Hornsea Project Three
Offshore Wind Farm

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Preliminary Environmental Information Report:
Annex 2.1 – Onshore HVAC Booster Station and Onshore HVDC Converter/HVAC Substation Flood Risk Assessment

Date: July 2017

Hornsea 3
Offshore Wind Farm

DONG energy

Environmental Impact Assessment

Preliminary Environmental Information Report

Volume 6

Annex 2. 1 – Onshore HVAC Booster Station and the Onshore HVDC Converter/HVAC Substation Flood Risk Assessment

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Liability

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Glossary

Term	Definition
Anglian Water	Anglian Water is a water company which supplies drinking water, drainage and sewerage services for the East of England via a network of pipe and pump infrastructure.
Aquifer	A body of permeable rock which can contain or transmit groundwater.
Catchments	An area that serves a watercourse with rainwater. Every part of land where the rainfall drains to a single watercourse is in the same catchment.
Climate change	A long term change in weather patterns, in the context of flood risk, climate change will produce more frequent severe rainfall.
Drainage Board (DB)	Drainage Boards are an integral part of water level management in the UK. Each DB is a local public authority established in areas of special drainage need in England and Wales. They have permissive powers to manage water levels within their respective drainage districts. They undertake works to reduce flood risk to people and property and manage water levels to meet local needs.
Exceptions Test	The Exceptions Test ensures that development is permitted in flood risk areas only in exceptional circumstances and when strict qualifying conditions have been met. It is carried out if the Sequential Test demonstrates that a development cannot be located in areas of low flood risk.
Flood Defences	A structure that is used to reduce the probability of floodwater affecting a particular area.
Flood risk assessment	A flood risk assessment is an assessment of the risk of flooding from all flood mechanisms, including the identification of flood mitigation measures, in order to satisfy the requirements of the NPPF and Planning Practice Guidance.
Flood Zone 1	Low Probability Land having a less than 1 in 1,000 annual probability of river or sea flooding.
Flood Zone 2	Medium Probability Land having between a 1 in 100 and 1 in 1,000 annual probability of river flooding; or land having between a 1 in 200 and 1 in 1,000 annual probability of sea flooding.
Flood Zone 3a	High Probability Land having a 1 in 100 or greater annual probability of river flooding; or Land having a 1 in 200 or greater annual probability of sea flooding.
Flood Zone 3b	The Functional Floodplain. This zone comprises land where water has to flow or be stored in times of flood. Local planning authorities should identify in their Strategic Flood Risk Assessments areas of functional floodplain and its boundaries accordingly, in agreement with the Environment Agency.
Geology	The scientific study of the origin, history and structure of the earth.
Greenfield Runoff Rate	Rates of surface water run-off from a site that is undeveloped (greenfield).
Groundwater	All water which is below the surface of the ground in the saturated zone and in direct contact with the ground or subsoil.
Hydrology	The study of the movement, distribution, and quality of water.
Lead Local Flood Authority (LLFA)	Lead Local Flood Authorities have responsibility for developing a Local Flood Risk Management Strategy for their area covering local sources of flooding. The local strategy produced must be consistent with the national strategy. It will set out the local organisations with responsibility for flood risk in the area, partnership arrangements to ensure co-ordination between these organisations, an assessment of the flood risk, and plans and actions for managing the risk.
National Planning Policy Framework (NPPF)	The National Planning Policy Framework sets out the Government's planning policies for England and how these are expected to be applied. It sets out the Government's requirements for the planning system only to the extent that it is relevant, proportionate and necessary to do so. It provides a framework within which local people and their accountable councils can produce their own distinctive local and neighbourhood plans, which reflect the needs and priorities of their communities. .
Sequential Test	A Sequential Test aims to steer new development to areas with the lowest probability of flooding by recommending that development is not allocated if there are reasonably available sites appropriate to the proposed development in areas with a lower probability of flooding.
Strategic Flood Risk Assessment	A Strategic Flood Risk Assessment provides information on areas at risk from all sources of flooding.
Surface water run-off	Surface water run-off is flow of water that occurs when excess stormwater, meltwater, or other sources of water flows over a surface.
Sustainable urban drainage systems (SuDs)	A sequence of management practices and control measures designed to mimic natural drainage processes by allowing rainfall to infiltrate, and by attenuating and conveying surface water runoff slowly at peak times.
Tidal (Coastal) flooding	Tidal flooding is caused by extreme tidal conditions including high tides and storm surges, overtopping local flood defences or coastal features.
UK Climate Projections 2009 (UKCP09)	Climate projections expressed in terms of absolute values. A projection of the response of the climate system to emission scenarios of greenhouse gases and aerosols, or radiative forcing scenarios based upon climate model simulations and past observations.
Water Framework Directive	Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy.
Water Quality	The physical, chemical and biological characteristics of water.

Acronyms

Acronym	Definition
BGS	British Geology Survey
DCO	Development Consent Order
FRA	Flood Risk Assessment
IDB	Internal Drainage Board
LDP	Local Development Plan
NCC	Norfolk County Council
NPPF	National Planning Policy Framework
NPS	National Policy Statement
PPG	Planning Practice Guidance

Acronym	Definition
SAAR	Standard-Period Average Annual Rainfall
SFRA	Strategic Flood Risk Assessment
SPZ	Source Protection Zone
SuDS	Sustainable Urban Drainage System

Units

Unit	Description
g	Gram (weight)
GW	Gigawatt (power)
ha	Hectare (area)
kg	Kilogram (weight)
km	Kilometre (distance)
kV	Kilovolt (electrical potential)
kW	Kilowatt (power)
litres/second	Litres per second (flow rate)
m	Metre (distance)
m^3	Metres cubed (volume)
mm/year	Millimetres per year (rainfall)
MW	Megawatt (power)

1. Introduction

1.1 Background

1.1.1.1 A site-specific Flood Risk Assessment (FRA) has been prepared for the development of the onshore HVAC booster station and the onshore HVDC converter/HVAC substation associated with the Hornsea Project Three offshore wind farm (hereafter referred to as Hornsea Three). As set out in volume 1, chapter 3: Project Description the onshore HVAC booster station is an option that would only be considered for the HVAC transmission option.

1.1.1.2 The FRAs have been produced in accordance with the Overarching National Policy Statement (NPS) for Energy EN-1, the National Planning Policy Framework (NPPF) and Planning Practice Guidance (PPG) ID7 and relevant local planning policies, and are presented in this annex (annex 2.1). The policies cover the requirements in respect to Nationally Significant Infrastructure Projects.

1.1.1.3 The FRAs support the Development Consent Order (DCO) application for Hornsea Three in accordance with the Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009 (as amended). It also forms part of the Hornsea Three Environmental Statement volume 3, chapter 2: Hydrology and Flood Risk.

1.1.1.4 Developments that are designed without regard to flood risk may endanger lives, damage property, cause disruption to the wider community, damage the environment, be difficult to insure and require additional expense on remedial works.

1.1.1.5 Current guidance on development and flood risk (PPG: ID7 Flood risk and coastal change) identifies several key aims for a development to ensure that it is sustainable in flood risk terms. These aims are as follows:

- The development should not be at a significant risk of flooding and should not be susceptible to damage due to flooding;
- The development should not be exposed to flood risk such that the health, safety and welfare of the users of the development, or the population elsewhere, is threatened;
- Normal operation of the development should not be susceptible to disruption as a result of flooding;
- Safe access to and from the development should be possible during flood events;
- The development should not increase flood risk elsewhere;
- The development should not prevent safe maintenance of watercourses or maintenance and operation of flood defences;
- The development should not be associated with an onerous or difficult operation and maintenance regime to manage flood risk. The responsibility for any operation and maintenance required should be clearly defined;
- Future users of the development should be made aware of any flood risk issues relating to the development;
- The development design should be such that future users will not have difficulty obtaining insurance or mortgage finance, or in selling all or part of the development, as a result of flood risk issues;
- The development should not lead to degradation of the environment; and
- The development should meet all of the above criteria for its entire lifetime, including consideration of the potential effects of climate change.

1.1.1.6 The FRA is undertaken with due consideration of these sustainability aims.

1.1.1.7 The key objectives of the FRA are:

- To assess the flood risk to the proposed development and to demonstrate the feasibility of appropriately designing the development such that any residual flood risk to the development and users would be acceptable;
- To assess the potential impact of the proposed development on flood risk elsewhere and to demonstrate the feasibility of appropriately designing the development such that the development would not increase flood risk elsewhere; and
- To satisfy the requirements of the NPS, the NPPF and PPG and DCO application guidance insofar as they require FRAs to be submitted in support of DCO applications.

1.2 Project scope

1.2.1.1 In order to achieve the aims outlined within 1.1.1.4, a staged approach has been adopted in undertaking the FRAs in accordance with NPS (EN-1), the NPPF and PPG. Initially screening studies have been undertaken utilising publically available information, records and data to identify whether there are any potential sources of flooding within the proposed onshore HVAC booster station and HVDC converter/HVAC substation sites and elsewhere in the hydrology and flood risk study area, which may warrant further consideration. Identified potential flooding issues are then assessed further within a specific flood risk section. The aim of the assessment is to review all available information and provide a qualitative analysis of the flood risk to the onshore HVAC booster station and HVDC converter/HVAC substation sites and identify any impact of the sites on flood risk elsewhere.

1.3 Report structure

1.3.1.1 This report has the following structure:

- Chapter 2 identifies the sources of information that have been consulted in preparation of the flood risk assessments;
- Chapter 3 sets out relevant legislation, guidance and local planning policy;
- Chapter 4 provides the FRA for the proposed onshore HVAC booster station; and
- Chapter 5 provides the FRA for the proposed onshore HVDC converter/HVAC substation.

1.3.1.2 The FRAs include a hydrological review of the onshore HVAC booster station and HVDC converter/HVAC substation sites; the vulnerability of the sites in line with the NPPF and PPG; a description of the flood risk management measures incorporated into the design of the onshore HVAC booster station and onshore HVDC converter/HVAC substation; and a summary.

1.3.1.3 The onshore export cable will be buried underground along the entire length of the cable route and will not result in any permanent, impermeable surfacing. Therefore the operation of the onshore export cable route will not lead to any impacts on flood risk on the site of the cable route itself or within the surrounding area. Therefore, only the onshore HVAC booster station and the HVDC converter/HVAC substation have been considered in this assessment.

1.3.1.4 The FRA is based on the ongoing design work for the onshore HVAC booster station and HVDC converter/HVAC substation. This will be further refined as the project design work progresses.

2. Information Sources

2.1.1.1 The information used in the preparation of report is set out in Table 2.1.

Table 2.1: Information sources consulted during the preparation of the report.

