The number of customers that would lose their supplies if a substation became flooded;
- Whether it is possible to quickly restore supplies to customers if a substation became flooded;
- The on-going network risk whilst the flooded substation is restored to full operation e.g. robustness of interconnection, repair time, availability of replacement plant, site access issues etc., and,
- The effect of supply loss on critical infrastructure.

3.3.4. Investigate Options for Flood Protection

Following the flood impact assessment, if it is decided flood protection is necessary there are a number of options that can be deployed including but not limited to; re-locating at-risk equipment, protecting the site and / or buildings (flood wall), or elevating at-risk equipment.

Any flood protection will need to take into account uncertainties and climate change. Based on current advice in ETR 138 it is recommended that designs should include the following;

- Uncertainty and Freeboard – Increase by 300mm
- Fluvial and Pluvial – Use an assumption of an additional 20% on the predicted flood depth to allow for climate change or at the designers discretion 600mm in line with BS 8533: 2017.
- Coastal – Use the latest information from the Environment Agency covering predicted sea level rise as a result of climate change. Any allowance should take into account the planned lifetime of the assets being protected i.e. if an asset has a 40 year life then sea level rise as a result of climate change should take into account a 40 year period.

In addition, an assessment should be made to verify if the site benefits from a flood defence scheme provided by the Environment Agency, site owner or any other party. If a flood defence scheme is either in existence or is proposed then the company may not need to install site specific flood defences if the following criteria are met:

- The flood defence provides or will provide resilience in line with section 3.2 of this code of practice
- The flood defence is in good condition
- The flood defence is subject to on-going maintenance.

3.3.5. Propose Appropriate Solution Based Flood Risk

The flood defence measures required at a substation location will depend on the site specific conditions, the potential flood depth and whether they are to be applied to a new or existing substation.

For existing substations, a cost/benefit assessment should be carried out based upon the methodology detailed below.

3.3.5.1. Cost Benefit Assessment

If the cost of the mitigation per MWh lost (associated with the loss of the substation in question) is less than or equal to £1000[1] then the mitigation may proceed. An alternative way of viewing this is that the cost of mitigation that can be justified without further assessment is £1000 multiplied by the MWh lost. As a guide, the average MWh over 1 week (7 days) is considered to be a reasonable approach for determining the MWh lost as it is thought that a typical event may result in 1 week's lost MWh.

If the cost of the mitigation per MWh lost is more than £1000 then critical infrastructure should also be considered. Critical infrastructure comprises those sectors which supply essential services to the citizen on which normal daily life in the UK depends. The use of the Electricity Supply Emergency Code (ESEC) should be used initially to identify such customers that may typically include:

- major airports and control facilities;
- railway operations;
- gas sites;
- licensed electricity generators;
- essential water and sewerage installations;
- hospitals;
- ports and docks;
- postal telecommunications and broadcasting services; and
- oil refineries and vital oil pipeline pumping stations.

In addition, enquiries to Control Operations and Emergency Planning may also be made to identify such customers. If critical infrastructure is identified, a weighting of 100 should be applied to their MWh lost and this should then be added to the total MWh lost for the site and used to re-calculate the cost of the mitigation per MWh lost. If this reduces the cost of the mitigation per MWh lost to less than or equal to £1000 then the flood mitigation may proceed.

3.4. Flood Defence Measures

The flood defence measures required at a substation location will depend on the site specific conditions, the potential flood depth and whether they are to be applied to a new or existing substation.

3.4.1. Major Substations

3.4.1.1. Existing Major Substation Sites

All major substation sites have been evaluated for flood risk in line with section 3.3 above utilising a combination of JBA (specialist flood consultants), Freedom Professional Services (civil engineering consultants) and our own in house experts, and by the end of the ED1 identified flood mitigation measures will be in place.

If any work is carried out at a major substation that includes the replacement, Installation, relocation of plant or that affects or may affect the integrity of existing flood mitigation measures then it should be treated in the same way as a new major substation site detailed below.

[1] A pragmatic approach has been taken to determine the threshold cost of mitigation per MWh lost based on assessing historic flood mitigation schemes.

3.4.1.2. New Major Substation Sites

For new major substation sites a Flood Risk Assessment (FRA) should be completed by a specialist flood consultant. The FRA should identify fluvial, pluvial and coastal flood risk using best available current data, and whether the site benefits from a flood defence scheme provided by the Environment Agency, site owner or any other party. The FRA should confirm the predicted flood depths the basis for calculating which should be consistent with the methodology used by the Environment Agency.