Source	Data	Information consulted/provided
Ordnance Survey (OS).	OS Mapping 1: 50 000 Sheet 133: North East Norfolk.	Area information, rivers and other watercourses, general site environs, built environment, catchment information.
	OS Mapping 1: 50 000 Sheet 134: Norwich & The Broads	
British Geological Survey (BGS).	BGS (online) Geology of Britain Viewer. Available at: http://mapapps.bgs.ac.uk/geologyofbritain/home.html	Site and area geology.
Environment Agency	Environment Agency data holdings, customer service and engagement team.	Current flood risk, local flood defences, flood levels, supplementary geology and groundwater information.
Groundsure	Enviro Insight Geo Insight	Classification of the underlying geology and hydrogeology. Flood risk from groundwater and surface water.
Internal Drainage Board (IDB).	Norfolk Rivers Internal Drainage Board.	Local Drainage Networks.
Local Planning Authorities (LPA).	Norfolk County Council. Broadland District Council. North Norfolk District Council. South Norfolk District Council	Flood Zoning. Local Development Framework.
Sewerage/Water Company.	Anglian Water.	Water and sewerage assets in the vicinity of the site.
Planning Policy.	National Planning Policy Framework (NPPF). Planning Practice Guidance.	FRA and Planning Guidance. Flood zoning for the site as used by the Environment Agency in England.
	NPS EN-1 Section 5.7.	NPS EN-1(5.7.6) refers applicants to this Practice Guide.
	UK Climate Projections (UKCP09).	Climate change prediction data.
Norfolk County Council.	Norfolk Minerals and Waste Development Framework, Core Strategy and Minerals and Waste Development Management Policies Development Plan Document 2010-2026. Revised Combined Strategic Flood Risk Assessment (SFRA).	Current Flood Zone/risk to the Site including historical flooding locations. Any relevant flood modelling complete for the Site.
	Norfolk Local Flood Risk Management Strategy, July 2015.	
	Norfolk Lead Local Flood Authority Statutory Consultee Guidance Document, April 2017.	
Broadland District Council.	Partnership of Broadland District Councils, Strategic FRA, Subsidiary Report A. North Norfolk District Council Area, December 2007.	
North Norfolk District Council.	Partnership of Norfolk District Councils, Strategic FRA, Subsidiary Report A. North Norfolk District Council Area, December 2007.	
South Norfolk District Council	Partnership of Norfolk District Councils, Strategic FRA, Subsidiary Report A. South Norfolk District Council Area, December 2007	

3. Legislation and Guidance

3.1.1 National Policy Statements

3.1.1.1 Planning policy for Nationally Significant Infrastructure Projects, specifically in relation to hydrology and flood risk is contained in the Overarching National Policy Statement (NPS) for Energy EN-1 (Department of Energy and Climate Change (DECC), 2011)). Section 5.7 of NPS EN-1 sets out the aims of planning policy on development and flood risk to ensure that flood risk from all sources of flooding is taken into account at all stages in the planning process. Guidance on what to be considered in the application is set out in volume 3, chapter 2: Hydrology and Flood Risk. In terms of mitigation and the management of flood risk, NPS (EN-1) paragraphs 5.7.20 and 5.7.21 state:

- *"Site layout and surface water drainage systems should cope with events that exceed the design capacity of the system, so that excess water can be safely stored on or conveyed from the site without adverse impacts";* and
- *"The surface water drainage arrangements for any project should be such that the volumes and peak flow rates of surface water leaving the site are no greater than the rates prior to the proposed project, unless specific off-site arrangements are made and result in the same net effect".*

3.1.2 National Planning Policy Framework (March 2012)

3.1.2.1 The NPPF sets out Government planning policies for England and how these are expected to be applied. The framework acts as guidance for local planning authorities and decision-takers, both in drawing up plans and making decisions about planning applications.

3.1.2.2 Paragraphs 99-108 states that new development should take into account climate change and that appropriate mitigation should be provided. It states that inappropriate development should be located away from high risk areas and that a sequential risk-based approach should be applied through the local planning system to the location of development. The guidance is set out below:

"Local Plans should take account of climate change over the longer term, including factors such as flood risk, coastal change, water supply and changes to biodiversity and landscape. New development should be planned to avoid increased vulnerability to the range of impacts arising from climate change. When new development is brought forward in areas which are vulnerable, care should be taken to ensure that risks can be managed through suitable adaptation measures, including through the planning of green infrastructure.

Inappropriate development in areas at risk of flooding should be avoided by directing development away from areas at highest risk, but where development is necessary, making it safe without increasing flood risk elsewhere. Local Plans should be support by Strategic Flood Risk Assessment and develop policies to manage flood risk from all sources, taking account of advice from the Environment Agency and other relevant flood risk management bodies, such as lead local flood authorities and internal drainage boards. Local Plans should apply a sequential, risk-based approach to the location of development to avoid where possible flood risk to people and property and manage any residual risk, taking account of the impacts of climate change, by:

- *Applying the Sequential Test;*
- *If necessary, applying the Exception Test;*
- *Safeguarding land from development that is required for current and future flood management;*
- *Using opportunities offered by new development to reduce the causes and impacts of flooding; and*
- *Where climate change is expected to increase flood risk so that some existing development may not be sustainable in the long-term, seeking opportunities to facilitate the relocation of development, including housing, to more sustainable locations.*

If, following application of the Sequential Test, it is not possible, consistent with wider sustainability objectives, for the development to be located in zones with a lower probability of flooding, the Exception Test can be applied if appropriate. For the Exception Test to be passed:

- *It must be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk, informed by a Strategic Flood Risk Assessment where one has been prepared; and*
- *A site-specific flood risk assessment must demonstrate that the development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.*

Both elements of the test will have to be passed for development to be allocated or permitted.

Where determining planning applications, local planning authorities should ensure flood risk is not increased elsewhere and only consider development appropriate in areas at risk of flooding where, informed by a site-specific flood risk assessment following the Sequential Test, and if required the Exception Test, it can be demonstrated that:

Within the site, the most vulnerable development is located in areas of lowest flood risk unless there are overriding reasons to prefer a different location; and

Development is appropriately flood resilient and resistant, including safe access and escape routes where required, and that any residual risk can be safely managed, including by emergency planning; and it gives priority to the use of sustainable drainage systems.

For individual developments on sites allocated in development plans through the Sequential Test, applicants need not apply the Sequential Test. Applications for minor development and changes of use *should not be subject to the Sequential or Exception Tests but should still meet the requirements for site-specific flood risk assessments".*

3.1.2.3 The remaining paragraphs (paragraphs 105 to 108) relate to development in coastal areas, in particular "*local authorities should reduce risk from coastal change by avoiding inappropriate development in vulnerable areas by adding to the impacts of physical changes to the coast*". Any areas likely to be affected by physical changes to the coast should be identified as a Coastal Change Management Area by the relevant local planning authority.

3.1.2.4 The NPPF requires the application of a sequential risk-based approach to determining the suitability of land for development in flood risk areas. The Sequential Test approach steers new development to areas of land with the lowest probability of flooding (i.e. Flood Zone 1). Where there are no reasonably available sites in Flood Zone 1, local planning authorities should take into account the flood risk vulnerability of land uses in their decision making and consider reasonably available sites in Flood Zone 2 (i.e. areas with a medium probability of flooding), applying the Exception Test if required. Only where there are no reasonably available sites in Flood Zones 1 and 2 should suitability of sites in Flood Zone 3 be considered, taking into account the flood risk vulnerability if land uses and applying the Exceptions Test if required. The Exception Test is a method to demonstrate and help ensure that flood risk to people and property will be managed satisfactorily, while allowing necessary development to go ahead in situations where suitable sites at lower risk of flooding are not available.

3.1.3 Planning Practice Guidance (online)

3.1.3.1 PPG ID7 Flood Risk and Coastal Change provides guidance to ensure the effective implementation of the NPPF planning policy for development in areas at risk of flooding.

3.1.3.2 PPG ID7 states that a site specific FRA is required for all proposals for new development in Flood Zones 2 and 3 and for any proposal of 1 hectare or greater in Flood Zone 1. An FRA should consider vulnerability to flooding from other sources as well as from river and sea flooding, and also the potential for any increased risk of flooding elsewhere resulting from a development. The guidance sets out a checklist of the information that should be included in a site-specific flood risk assessment, including the following key stages:

- Development site and location – including current use of the site;
- Development proposals;
- Sequential test – for developments in flood zones 2 and 3 only. If the development site is wholly within flood zone 1 it is not necessary to undertake this stage
- Climate change – how is the flood risk of the site likely to be affected by climate change;
- Site-specific flood risk – what are the main sources of flooding on the site, what is the probability of the site flooding, how will the development be made safe from flooding; ensure that the development and any flood risk measures do not increase the risk of flooding off-site; and
- Surface water management.

3.1.4 Climate change

3.1.4.1 The NPPF sets out how the planning system should help minimise vulnerability and provide resilience to the impacts of climate change. NPPF and supporting planning practice guidance on Flood Risk and Coastal Change explain when and how FRAs should be used. This includes demonstrating how flood risk will be managed now and over the development's lifetime, taking climate change into account.

3.1.4.2 In February 2016 the Environment Agency updated advice on climate change allowances to support the NPPF. The new guidance requires that FRAs and SFRAs, assess both the central and upper end allowances (Table 3.1) to understand the range of impacts. Upper end and central allowances are based on percentiles. The central allowance is based on the 50th percentile which is the point at which half of the possible scenarios for peak rainfall intensity fall below it and half fall above it. The upper end allowance is based on the 90th percentile. Further information on the climate change allowances can be found at (https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances).

Table 3.1: Peak rainfall intensity allowance in small and urban catchments (use 1961 to 1990 baseline).

Applies across all of England	Total potential change anticipated for 2010 to 2039	Total potential change anticipated for 2040 to 2059	Total potential change anticipated for 2060 to 2115
Upper End	10%	20%	40%
Central	5%	10%	20%

3.1.4.3 Norfolk County Council Lead Local Flood Authority: Statutory Consultee for Planning Guidance Document refers all developers to the Flood risk assessment: climate change allowances guidance for all developments.

3.1.4.4 In line with the Environment Agency's Flood risk assessments: climate change allowance guidance, RPS has added 20% and 40% to all attenuation/runoff calculations for the development to account for climate change (assuming a 1 in 100 year rainfall event).

4. Onshore HVAC Booster Station Flood Risk Assessment

4.1 Site setting

4.1.1 Site location

4.1.1.1 The proposed location of the onshore HVAC booster station is National Grid Reference TG 11336 33206 approximately 2.7 km north of the village of Saxthorpe (see Figure 4.1). The site is bounded by a wooded area to the north and east, with agricultural land to the south and east. Access to the site is gained via Sweetbriar Lane.

4.1.2 Existing site

4.1.2.1 The site has no buildings, structures or development and its topography gently slopes from east to west. It is currently used for agricultural purposes.

4.1.3 Proposed development

4.1.3.1 The proposed development comprises an onshore HVAC booster station as part of the Hornsea Three project. The booster station is an option for only the HVAC transmission system. If it is required it will contain reactive compensation equipment to allow the power delivered to the National Grid to be useable. The onshore HVAC booster station and associated permanent infrastructure will occupy a site of up to 2.5 ha, including some land which may be used for landscaping. The HVAC booster station is expected to have an operational life of 25 years, and a design life of 50 years. Indicative layouts are currently being developed and will be presented in the Environmental Statement. For the purpose of this FRA, the design envelope for the onshore HVAC booster station is set out below:

- Up to six buildings to house the equipment; and
- Associated infrastructure including access roads.

4.1.4 Hydrological overview

4.1.4.1 This section assesses the baseline hydrological characteristics of the proposed development site. A 1 km buffer was selected for the onshore HVAC booster station to identify any potential receptors that might be affected by the proposed development. The 1 km buffer is considered an appropriate buffer to identify changes in flood risk in the surrounding area.

Fluvial and tidal flooding

4.1.4.2 The Environment Agency's flood map (Figure 4.1) indicates that the site of the onshore HVAC booster station is within Flood Zone 1, defined as land assessed as having a less than 1 in 1,000 annual probability of river or sea flooding (<0.1%).

4.1.4.3 The Norfolk County Council and Partnership of Norfolk District Council's SFRA Flood Zone Maps replicate the Environment Agency's flood mapping indicating that the site is located within Flood Zone 1.

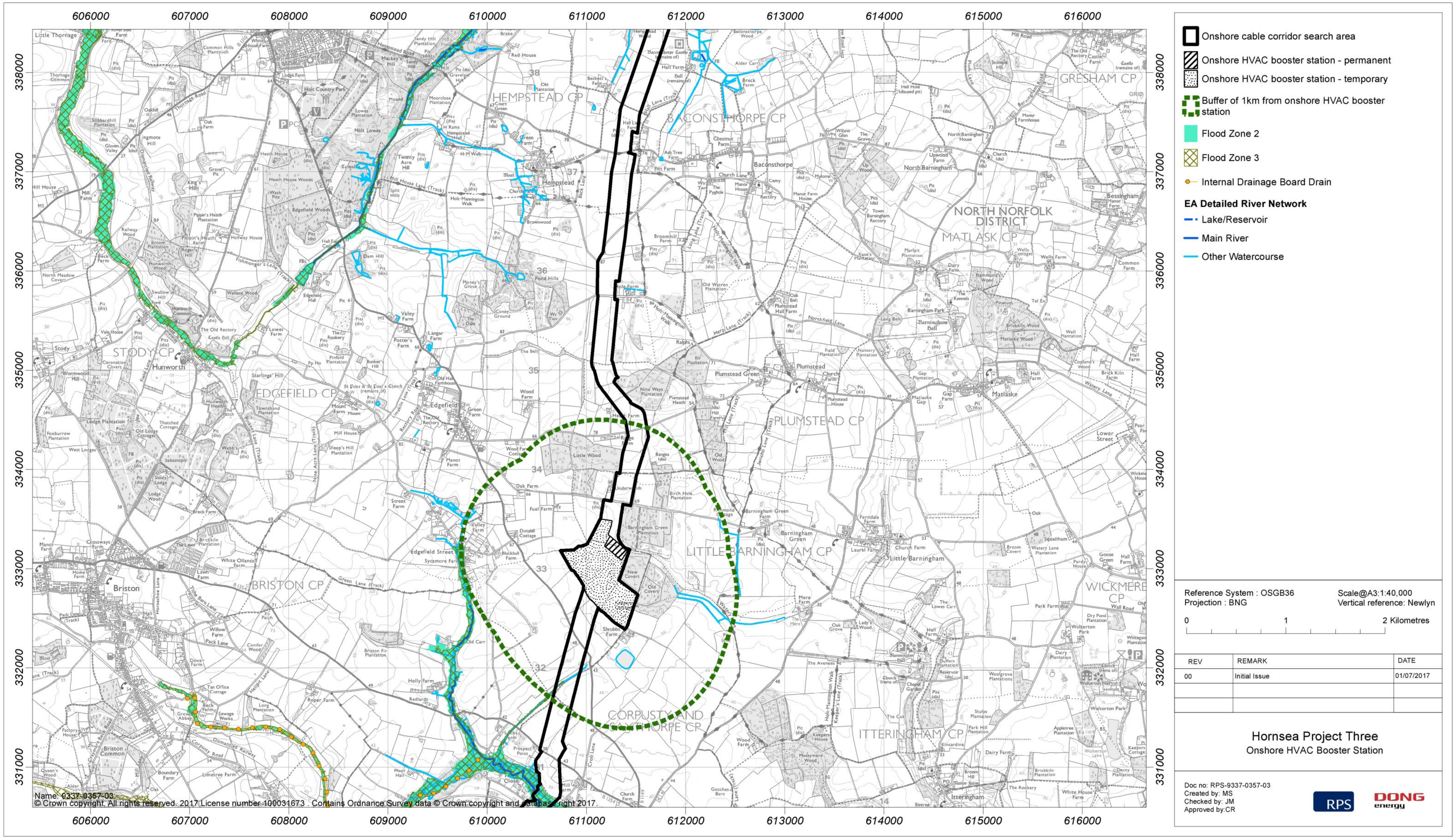

Figure 4.1: Onshore HVAC Booster Station site location plan/Environment Agency flood map.

Flooding from rising/high groundwater

4.1.4.4 BGS geology online map (accessed March 2017) indicates that the site is underlain by Mid Pleistocene glaciofluvial (Sand and Gravel) and Mid Pleistocene diamicton till superficial deposits. The superficial deposits are underlain by bedrock consisting of the undifferentiated Chalk Formations of the White Chalk Subgroup (white, well-bedded, flint-free chalk with common marl seams).

4.1.4.5 The chalks are classified by the Environment Agency under the Water Framework Directive as a principal aquifer, defined as "… *layers of rock or drift deposits that have high intergranular and/or fracture permeability - meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale*".

4.1.4.6 North Norfolk County Council SFRA indicates that no groundwater flooding has been reported at the site.

4.1.4.7 Based on the information outlined above and the author's professional judgement the potential for groundwater flooding is considered to be at low to medium.

Source Protection Zones

4.1.4.8 Environment Agency mapping shows the site is not located within a groundwater Source Protection Zone (SPZ).

Surface water flooding

4.1.4.9 Surface water or pluvial flooding is defined as flooding caused by rainfall generated overland flow, before the runoff enters a watercourse or sewer. In such events sewerage and drainage systems and surface watercourses may be overwhelmed.

4.1.4.10 As shown in Figure 4.2, the Environment Agency's surface water flood mapping indicates that the majority of the site is at 'very low' risk of surface water flooding. A localised area along the north eastern corner of the site is defined as being at low risk of surface water flooding.

4.1.4.11 Based on the relatively flat lying and primarily agricultural landscape of the site the majority of surface runoff will either infiltrate into exposed permeable natural surfaces and soils, or be conveyed to local drainage network.

Reservoir failure assessment

4.1.4.12 Environment Agency mapping shows that the site is not at risk of reservoir flooding.

Flood defence measures

4.1.4.13 Environment Agency and SFRA mapping indicates that there are no flood defences within the immediate vicinity of the development site.

Sewer/Water main failure assessment

4.1.4.14 Water asset plans for the site will be sourced from Anglian Water, but are not available to Hornsea Three at the time of preparing the PEIR. As the site is currently agricultural land, with the surrounding area being a mixture of wooded areas and agricultural fields, it is anticipated that no water assets would be present within the vicinity of the site.

4.1.4.15 However, if any adopted sewers are present in close proximity to the site they are assumed to have been designed to industry standards (e.g. sewers for adoption). The most common causes of flooding from sewers are: inadequate flow capacity; blockages; pumping station failures; burst water mains; water inflow from rivers or the sea; tide locking; siltation; fats/greases; and sewer collapse. Should any of these events occur there is a risk of flooding in the vicinity of the sewer by surcharge where the flood is in excess of the sewer capacity (usually 1 in 30 year event or greater).

4.1.4.16 The DG5 register is a register of properties that have flooded as a result of hydraulic inadequacy of the public sewer network. The DG 5 register requires all water companies to keep a record of any properties that have been affected by sewer flooding. According to the Norfolk County Council SFRA and Flood Risk Management Strategy, there are no records of historical sewerage flooding on the site as a consequence of a failure in artificial drainage (e.g. sewers).

4.1.4.17 Taking into account the above, the absence of any historical sewer flooding specific to the site and the author's professional judgement, the overall risk of flooding via artificial drainage system to the site has been assessed to be low.

Historic flooding

4.1.4.18 Norfolk County Council, SFRA and Flood Risk Management Strategy (NCC, 2010) mapping indicates that the site has not been affected by historical flooding.

Current flood risk

4.1.4.19 The site is located within Flood Zone 1 being within an area considered at low risk of flooding from fluvial or tidal sources.

4.1.4.20 It has been determined that the main risk of flooding to the site is from groundwater.

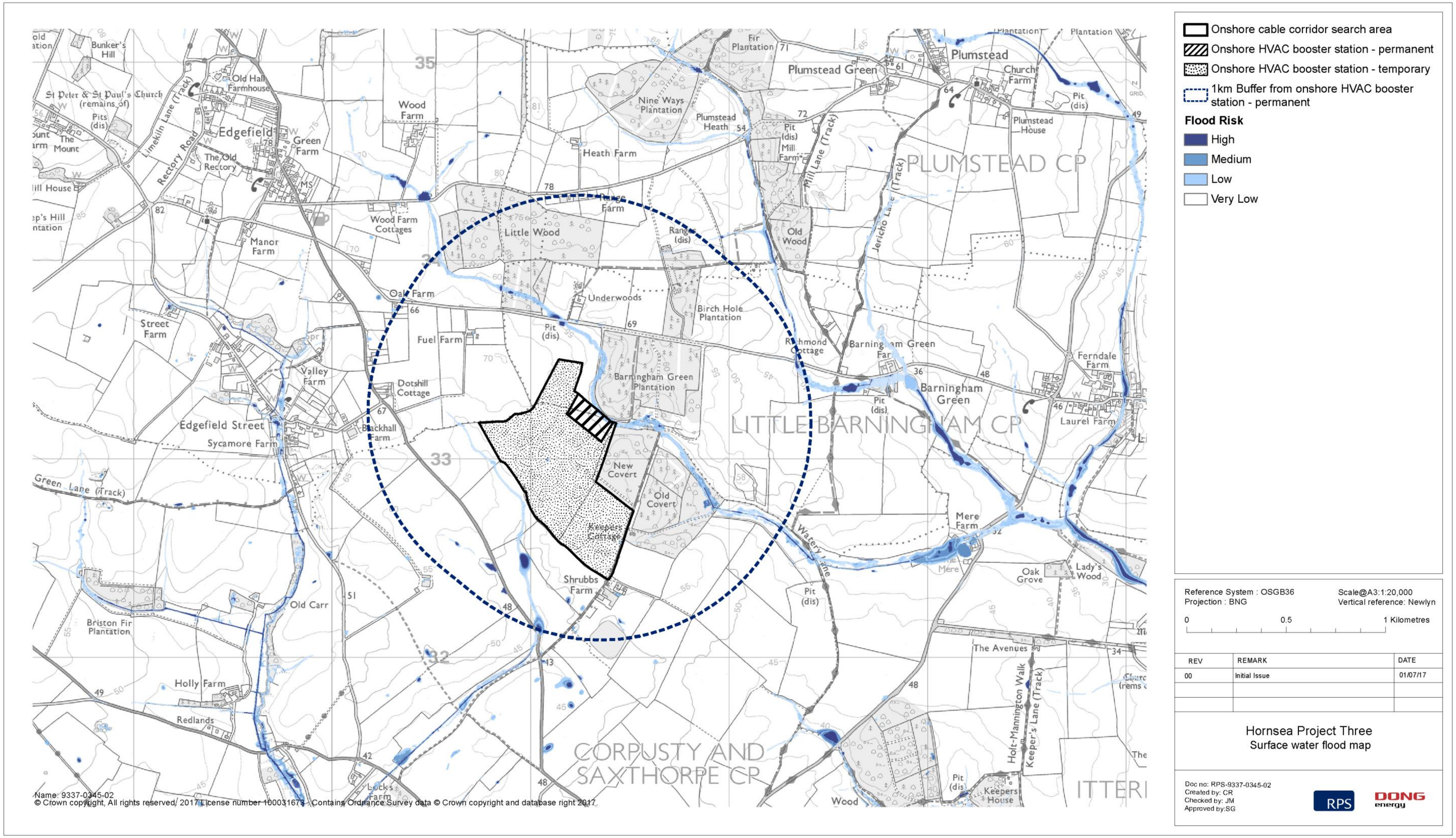

Figure 4.2: Onshore HVAC Booster Station surface water flood map.

4.2 Flood risk management

4.2.1 Site vulnerability

4.2.1.1 Applying the Flood Risk Vulnerability Classification in Table 2 of the PPG Flood Risk and Coastal Change (DCLG, 2014), an electricity HVAC Booster station is classified as "*Essential infrastructure*".

4.2.1.2 Table 3 of PPG (Table 4.1 of this report) states that "*Essential Infrastructure*" uses are appropriate within Flood Zone 1 and 2, and also in Flood Zone 3.

Table 4.1: Flood risk vulnerability and flood zone 'compatibility' as identified in table 3 of NPPF technical guidance.

Flood Risk Vulnerability classification (see Table 2 of NPPF Technical Guidance)	Essential Infrastructure	Water Compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
Zone 1	Yes	Yes	Yes	Yes	Yes
Zone 2	Yes	Yes	Exception test required	Yes	Yes
Zone 3a	Exception test required	Yes	No	Exception test required	Yes
Zone 3b Functional Floodplain	Exception test required	Yes	No	No	No

Key: Yes: Development is appropriate, No: Development should not be permitted.

4.2.2 Sequential Test

4.2.2.1 The Sequential Test is designed to demonstrate that there are no reasonably available sites in areas with a lower probability of flooding that would be appropriate for this type of development.

4.2.2.2 Local Planning Authorities allocating land in Local Development Plans (LDPs) for development should apply the Sequential Test to demonstrate that there are no reasonably available sites in areas with a lower probability of flooding that would be appropriate to the type of development or land use proposed.

4.2.2.3 In areas at risk of river or sea flooding, preference should be given to locating new development in Flood Zone 1. If there is no reasonably available site in Flood Zone 1, the flood vulnerability of the proposed development can be taken into account in locating development in Flood Zone 2 and then Flood Zone 3. Within each Flood Zone new development should be directed to sites at the lowest probability of flooding from all sources as indicated by the SFRA.