Clearly it is desirable for any new major substation site to be situated outside of an identified flood plain or away from identified flood risk. However if this is not possible then the substation should be elevated above the identified risk taking into consideration the required level of protection including allowance for freeboard and climate change.

3.4.2. Distribution Substations

3.4.2.1. Existing Distribution Substations Sites

In general, existing distribution substations will not be flood defended unless a specific requirement is identified for a specific site e.g. where a substation is affected by recurring flood events.

The decision as to what flood mitigation measures to undertake will depend on an assessment of the individual substation but should take into consideration the prospective flood depth and the height of the critical equipment which will be dependent on the type of switchgear.

Protection afforded by barriers is not considered an acceptable permanent solution for distribution substations as their effectiveness has proved to be unreliable and will require an on-going level of maintenance. Our preferred option is to re-locate the substation outside the area of the flood risk.

3.4.2.2. New and Replacement Distribution Substation sites

Where a substation has been identified for asset replacement or where a new substation is to be installed as part of a customer's development then a FRA should be carried out.

It is considered unacceptable for new distribution substations to be built in a flood zone. However if no reasonable alternative can be found then the FRA should be completed by a specialist flood consultant. The FRA should identify fluvial, pluvial and coastal flood risk using best available current data, and whether the site benefits from a flood defence scheme provided by the Environment Agency, site owner or any other party. The FRA should confirm the predicted flood depths the basis for calculating which should be consistent with the methodology used by the Environment Agency.

In the case of a new substation as part of a customer's development, the developer shall be responsible for the FRA and it should be made available to the company along with the proposed flood mitigation measures for the development. All costs associated with compliance with this policy shall be met by the developer.

In general, new substations shall not be located at the basement level of a proposed development unless the developer provides sufficient evidence that the potential flood risk has been mitigated and the substation does not create a confined space.

If a distribution substation has to be sited in a flood zone then elevation of the substation above the prospective flood level is our preferred mitigation measure the design of which should include consideration of safe means of access is to be afforded both for day to day operations and maintenance including replacement (if required) of the largest piece of equipment.

The design should provide the same level of protection as afforded to primary substations with less than 10,000 customers including allowance for freeboard and climate change as detailed earlier in this code of practice.

Protection afforded by barriers is not considered an acceptable permanent solution for distribution substations as their effectiveness has proved to be unreliable and will require an on-going level of maintenance.

4. References

4.1. External Documentation

Reference	Title
BS 8533: 2017	Assessing and managing flood risk in development - Code of practice
ESEC	Electricity Supply Emergency code
ESQCR	The Electricity Supply, Quality and Continuity Regulations 2002.
ETR 138	Resilience to Flooding of Grid and Primary Substations (Revision 3, 2018)
RRP	Regulatory Reporting Pack

4.2. Internal Documentation

Reference	Title
n/a	

4.3. Amendments from Previous Version

Reference	Description
All	Total re-write of the entire document

5. Definitions

Term	Definition
Bulk Supply point	A substation containing equipment operating at a primary voltage of 132kV.
Distribution Substation	A substation containing equipment operating at a primary voltage of 20kV or below.
EHV	Extra high voltage.
FRA	Flood Risk Assessment
Grid Supply point	A substation containing equipment operating at a primary voltage of 275kV or 400kV.
HV	High voltage.
LV	Low voltage.
Major substation	Any primary substation, supply point or grid supply point.
MWh	Megawatt hour.
Primary Substation	A substation containing equipment operating at a primary voltage of 66kV or 33kV.

6. Authority for Issue

6.1. CDS Assurance

I sign to confirm that I have completed and checked this document and I am satisfied with its content and submit it for approval and authorisation.

		Date
Liz Beat	Governance Administrator	04/01/2023

6.2. Author

I sign to confirm that I have completed and checked this document and I am satisfied with its content and submit it for approval and authorisation.

Review Period - This document should be reviewed within the following time period;

Standard CDS review of 3 years?	Non Standard Review Period & Reason	
Yes	Period: n/a	Reason: n/a
Should this document be displayed on the Northern Powergrid external website?		No
		Date
Chris Parkes	Asset Management Engineer	04/01/2023

6.3. Technical Assurance

I sign to confirm that I am satisfied with all aspects of the content and preparation of this document and submit it for approval and authorisation.

		Date
Paul Buttery	Building and Civil Manager	04/01/2023
Joe Helm	Policy & Standards Manager	04/01/2023

6.4. Authorisation

Authorisation is granted for publication of this document.

		Date
Paul Black	System Engineering Manager	06/01/2023