4.2.2.4 The Sequential Test therefore seeks the allocation of land for development in flood areas of least risk where practicable (i.e. preferentially steer towards Zone 1). Developers should also have regard to the Sequential Test when evaluating sites where LDPs have not been subject to SFRA and/or the Sequential Test and where it is necessary to demonstrate that there are no alternative sites with a lower probability of flooding for the given end use.

4.2.2.5 NCC SFRA flood mapping shows that the entire development is located within Flood Zone 1 and has therefore passed the Sequential Test requirement of locating development within 'low' flood risk zones.

4.2.2.6 As the proposed onshore HVAC booster station site is located within Flood Zone 1 and has passed the Sequential Test there is no need to undertake an Exceptions Test.

4.3 Drainage strategy

4.3.1 Surface water drainage

4.3.1.1 The sustainable management of surface water is an essential element of reducing future flood risk to the site and its surroundings.

4.3.1.2 Undeveloped sites generally rely on natural drainage to convey or absorb rainfall, with the water soaking into the ground or flowing across the surface into watercourses.

4.3.1.3 The effect of development is generally to reduce the permeability of at least part of the site, which markedly changes the site's response to rainfall. Without specific measures to manage surface water, the volume of water and peak flow rate are likely to increase. Inadequate surface water drainage arrangements can increase the risk of flooding to others.

4.3.1.4 Surface water arising from a developed site should, as far as is practicable be managed in a sustainable manner to mimic the surface water flows arising from the site prior to the proposed development while reducing the risk of flooding at the site and elsewhere, taking climate change into account.

4.3.2 Sustainable drainage options

4.3.2.1 The NPPF and associated PPG, sustainable urban drainage systems (SuDS) Manual (CIRIA, 2015) and also the North Norfolk Core Strategy (North Norfolk District Council, 2008) promote sustainable water management through the use of SuDS. A hierarchy of techniques is identified:

- Prevention – the use of good site design and housekeeping measures on individual sites to prevent runoff and pollution (e.g. minimise areas of hard standing).
- Source Control – control of runoff at or very near its source (such as the use of rainwater harvesting).
- Site Control – management of water from several sub-catchments (including routing water from roofs and car parks to one/several large soakaways for the whole site).
- Regional Control – management of runoff from several sites, typically in a detention pond or wetland.

4.3.2.2 The implementation of SuDS as opposed to conventional drainage systems, provides several benefits by:

- Reducing peak flows to watercourses or sewers and potentially reducing the risk of flooding downstream;
- Reducing the volumes and frequency of water flowing directly to watercourses or sewers from developed sites;
- Improving water quality over conventional surface water sewers by removing pollutants from diffuse pollutant sources;
- Reducing potable water demand through rainwater harvesting;
- Improving amenity through the provision of public open spaces and wildlife habitat; and
- Replicating natural drainage patterns, including the recharge of groundwater so that base flows are maintained.

4.3.3 Runoff rate calculations

4.3.3.1 An assessment of the current and proposed runoff rates was undertaken to determine the surface water attenuation requirements for the site in line with The SuDS Manual (2015), which indicates that the flow rate discharged from the site must not exceed that prior to the proposed development for the:

- 1 in 1 year event;
- 1 in 30 year event; and
- 1 in 100 year event.

4.3.3.2 The rates of runoff were determined using the current 'industry best practice' guidelines as outlined in the Interim Code of Practice for SuDS and the Non-statutory technical standards for sustainable drainage systems (March 2015). The Defra/Environment Agency recommended methodology for sites up to 50 hectares in area is the Institute of Hydrology Report 124 method (IoH 124). The runoff rates were calculated using the Micro Drainage WinDes software suite and are present within Table 4.2.

4.3.4 Current runoff rate

4.3.4.1 The site has been assessed against a 'greenfield' baseline, assumed to be 100% permeable surfacing.

4.3.4.2 The following parameters were incorporated into the greenfield site runoff calculations:

- Catchment Area: 2.5 ha (assume 100% permeable and 0% low permeable surfacing (hardstanding/buildings));
- Standard-period Average Annual Rainfall (SAAR): 684 mm/year;
- Soil: 0.150 (global soil index);
- Region No: 5 (catchment based on FSR Figure I.2.4.).

4.3.4.3 The peak runoff rate for a 1 in 1 year event is 0.90 litres/second. This runoff rate is defined in Table 4.2

4.3.5 Post-development runoff rate

4.3.5.1 The proposed land use is a HVAC booster station with an operational life of 50 years. The development of the site will result in an increase in impermeable surfaces with the introduction of building structures and concrete hardstanding associated with on-site equipment and access roads within the proposed site of the onshore HVAC booster station. It does not consider off site access roads as these are assessed in volume 3, chapter 7: Traffic and Transport.

4.3.5.2 The post-development rates of runoff have been calculated on a 'worst-case' basis assuming that the entire site of the onshore HVAC booster station site would comprise low permeable surfacing. As design work progresses, run off calculations will be refined accordingly.

4.3.5.3 The following parameters have been incorporated into the runoff calculations for the proposed onshore HVAC booster station:

- Catchment Area: 2.5 ha (assume 100% low permeable surfacing (buildings/concrete/asphalt));
- SAAR: 684 mm/year;
- Soil: 0.150;
- Region No: 5.

4.3.5.4 Table 4.2 summarises the results of the runoff calculations and shows that following the construction of the proposed onshore HVAC booster station there will be an increase in surface water runoff rates from the site.

Table 4.2: HVAC Booster Station Runoff characteristics.

Annual Probability (Return Period, years)	Current (Greenfield) Runoff (l/s)	Proposed (Unmitigated) Runoff (l/s)	Unmitigated Increase in Runoff (l/s)
100% (1)	0.90	5.10	4.20
3.33% (30)	2.40	10.40	8.00
1% (100)	3.50	12.20	8.70
1% + 20% Climate Change	4.20	14.64	10.44
1% + 40% Climate Change	4.90	17.08	12.18

4.3.6 Attenuation requirements

4.3.6.1 The attenuation volume required to restrict the surface water runoff rate from the addition low permeable surfacing to the existing 1 in 1 year rate for a 1 in 100 year rainfall event plus climate change (+ 20% and 40%) has been determined using the industry standard Micro Drainage WinDes software suite incorporating the following parameters:

- Catchment Area: approximately 2.5 ha (100%);
- Cv (proportion of rainfall forming surface water runoff): assume a factor of 75% for the development in summer, and 84% in winter (weighted average based on proposed land use);
- Runoff rate: 0.90 l/s; and
- Assuming no infiltration losses.

4.3.6.2 The system was modelled within WinDes as a tank/pond with controlled discharge via an orifice outflow control. The WinDes calculation sheets are included within Appendix A.

4.3.6.3 The attenuation volume required to restrict runoff from a 1 in 100 year storm event (plus a 20% and 40% allowance for climate change) to the 1 in 1 year (100% annual probability) current runoff rate of 0.90 l/s, is approximately 3,236 m^3 and 3,822 m^3 respectively for the site.

4.4 Summary and conclusions

4.4.1 Summary

4.4.1.1 A site-specific FRA in accordance with section 5.7 of the NPS EN-1, the NPPF and associated Planning Practice Guidance ID7 has been undertaken for the proposed onshore HVAC booster station at a site located 2.7 km north of the village Saxthorpe.

4.4.2 Flood risk

4.4.2.1 Environment Agency mapping shows that the proposed development is located in Flood Zone 1 at 'low' risk of flooding (less than 1 in 1,000 annual probability of river or sea flooding in any year (<0.1%)).

4.4.2.2 There is no historical evidence of flooding at the site.

4.4.2.3 The site is located within a flat lying and primarily agricultural landscape, indicating that the potential surface water flood risk to the site is low. The majority of surface runoff will either infiltrate into exposed permeable natural surfaces soils, or given the flat nature of the surrounding topography pluvial flooding will be localised at the point of origin with low mobility.

4.4.2.4 The site has been assessed to be at low to medium risk of groundwater flooding.

4.4.2.5 The risk of flooding from infrastructure failure including adopted sewers is considered to be low.

4.4.2.6 The site is not at risk of flooding from a reservoir failure.

4.4.2.7 The proposed development is defined as "*Essential Infrastructure*" in Table 2 of Planning Practice Guidance ID7 and is suitable for the present flood zone and the zone including climate change.

4.4.2.8 The proposed development is located within Environment Agency Flood Zone 1 and SFRA Flood Zone 1. Therefore, there is no requirement for either a Sequential or Exceptions Test.

4.4.2.9 There will be an increase in low permeability cover; and surface runoff will need to be controlled at an agreed runoff rate. WinDes calculations indicate that the overall attenuation requirement for the 2.5 ha development assuming no loss via infiltration is 3,236 m^3 and 3,822 m^3 for the 1 in 100 year storm event plus a 20% and 40% allowance for climate change respectively.

4.4.3 Conclusion

4.4.3.1 This FRA and supporting documentation shows that the proposed development at this location meets the requirements of NPS EN-1 and the NPPF.

5. Onshore HVDC Converter/HVAC Substation Flood Risk Assessment

5.1 Site setting

5.1.1 Site location

5.1.1.1 The proposed HVDC converter/HVAC substation site is located at National Grid Reference TG 21000 03541 approximately 5.6 km south west of Norwich City Centre (Figure 5.1). The site is bounded by the Norwich Southern Bypass (A47) to the north, enclosed agricultural fields to the south and east, and Main Road to the west with agricultural fields beyond. Access to the site is gained via Main Road (B113).

5.1.2 Existing site

5.1.2.1 The site contains no buildings, structures or development and its topography slopes from the east to the west. It is currently used for agricultural purposed with enclosed fields separated by hedging.

5.1.3 Proposed development

5.1.3.1 The proposed development comprises an onshore HVDC converter/HVAC substation as part of the Hornsea Three project. It will contain the electrical components for transforming the power supplied by the offshore wind farm to 400 kV. If a HVDC transmission system is used it will also house equipment to convert the power from HVDC to HVAC.

5.1.3.2 Based on current ongoing design work for the onshore HVDC converter/HVAC substation and associated permanent infrastructure, it is estimated that approximately 100,000 m^2 of impermeable land could be created. This will be further refined as project design work progresses and the FRA updated. The HVDC converter/HVAC substation is expected to have an operational life of 25 years and a design life of 50 years. For the purpose of this FRA, the design envelope for the onshore HVDC converter/HVAC substation is set out below:

- Up to three main buildings (HVAC scenario) or up to two main buildings (HVDC scenario);
- Concrete/Tarmac internal access roads and compacted aggregate fill covering; and
- Concrete/Tarmac external access roads;

5.1.4 Hydrological overview

5.1.4.1 This section assesses the baseline hydrological characteristics of the proposed development site. A 1 km buffer was selected for the onshore HVDC converter/HVAC substation to identify any potential receptors that might be affected by the proposed development. The 1 km buffer is considered an appropriate buffer to identify changes in flood risk in the surrounding area.

Fluvial and tidal flooding

5.1.4.2 Environment Agency's flood map (Figure 5.1) indicates that the site of the onshore HVDC converter/HVAC substation is within Flood Zone 1, defined as land assessed as having a less than 1 in 1,000 annual probability of river or sea flooding (<0.1%).

5.1.4.3 The Norfolk County Council and Partnership of Norfolk District Council's SFRA Flood Zone Maps replicate the Environment Agency's flood mapping indicating that the site is located within Flood Zone 1.

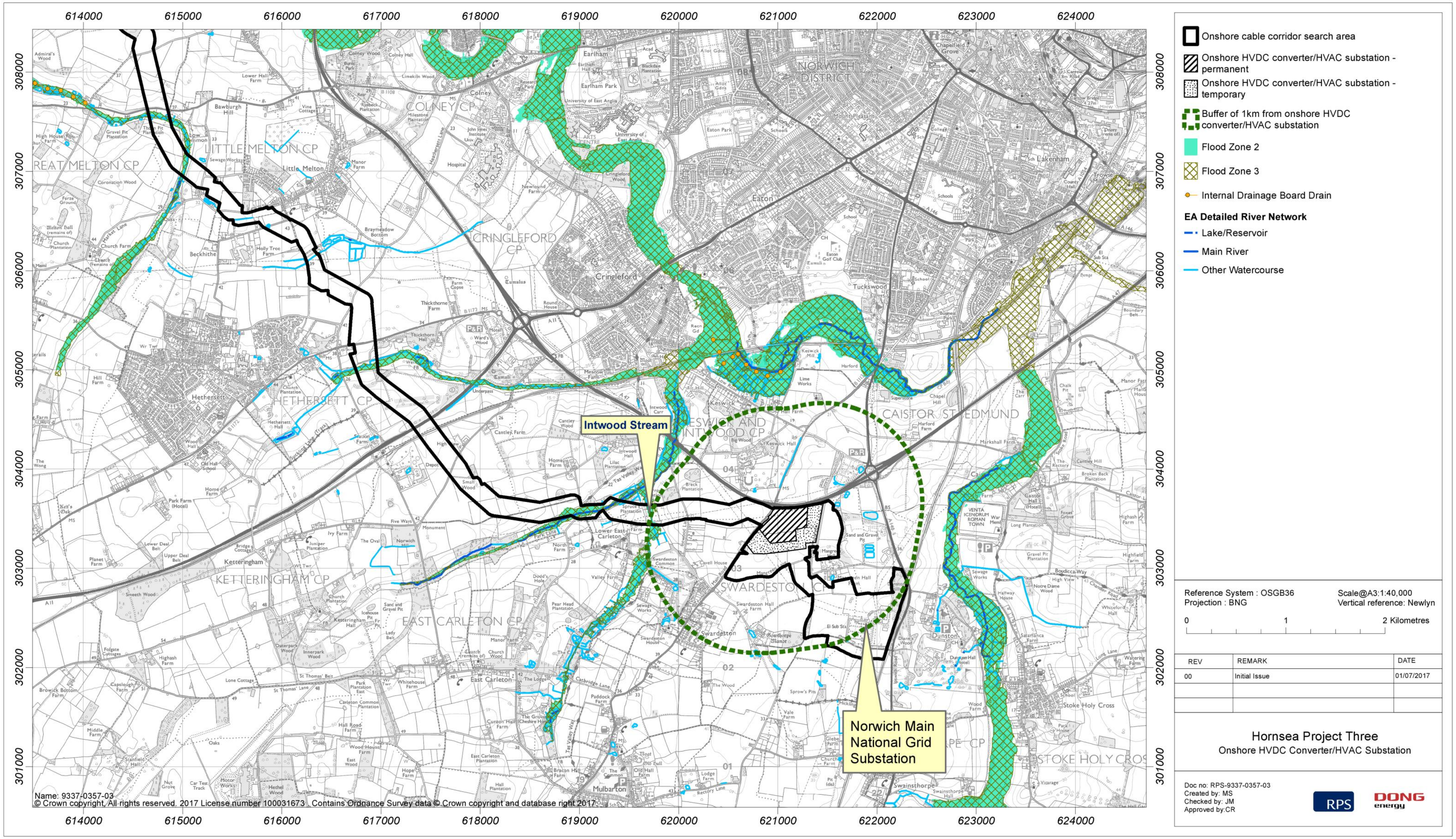

Figure 5.1: Onshore HVDC converter/HVAC substation site location plan/Environment Agency flood zone map.

Flooding from rising/high groundwater

5.1.4.4 BGS geology online map (accessed March 2017) indicates that the site is underlain by Lowestoft formation superficial deposits consisting sands, gravels, silts, clays and chalky till. The superficial deposits are underlain by bedrock consisting of the undifferentiated Chalk Formations of the White Chalk Subgroup (white, well-bedded, flint-free chalk with common marl seams).

5.1.4.5 The chalks are classified by the Environment Agency under the Water Framework Directive as a principal aquifer, defined as "… *layers of rock or drift deposits that have high intergranular and/or fracture permeability - meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale"*.

5.1.4.6 North Norfolk County Council SFRA indicates that no groundwater flooding has been reported at the site.

5.1.4.7 Based on the information outlined above the potential for groundwater flooding is considered to be at low to medium.

Source Protection Zones

5.1.4.8 Environment Agency mapping shows the site is not located within a Groundwater Source Protection Zone (SPZ).

Surface water flooding

5.1.4.9 Surface water or pluvial flooding is defined as flooding caused by rainfall generated overland flow, before the runoff enters a watercourse or sewer. In such events sewerage and drainage systems and surface watercourses may be overwhelmed.

5.1.4.10 Figure 5.2 of the Environment Agency's surface water flood mapping indicates that the majority of the site is at 'very low' risk of surface water flooding. A localised area along the north and western extent of the site is defined at being at low risk of surface water flooding.

5.1.4.11 Based on the primarily agricultural landscape of the site, the majority of surface runoff will either infiltrate into exposed permeable natural surfaces and soils, or be conveyed to local drainage network.

Reservoir failure assessment

5.1.4.12 Environment Agency mapping shows that the site is not at risk of reservoir flooding.

Flood defence measures

5.1.4.13 Environment Agency and SFRA mapping indicates that there are no flood defences within the immediate vicinity of the development site.

Sewer/water main failure assessment

5.1.4.14 Water asset plans for the site will be sourced from Anglian Water, but are not available to Hornsea Three at the time of preparing the PEIR. As the site is currently agricultural land it is anticipated that no sewer/water assets are present within the site boundary.

5.1.4.15 However, if any adopted sewers in close proximity to the site would be assumed to have been designed to industry standards (e.g. sewers for adoption). However; the most common causes of flooding from sewers are; inadequate flow capacity, blockages, pumping station failures, burst water mains, water inflow from rivers or the sea, tide locking, siltation, fats/greases, and sewer collapse. Should any of these events occur there is a risk of flooding within the vicinity of the sewer by surcharge where the flood is in excess of the sewer capacity (usually 1 in 30 year event or greater).

5.1.4.16 Under the DG 5 register requirements all water companies are obliged to keep a record of any properties that have been affected by sewer flooding. The Norfolk County Council SFRA and Flood Risk Management Strategy do not provide any records relating to historical flooding on site as a consequence of a failure in artificial drainage (e.g. sewers).

5.1.4.17 Taking into account the above and absence of any historical sewer flooding specific to the application site the overall risk of flooding via artificial drainage system to the development site has been assessed to be low.

Historic flooding

5.1.4.18 Norfolk County Council (NCC) SFRA and Flood Risk Management Strategy (NCC, 2010) mapping indicates that the site has not been affected by historical flooding.

Current flood risk

5.1.4.19 The site is located within Flood Zone 1, an area considered at low risk of flooding from fluvial or tidal sources.

5.1.4.20 It has been determined that the main risk of flooding to the site is from groundwater sources.

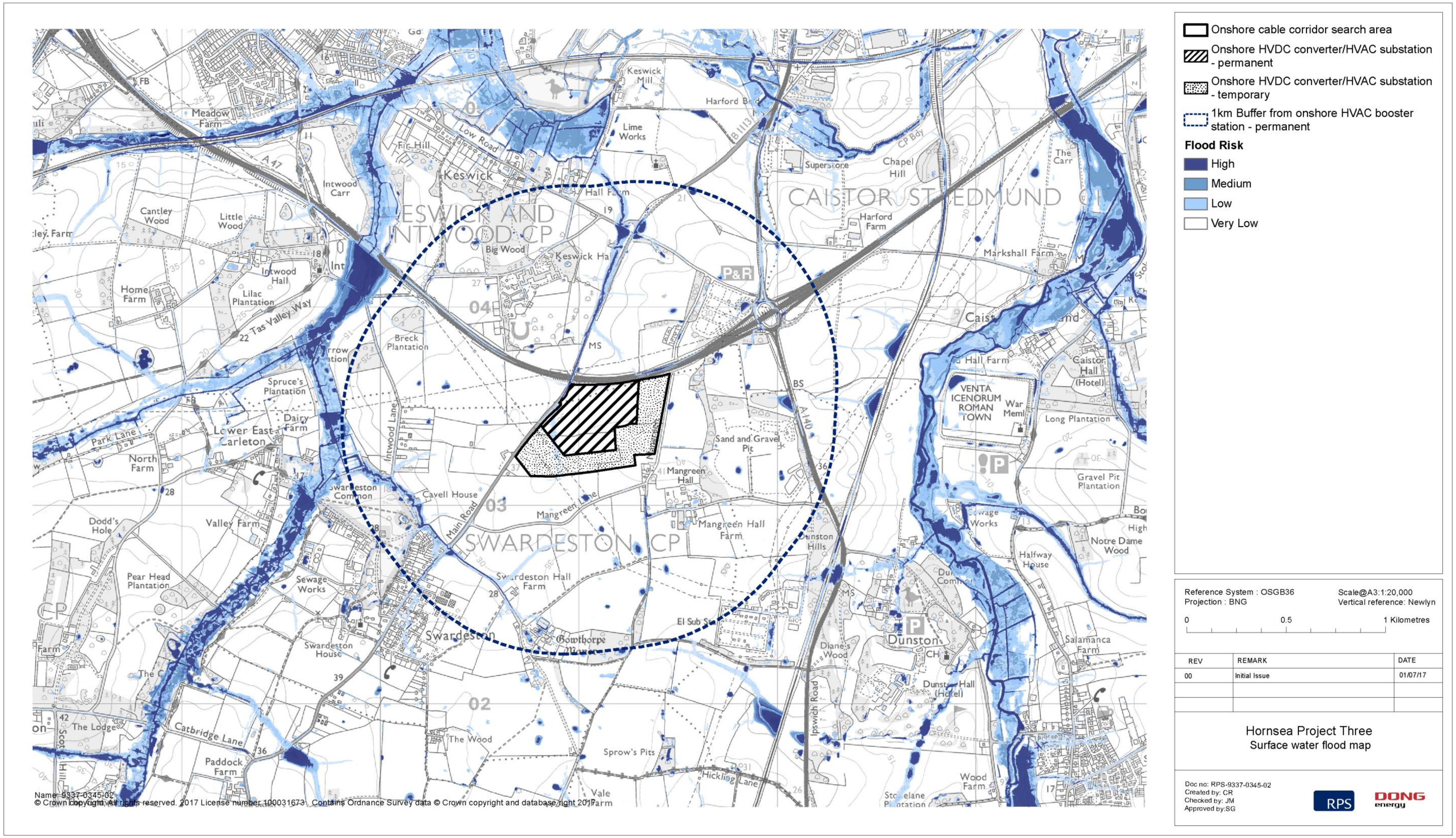

Figure 5.2: Onshore HVDC converter/HVAC substation surface water flood map

5.2 Flood risk management

5.2.1 Site vulnerability

5.2.1.1 Applying the Flood Risk Vulnerability Classification in Table 2 of the PPG Flood Risk and Coastal Change (DCLG, 2014), onshore electricity HVDC Converter Station/HVAC Substation developments are classified as "*Essential infrastructure*".

5.2.1.2 Table 3 of PPG (Table.5.1 of this report) states that "*Essential Infrastructure*" uses are appropriate within Flood Zone 1 and 2, and also in Flood Zone 3.

Table.5.1: Flood risk vulnerability and flood zone 'compatibility' as identified in table 3 of NPPF technical guidance.

Flood Risk Vulnerability classification (see Table 2 of NPPF Technical Guidance)	Essential Infrastructure	Water Compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
Zone 1	Yes	Yes	Yes	Yes	Yes
Zone 2	Yes	Yes	Exception test required	Yes	Yes
Zone 3a	Exception test required	Yes	No	Exception test required	Yes
Zone 3b Functional Floodplain	Exception test required	Yes	No	No	No

Key: Yes: Development is appropriate, No: Development should not be permitted.

5.2.2 Sequential Test

5.2.2.1 The Sequential Test is designed to demonstrate that there are no reasonably available sites in areas with a lower probability of flooding that would be appropriate for this type of development.

5.2.2.2 Local Planning Authorities allocating land in Local Development Plans (LDPs) for development should apply the Sequential Test to demonstrate that there are no reasonably available sites in areas with a lower probability of flooding that would be appropriate to the type of development or land use proposed. In areas at risk of river or sea flooding, preference should be given to locating new development in Flood Zone 1. If there is no reasonably available site in Flood Zone 1, the flood vulnerability of the proposed development can be taken into account in locating development in Flood Zone 2 and then Flood Zone 3. Within each Flood Zone new development should be directed to sites at the lowest probability of flooding from all sources as indicated by the (SFRA).

5.2.2.3 The Sequential Test therefore seeks the allocation of land for development in flood areas of least risk where practicable (i.e. preferentially steer towards Zone 1). Developers should also have regard to the Sequential Test when evaluating sites where LDPs have not been subject to SFRA and/or the Sequential Test and where it is necessary to demonstrate that there are no alternative sites with a lower probability of flooding for the given end use.

5.2.2.4 North County Council SFRA flood mapping shows that the entire development is located within Flood Zone 1 and has therefore passed the Sequential Test requirement of locating development within 'low' flood risk zones.

5.2.2.5 As the proposed built development is located within Flood Zone 1 and has passed the Sequential Test there is no need to undertake an Exceptions Test.

5.3 Drainage strategy

5.3.1 Surface water drainage

5.3.1.1 The sustainable management of surface water is an essential element of reducing future flood risk to the site and its surroundings.

5.3.1.2 Undeveloped sites generally rely on natural drainage to convey or absorb rainfall, the water soaking into the ground or flowing across the surface into watercourses.

5.3.1.3 The effect of development is generally to reduce the permeability of at least part of the site, which markedly changes the site's response to rainfall. Without specific measures to manage surface water the volume of water and peak flow rate are likely to increase. Inadequate surface water drainage arrangements can threaten the development itself and increase the risk of flooding to others.

5.3.1.4 Surface water arising from a developed site should as far as is practicable be managed in a sustainable manner to mimic the surface water flows arising from the site prior to the proposed development while reducing the risk of flooding at the site and elsewhere, taking climate change into account.

5.3.2 Sustainable drainage options

5.3.2.1 The NPPF and associated PPG, Sustainable urban drainage systems (SuDS) Manual (CIRIA, 2015) and also the Joint Core Strategy for Broadland, Norwich and South Norfolk (Broadland District Council *et al.*, 2014) promote sustainable water management through the use of SuDS. A hierarchy of techniques is identified:

- Prevention – the use of good site design and housekeeping measures on individual sites to prevent runoff and pollution (e.g. minimise areas of hard standing).
- Source Control – control of runoff at or very near its source (such as the use of rainwater harvesting).
- Site Control – management of water from several sub-catchments (including routing water from roofs and car parks to one/several large soakaways for the whole site).
- Regional Control – management of runoff from several sites, typically in a detention pond or wetland.

5.3.2.2 The implementation of SuDS as opposed to conventional drainage systems, provides several benefits by:

- Reducing peak flows to watercourses or sewers and potentially reducing the risk of flooding downstream;
- Reducing the volumes and frequency of water flowing directly to watercourses or sewers from developed sites;
- Improving water quality over conventional surface water sewers by removing pollutants from diffuse pollutant sources;
- Reducing potable water demand through rainwater harvesting;
- Improving amenity through the provision of public open spaces and wildlife habitat; and
- Replicating natural drainage patterns, including the recharge of groundwater so that base flows are maintained.

5.3.3 Runoff rate calculations

5.3.3.1 An assessment of the current and proposed runoff rates was undertaken to determine the surface water attenuation requirements for the site in line with The SuDS Manual (2015), which indicates that sites the flow rate discharged from the site must not exceed that prior to the proposed development for the:

- 1 in 1 year event;
- 1 in 30 year event; and
- 1 in 100 year event.

5.3.3.2 The rates of runoff were determined using the current 'industry best practice' guidelines as outlined in the Interim Code of Practice for SuDS and the Non-statutory technical standards for sustainable drainage systems (March 2015). The Defra/Environment Agency recommended methodology for sites up to 50 hectares in area is the Institute of Hydrology Report 124 method (IoH 124). The runoff rates were calculated using the Micro Drainage WinDes software suite and are present within Table 5.2.

5.3.4 Current runoff rate

5.3.4.1 The site is has been assessed against a 'greenfield' baseline, assumed to be 100% permeable surfacing.

5.3.4.2 The following parameters were incorporated into the greenfield site runoff calculations:

- Fenced construction Area: 10 ha (assume 100% permeable and 0% low permeable surfacing (hardstanding/buildings);
- Standard-period Average Annual Rainfall (SAAR): 619 mm/year;
- Soil: 0.400; and
- Region No: 5.

5.3.4.3 The peak runoff rate for a 1 in 1 year event is 25.6 litres/second.

5.3.5 Post-development runoff rate

5.3.5.1 The proposed land use (as noted in Section 3.3) is a HVDC converter station/HVAC substation with an operational life of 50 years. The development of the site will result in an increase in impermeable surfaces, with the introduction of building structures and concrete hardstand associated with on-site equipment and access roads.

5.3.5.2 The post –development runoff calculations are based on a worst case basis assuming that the entire onshore HVDC converter/HVAC substation site would comprise low permeable surfacing. As design works progresses run-off calculations will be refined accordingly.

5.3.5.3 The following parameters have been incorporated into the runoff calculations for the proposed development:

- Fenced Construction Area: 10 ha (assume 100% low permeable surfacing (buildings/concrete/asphalt));
- SAAR: 619 mm/year;
- Soil: 0.400; and
- Region No: 5.

5.3.5.4 Table 5.2 summarises the results of the runoff calculations and shows that following the construction of the proposed onshore HVDC converter/HVAC substation there will be an increase in surface water runoff rates from the site.

Table 5.2: HVDC Converter Station Runoff characteristics.

Annual Probability (Return Period, years)	Current (Greenfield) Runoff (l/s)	Proposed (Unmitigated) Runoff (l/s)	Unmitigated Increase in Runoff (l/s)
100% (1)	25.60	77.70	52.10
3.33% (30)	70.80	159.60	88.80
1% (100)	104.90	189.80	84.90
1% + 20% Climate Change	125.88	227.76	101.88
1% + 40% Climate Change	146.86	265.72	118.86

5.3.6 Attenuation requirements

5.3.6.1 The attenuation volume required to restrict the surface water runoff rate from the addition low permeable surfacing to the existing 1 in 1 year rate for a 1 in 100 year rainfall event plus climate change (+ 20% and 40%) has been determined using the industry standard Micro Drainage WinDes software suite incorporating the following parameters:

- Catchment Area: approximately 10 ha (100% of the site);
- Cv (proportion of rainfall forming surface water runoff): assume a factor of 75% for the development in summer, and 84% in winter (weighted average based on proposed land use);
- Runoff rate: 25.6 l/s; and
- Assuming no infiltration losses.

5.3.6.2 The system was modelled within WinDes as a tank/pond with controlled discharge via an orifice outflow control. The WinDes calculation sheets are included within Appendix B.

5.3.6.3 The attenuation volume required to restrict runoff from a 1 in 100 year storm event (plus a 20% and 40% allowance for climate change) to the 1 in 1 year (100% annual probability) current runoff rate of 25.6 l/s, has been determined to be approximately 8,545 m^3 and 10,350 m^3 respectively for the site.

5.4 Summary and conclusions

5.4.1 Summary

5.4.1.1 A site-specific FRA in accordance with section 5.7 of the NPS EN-1, the NPPF and associated PPG ID7 has been undertaken for the proposed onshore HVDC converter/HVAC substation located approximately 5.6 km south west of Norwich City Centre.

5.4.2 Flood risk

5.4.2.1 Environment Agency mapping shows that the proposed development is located in Flood Zone 1 at 'low' risk of flooding (less than 1 in 1,000 annual probability of river or sea flooding in any year (<0.1%)).

5.4.2.2 There is no historical evidence of flooding at the site.

5.4.2.3 The site is located within a primarily agricultural landscape. The majority of surface runoff will either infiltrate into exposed permeable natural surfaces soils, or be conveyed to the local drainage network. The Environment Agency surface water flood map indicates that localised areas within the northern and western extent of the site is at low risk of surface water flooding.

5.4.2.4 The site has been assessed to be at low to medium risk of groundwater flooding.

5.4.2.5 The risk of flooding from infrastructure failure including flood defences and adopted sewers is considered to be low.

5.4.2.6 The site is not at risk of flooding from a reservoir failure.

5.4.2.7 The proposed development is defined as "*Essential Infrastructure*" in Table 2 of Planning Practice Guidance ID7 and is suitable for the present flood zone and the zone including climate change.

5.4.2.8 The proposed development is located within Environment Agency Flood Zone 1 and SFRA Flood Zone 1 therefore there is no requirement for either a Sequential or Exception Test.

5.4.2.9 There will be an increase in low permeability cover; and surface runoff will need to be controlled at an agreed runoff rate. WinDes calculations indicate that the overall attenuation requirement for the 10 ha development assuming no loss via infiltration is 8,545 m^3 and 10,350 m^3 for the 1 in 100 year storm event plus a 20% and 40% allowance for climate change respectively.

5.4.3 Conclusion

5.4.3.1 This FRA and supporting documentation shows that the onshore HVAC booster station and HVDC converter/HVAC substation at the proposed locations meets the requirements of NPS EN-1 and the NPPF.

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Ordnance Survey 1:10,000 Scale Electronic Data Mapping for assessment area.

Ordnance Survey Mapping (2016) 1: 50 000 Sheet 134: Norwich & The Broads. Landranger Series. Southampton, Ordnance Survey.

Appendix A WinDes Calculations for Onshore HVAC Booster Station

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Micro Drainage	Source Control W.12.4	

Summary of Results for 100 year Return Period (+20%)

Outflow is too low. Design is unsatisfactory.

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	8.480	0.480	0.4	0.0	0.4	840.1	O K
30 min Summer	8.555	0.555	0.4	0.0	0.4	970.6	O K
60 min Summer	8.641	0.641	0.5	0.0	0.5	1121.1	O K
120 min Summer	8.740	0.740	0.5	0.0	0.5	1294.4	O K
180 min Summer	8.804	0.804	0.5	0.0	0.5	1407.6	O K
240 min Summer	8.853	0.853	0.6	0.0	0.6	1493.5	O K
360 min Summer	8.927	0.927	0.6	0.0	0.6	1623.0	O K
480 min Summer	8.983	0.983	0.6	0.0	0.6	1720.9	O K
600 min Summer	9.029	1.029	0.6	0.0	0.6	1800.5	O K
720 min Summer	9.067	1.067	0.6	0.0	0.6	1867.7	O K
960 min Summer	9.147	1.147	0.6	0.0	0.6	2008.0	O K
1440 min Summer	9.269	1.269	0.7	0.0	0.7	2221.0	O K
2160 min Summer	9.401	1.401	0.7	0.0	0.7	2451.4	O K
2880 min Summer	9.500	1.500	0.7	0.0	0.7	2624.8	O K
4320 min Summer	9.556	1.556	0.8	0.0	0.8	2723.7	O K
5760 min Summer	9.592	1.592	0.8	0.0	0.8	2785.4	O K
7200 min Summer	9.615	1.615	0.8	0.0	0.8	2826.0	O K
8640 min Summer	9.630	1.630	0.8	0.0	0.8	2852.8	O K

Storm Event	Rain (mm/hr)	Overflow Volume (m³)	Time-Peak (mins)
15 min Summer	179.305	0.0	27
30 min Summer	103.599	0.0	42
60 min Summer	59.858	0.0	72
120 min Summer	34.585	0.0	132
180 min Summer	25.091	0.0	192
240 min Summer	19.982	0.0	252
360 min Summer	14.497	0.0	372
480 min Summer	11.545	0.0	492
600 min Summer	9.676	0.0	612
720 min Summer	8.376	0.0	732
960 min Summer	6.771	0.0	970
1440 min Summer	5.017	0.0	1450
2160 min Summer	3.718	0.0	2168
2880 min Summer	3.005	0.0	2888
4320 min Summer	2.108	0.0	4328
5760 min Summer	1.639	0.0	5768
7200 min Summer	1.349	0.0	7208
8640 min Summer	1.150	0.0	8648

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Micro Drainage	Source Control W.12.4	

Summary of Results for 100 year Return Period (+20%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
10080 min Summer	9.640	1.640	0.8	0.0	0.8	2870.0	O K
15 min Winter	8.538	0.538	0.4	0.0	0.4	940.9	O K
30 min Winter	8.621	0.621	0.5	0.0	0.5	1087.1	O K
60 min Winter	8.718	0.718	0.5	0.0	0.5	1255.7	O K
120 min Winter	8.829	0.829	0.5	0.0	0.5	1449.9	O K
180 min Winter	8.901	0.901	0.6	0.0	0.6	1576.7	O K
240 min Winter	8.956	0.956	0.6	0.0	0.6	1673.1	O K
360 min Winter	9.039	1.039	0.6	0.0	0.6	1818.3	O K
480 min Winter	9.102	1.102	0.6	0.0	0.6	1928.2	O K
600 min Winter	9.153	1.153	0.6	0.0	0.6	2017.5	O K
720 min Winter	9.196	1.196	0.7	0.0	0.7	2093.0	O K
960 min Winter	9.286	1.286	0.7	0.0	0.7	2250.6	O K
1440 min Winter	9.423	1.423	0.7	0.0	0.7	2489.9	O K
2160 min Winter	9.571	1.571	0.8	0.0	0.8	2749.4	O K
2880 min Winter	9.683	1.683	0.8	0.0	0.8	2945.1	O K
4320 min Winter	9.748	1.748	0.8	0.0	0.8	3058.9	Flood Risk
5760 min Winter	9.789	1.789	0.8	0.0	0.8	3131.2	Flood Risk
7200 min Winter	9.817	1.817	0.8	0.0	0.8	3179.9	Flood Risk
8640 min Winter	9.836	1.836	0.8	0.0	0.8	3213.2	Flood Risk

Storm Event	Rain (mm/hr)	Overflow Volume (m³)	Time-Peak (mins)
10080 min Summer	1.005	0.0	10088
15 min Winter	179.305	0.0	27
30 min Winter	103.599	0.0	42
60 min Winter	59.858	0.0	72
120 min Winter	34.585	0.0	132
180 min Winter	25.091	0.0	190
240 min Winter	19.982	0.0	250
360 min Winter	14.497	0.0	368
480 min Winter	11.545	0.0	488
600 min Winter	9.676	0.0	606
720 min Winter	8.376	0.0	726
960 min Winter	6.771	0.0	964
1440 min Winter	5.017	0.0	1442
2160 min Winter	3.718	0.0	2152
2880 min Winter	3.005	0.0	2860
4320 min Winter	2.108	0.0	4284
5760 min Winter	1.639	0.0	5704
7200 min Winter	1.349	0.0	7128
8640 min Winter	1.150	0.0	8552

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Micro Drainage	Source Control W.12.4	

Summary of Results for 100 year Return Period (+20%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
10080 min Winter	9.849	1.849	0.8	0.0	0.8	3236.0	Flood Risk

Storm Event	Rain (mm/hr)	Overflow Volume (m³)	Time-Peak (mins)
10080 min Winter	1.005	0.0	9888

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Micro Drainage	Source Control W.12.4	

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
Site Location	GB 611350 333200 TG 11350 33200
C (1km)	-0.024
D1 (1km)	0.319
D2 (1km)	0.371
D3 (1km)	0.236
E (1km)	0.311
F (1km)	2.479
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+20

Time / Area Diagram

Total Area (ha) 2.500

Time (mins)	Area (ha)	Time (mins)	Area (ha)	Time (mins)	Area (ha)
0-4	1.000	4-8	1.000	8-12	0.500

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Micro Drainage	Source Control W.12.4	

Model Details

Storage is Online Cover Level (m) 10.000

Tank or Pond Structure

Invert Level (m) 8.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	1750.0	2.800	1750.0	5.600	1750.0	8.400	1750.0
0.400	1750.0	3.200	1750.0	6.000	1750.0	8.800	1750.0
0.800	1750.0	3.600	1750.0	6.400	1750.0	9.200	1750.0
1.200	1750.0	4.000	1750.0	6.800	1750.0	9.600	1750.0
1.600	1750.0	4.400	1750.0	7.200	1750.0	10.000	1750.0
2.000	1750.0	4.800	1750.0	7.600	1750.0		
2.400	1750.0	5.200	1750.0	8.000	1750.0		

Orifice Outflow Control

Diameter (m) 0.017 Discharge Coefficient 0.600 Invert Level (m) 8.000

Weir Overflow Control

Discharge Coef 0.544 Width (m) 1.000 Invert Level (m) 10.000

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Micro Drainage	Source Control W.12.4	

Summary of Results for 100 year Return Period (+40%)

Outflow is too low. Design is unsatisfactory.

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	8.490	0.490	0.4	0.0	0.4	980.2	O K
30 min Summer	8.566	0.566	0.5	0.0	0.5	1132.4	O K
60 min Summer	8.654	0.654	0.5	0.0	0.5	1308.1	O K
120 min Summer	8.755	0.755	0.5	0.0	0.5	1510.5	O K
180 min Summer	8.821	0.821	0.5	0.0	0.5	1642.8	O K
240 min Summer	8.872	0.872	0.6	0.0	0.6	1743.2	O K
360 min Summer	8.947	0.947	0.6	0.0	0.6	1894.7	O K
480 min Summer	9.005	1.005	0.6	0.0	0.6	2009.4	O K
600 min Summer	9.051	1.051	0.6	0.0	0.6	2102.7	O K
720 min Summer	9.091	1.091	0.6	0.0	0.6	2181.7	O K
960 min Summer	9.173	1.173	0.7	0.0	0.7	2346.3	O K
1440 min Summer	9.298	1.298	0.7	0.0	0.7	2596.9	O K
2160 min Summer	9.434	1.434	0.7	0.0	0.7	2869.0	O K
2880 min Summer	9.537	1.537	0.7	0.0	0.7	3074.6	O K
4320 min Summer	9.598	1.598	0.8	0.0	0.8	3196.5	O K
5760 min Summer	9.637	1.637	0.8	0.0	0.8	3274.9	O K
7200 min Summer	9.664	1.664	0.8	0.0	0.8	3328.8	O K
8640 min Summer	9.683	1.683	0.8	0.0	0.8	3366.6	O K

Storm Event	Rain (mm/hr)	Overflow Volume (m³)	Time-Peak (mins)
15 min Summer	209.189	0.0	27
30 min Summer	120.865	0.0	42
60 min Summer	69.834	0.0	72
120 min Summer	40.349	0.0	132
180 min Summer	29.273	0.0	192
240 min Summer	23.313	0.0	252
360 min Summer	16.914	0.0	372
480 min Summer	13.470	0.0	492
600 min Summer	11.289	0.0	612
720 min Summer	9.772	0.0	732
960 min Summer	7.900	0.0	972
1440 min Summer	5.853	0.0	1450
2160 min Summer	4.337	0.0	2172
2880 min Summer	3.506	0.0	2888
4320 min Summer	2.460	0.0	4328
5760 min Summer	1.913	0.0	5768
7200 min Summer	1.574	0.0	7208
8640 min Summer	1.342	0.0	8648

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Micro Drainage	Source Control W.12.4	

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
10080 min Summer	9.697	1.697	0.8	0.0	0.8	3393.1	O K
15 min Winter	8.549	0.549	0.4	0.0	0.4	1097.8	O K
30 min Winter	8.634	0.634	0.5	0.0	0.5	1268.4	O K
60 min Winter	8.733	0.733	0.5	0.0	0.5	1465.2	O K
120 min Winter	8.846	0.846	0.6	0.0	0.6	1692.0	O K
180 min Winter	8.920	0.920	0.6	0.0	0.6	1840.1	O K
240 min Winter	8.976	0.976	0.6	0.0	0.6	1952.8	O K
360 min Winter	9.061	1.061	0.6	0.0	0.6	2122.6	O K
480 min Winter	9.126	1.126	0.6	0.0	0.6	2251.3	O K
600 min Winter	9.178	1.178	0.7	0.0	0.7	2356.0	O K
720 min Winter	9.222	1.222	0.7	0.0	0.7	2444.6	O K
960 min Winter	9.315	1.315	0.7	0.0	0.7	2629.5	O K
1440 min Winter	9.455	1.455	0.7	0.0	0.7	2910.9	O K
2160 min Winter	9.609	1.609	0.8	0.0	0.8	3217.1	O K
2880 min Winter	9.724	1.724	0.8	0.0	0.8	3448.8	Flood Risk
4320 min Winter	9.794	1.794	0.8	0.0	0.8	3588.4	Flood Risk
5760 min Winter	9.840	1.840	0.8	0.0	0.8	3679.6	Flood Risk
7200 min Winter	9.872	1.872	0.8	0.0	0.8	3743.2	Flood Risk
8640 min Winter	9.894	1.894	0.8	0.0	0.8	3788.8	Flood Risk

Storm Event	Rain (mm/hr)	Overflow Volume (m³)	Time-Peak (mins)
10080 min Summer	1.172	0.0	10088
15 min Winter	209.189	0.0	27
30 min Winter	120.865	0.0	42
60 min Winter	69.834	0.0	72
120 min Winter	40.349	0.0	132
180 min Winter	29.273	0.0	190
240 min Winter	23.313	0.0	250
360 min Winter	16.914	0.0	368
480 min Winter	13.470	0.0	488
600 min Winter	11.289	0.0	606
720 min Winter	9.772	0.0	726
960 min Winter	7.900	0.0	966
1440 min Winter	5.853	0.0	1444
2160 min Winter	4.337	0.0	2160
2880 min Winter	3.506	0.0	2864
4320 min Winter	2.460	0.0	4284
5760 min Winter	1.913	0.0	5712
7200 min Winter	1.574	0.0	7136
8640 min Winter	1.342	0.0	8552

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Micro Drainage	Source Control W.12.4	

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
10080 min Winter	9.911	1.911	0.8	0.0	0.8	3821.7	Flood Risk

Storm Event	Rain (mm/hr)	Overflow Volume (m³)	Time-Peak (mins)
10080 min Winter	1.172	0.0	9976

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Micro Drainage	Source Control W.12.4	

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
Site Location	GB 611350 333200 TG 11350 33200
C (1km)	-0.024
D1 (1km)	0.319
D2 (1km)	0.371
D3 (1km)	0.236
E (1km)	0.311
F (1km)	2.479
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+40

Time / Area Diagram

Total Area (ha) 2.500

Time (mins)	Area (ha)	Time (mins)	Area (ha)	Time (mins)	Area (ha)
0-4	1.000	4-8	1.000	8-12	0.500

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3rd Floor 34 Lisbon Street Leeds LS1 4LX		Micro Drainage
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File 1 in 100 yr plus ...	Checked By	
Micro Drainage	Source Control W.12.4	

Model Details

Storage is Online Cover Level (m) 10.000

Tank or Pond Structure

Invert Level (m) 8.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	2000.0	2.800	2000.0	5.600	2000.0	8.400	2000.0
0.400	2000.0	3.200	2000.0	6.000	2000.0	8.800	2000.0
0.800	2000.0	3.600	2000.0	6.400	2000.0	9.200	2000.0
1.200	2000.0	4.000	2000.0	6.800	2000.0	9.600	2000.0
1.600	2000.0	4.400	2000.0	7.200	2000.0	10.000	2000.0
2.000	2000.0	4.800	2000.0	7.600	2000.0		
2.400	2000.0	5.200	2000.0	8.000	2000.0		

Orifice Outflow Control

Diameter (m) 0.017 Discharge Coefficient 0.600 Invert Level (m) 8.000

Weir Overflow Control

Discharge Coef 0.544 Width (m) 1.000 Invert Level (m) 10.000

Appendix B WinDes Calculations for Onshore HVDC Converter/HVAC Substation

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Date 29/03/2017 16:06 File 1 in 100 yr plus ...	Designed By jonathan.m... Checked By	
Micro Drainage	Source Control W.12.4	

Summary of Results for 100 year Return Period (+20%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	8.781	0.781	15.5	0.0	15.5	3512.6	O K
30 min Summer	8.883	0.883	16.5	0.0	16.5	3975.5	O K
60 min Summer	8.998	0.998	17.6	0.0	17.6	4491.3	O K
120 min Summer	9.124	1.124	18.7	0.0	18.7	5056.1	O K
180 min Summer	9.201	1.201	19.4	0.0	19.4	5403.8	O K
240 min Summer	9.257	1.257	19.9	0.0	19.9	5654.3	O K
360 min Summer	9.334	1.334	20.5	0.0	20.5	6004.6	O K
480 min Summer	9.388	1.388	20.9	0.0	20.9	6243.9	O K
600 min Summer	9.426	1.426	21.2	0.0	21.2	6418.6	O K
720 min Summer	9.456	1.456	21.4	0.0	21.4	6550.6	O K
960 min Summer	9.523	1.523	21.9	0.0	21.9	6853.3	O K
1440 min Summer	9.602	1.602	22.5	0.0	22.5	7209.5	O K
2160 min Summer	9.649	1.649	22.9	0.0	22.9	7421.0	O K
2880 min Summer	9.664	1.664	23.0	0.0	23.0	7486.4	O K
4320 min Summer	9.594	1.594	22.5	0.0	22.5	7172.7	O K
5760 min Summer	9.530	1.530	22.0	0.0	22.0	6886.4	O K
7200 min Summer	9.469	1.469	21.5	0.0	21.5	6608.8	O K
8640 min Summer	9.409	1.409	21.1	0.0	21.1	6342.2	O K
10080 min Summer	9.353	1.353	20.6	0.0	20.6	6088.9	O K

Storm Event	Rain (mm/hr)	Overflow Volume (m³)	Time-Peak (mins)
15 min Summer	188.954	0.0	55
30 min Summer	107.076	0.0	69
60 min Summer	60.677	0.0	98
120 min Summer	34.384	0.0	156
180 min Summer	24.664	0.0	216
240 min Summer	19.485	0.0	274
360 min Summer	13.977	0.0	392
480 min Summer	11.042	0.0	508
600 min Summer	9.196	0.0	626
720 min Summer	7.920	0.0	744
960 min Summer	6.366	0.0	980
1440 min Summer	4.679	0.0	1452
2160 min Summer	3.439	0.0	2160
2880 min Summer	2.764	0.0	2484
4320 min Summer	1.945	0.0	3208
5760 min Summer	1.516	0.0	4000
7200 min Summer	1.250	0.0	4832
8640 min Summer	1.067	0.0	5640
10080 min Summer	0.934	0.0	6464

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Micro Drainage	Source Control W.12.4	

Summary of Results for 100 year Return Period (+20%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Winter	8.875	0.875	16.4	0.0	16.4	3935.9	O K
30 min Winter	8.990	0.990	17.5	0.0	17.5	4455.0	O K
60 min Winter	9.119	1.119	18.7	0.0	18.7	5034.0	O K
120 min Winter	9.260	1.260	19.9	0.0	19.9	5670.2	O K
180 min Winter	9.347	1.347	20.6	0.0	20.6	6063.1	O K
240 min Winter	9.410	1.410	21.1	0.0	21.1	6347.1	O K
360 min Winter	9.499	1.499	21.8	0.0	21.8	6746.8	O K
480 min Winter	9.561	1.561	22.2	0.0	22.2	7022.3	O K
600 min Winter	9.606	1.606	22.5	0.0	22.5	7225.5	O K
720 min Winter	9.640	1.640	22.8	0.0	22.8	7380.9	O K
960 min Winter	9.719	1.719	23.3	0.0	23.3	7735.8	Flood Risk
1440 min Winter	9.815	1.815	24.0	0.0	24.0	8167.7	Flood Risk
2160 min Winter	9.880	1.880	24.4	0.0	24.4	8461.5	Flood Risk
2880 min Winter	9.899	1.899	24.6	0.0	24.6	8544.5	Flood Risk
4320 min Winter	9.804	1.804	23.9	0.0	23.9	8119.6	Flood Risk
5760 min Winter	9.721	1.721	23.4	0.0	23.4	7744.0	Flood Risk
7200 min Winter	9.637	1.637	22.8	0.0	22.8	7366.7	O K
8640 min Winter	9.555	1.555	22.2	0.0	22.2	6999.2	O K
10080 min Winter	9.477	1.477	21.6	0.0	21.6	6648.7	O K

Storm Event	Rain (mm/hr)	Overflow Volume (m³)	Time-Peak (mins)
15 min Winter	188.954	0.0	54
30 min Winter	107.076	0.0	69
60 min Winter	60.677	0.0	98
120 min Winter	34.384	0.0	154
180 min Winter	24.664	0.0	212
240 min Winter	19.485	0.0	270
360 min Winter	13.977	0.0	384
480 min Winter	11.042	0.0	500
600 min Winter	9.196	0.0	614
720 min Winter	7.920	0.0	730
960 min Winter	6.366	0.0	962
1440 min Winter	4.679	0.0	1420
2160 min Winter	3.439	0.0	2088
2880 min Winter	2.764	0.0	2724
4320 min Winter	1.945	0.0	3384
5760 min Winter	1.516	0.0	4296
7200 min Winter	1.250	0.0	5208
8640 min Winter	1.067	0.0	6080
10080 min Winter	0.934	0.0	6976

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Micro Drainage	Source Control W.12.4	

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
Site Location	GB 621150 304100 TG 21150 04100
C (1km)	-0.024
D1 (1km)	0.291
D2 (1km)	0.351
D3 (1km)	0.244
E (1km)	0.312
F (1km)	2.488
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+20

Time / Area Diagram

Total Area (ha) 10.000

Time (mins)	Area (ha)	Time (mins)	Area (ha)	Time (mins)	Area (ha)	Time (mins)	Area (ha)	Time (mins)	Area (ha)	Time (mins)	Area (ha)
0-4	1.000	8-12	1.000	16-20	1.000	24-28	1.000	32-36	1.000		
4-8	1.000	12-16	1.000	20-24	1.000	28-32	1.000	36-40	1.000		

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Model Details

Storage is Online Cover Level (m) 10.000

Tank or Pond Structure

Invert Level (m) 8.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	4500.0	2.800	4500.0	5.600	4500.0	8.400	4500.0
0.400	4500.0	3.200	4500.0	6.000	4500.0	8.800	4500.0
0.800	4500.0	3.600	4500.0	6.400	4500.0	9.200	4500.0
1.200	4500.0	4.000	4500.0	6.800	4500.0	9.600	4500.0
1.600	4500.0	4.400	4500.0	7.200	4500.0	10.000	4500.0
2.000	4500.0	4.800	4500.0	7.600	4500.0		
2.400	4500.0	5.200	4500.0	8.000	4500.0		

Orifice Outflow Control

Diameter (m) 0.093 Discharge Coefficient 0.600 Invert Level (m) 8.000

Weir Overflow Control

Discharge Coef 0.544 Width (m) 1.000 Invert Level (m) 10.000

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Micro Drainage	Source Control W.12.4	

Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	8.782	0.782	15.5	0.0	15.5	4103.1	O K
30 min Summer	8.885	0.885	16.5	0.0	16.5	4644.7	O K
60 min Summer	9.000	1.000	17.6	0.0	17.6	5249.5	O K
120 min Summer	9.127	1.127	18.8	0.0	18.8	5915.4	O K
180 min Summer	9.205	1.205	19.4	0.0	19.4	6328.2	O K
240 min Summer	9.262	1.262	19.9	0.0	19.9	6627.6	O K
360 min Summer	9.343	1.343	20.6	0.0	20.6	7051.5	O K
480 min Summer	9.399	1.399	21.0	0.0	21.0	7346.0	O K
600 min Summer	9.441	1.441	21.3	0.0	21.3	7565.3	O K
720 min Summer	9.473	1.473	21.6	0.0	21.6	7734.8	O K
960 min Summer	9.547	1.547	22.1	0.0	22.1	8120.5	O K
1440 min Summer	9.638	1.638	22.8	0.0	22.8	8601.4	O K
2160 min Summer	9.704	1.704	23.2	0.0	23.2	8944.6	Flood Risk
2880 min Summer	9.725	1.725	23.4	0.0	23.4	9058.2	Flood Risk
4320 min Summer	9.660	1.660	22.9	0.0	22.9	8716.3	O K
5760 min Summer	9.603	1.603	22.5	0.0	22.5	8416.0	O K
7200 min Summer	9.548	1.548	22.1	0.0	22.1	8129.5	O K
8640 min Summer	9.495	1.495	21.7	0.0	21.7	7849.3	O K
10080 min Summer	9.444	1.444	21.3	0.0	21.3	7580.0	O K

Storm Event	Rain (mm/hr)	Overflow Volume (m³)	Time-Peak (mins)
15 min Summer	220.446	0.0	55
30 min Summer	124.922	0.0	69
60 min Summer	70.790	0.0	98
120 min Summer	40.115	0.0	158
180 min Summer	28.775	0.0	216
240 min Summer	22.732	0.0	274
360 min Summer	16.306	0.0	392
480 min Summer	12.882	0.0	510
600 min Summer	10.729	0.0	628
720 min Summer	9.240	0.0	746
960 min Summer	7.427	0.0	982
1440 min Summer	5.459	0.0	1456
2160 min Summer	4.012	0.0	2164
2880 min Summer	3.225	0.0	2744
4320 min Summer	2.269	0.0	3388
5760 min Summer	1.769	0.0	4128
7200 min Summer	1.458	0.0	4928
8640 min Summer	1.245	0.0	5784
10080 min Summer	1.089	0.0	6576

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Summary of Results for 100 year Return Period (+40%)

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Overflow (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Winter	8.876	0.876	16.4	0.0	16.4	4597.1	O K
30 min Winter	8.991	0.991	17.5	0.0	17.5	5204.5	O K
60 min Winter	9.121	1.121	18.7	0.0	18.7	5883.3	O K
120 min Winter	9.263	1.263	19.9	0.0	19.9	6632.3	O K
180 min Winter	9.352	1.352	20.6	0.0	20.6	7098.3	O K
240 min Winter	9.417	1.417	21.1	0.0	21.1	7437.3	O K
360 min Winter	9.508	1.508	21.8	0.0	21.8	7919.2	O K
480 min Winter	9.573	1.573	22.3	0.0	22.3	8256.5	O K
600 min Winter	9.621	1.621	22.7	0.0	22.7	8509.7	O K
720 min Winter	9.659	1.659	22.9	0.0	22.9	8707.2	O K
960 min Winter	9.744	1.744	23.5	0.0	23.5	9155.1	Flood Risk
1440 min Winter	9.853	1.853	24.3	0.0	24.3	9726.6	Flood Risk
2160 min Winter	9.936	1.936	24.8	0.0	24.8	10165.8	Flood Risk
2880 min Winter	9.971	1.971	25.0	0.0	25.0	10349.8	Flood Risk
4320 min Winter	9.882	1.882	24.5	0.0	24.5	9882.1	Flood Risk
5760 min Winter	9.811	1.811	24.0	0.0	24.0	9507.3	Flood Risk
7200 min Winter	9.738	1.738	23.5	0.0	23.5	9124.4	Flood Risk
8640 min Winter	9.665	1.665	23.0	0.0	23.0	8743.5	O K
10080 min Winter	9.595	1.595	22.5	0.0	22.5	8371.4	O K

Storm Event	Rain (mm/hr)	Overflow Volume (m³)	Time-Peak (mins)
15 min Winter	220.446	0.0	54
30 min Winter	124.922	0.0	69
60 min Winter	70.790	0.0	98
120 min Winter	40.115	0.0	156
180 min Winter	28.775	0.0	212
240 min Winter	22.732	0.0	270
360 min Winter	16.306	0.0	386
480 min Winter	12.882	0.0	502
600 min Winter	10.729	0.0	616
720 min Winter	9.240	0.0	732
960 min Winter	7.427	0.0	964
1440 min Winter	5.459	0.0	1426
2160 min Winter	4.012	0.0	2104
2880 min Winter	3.225	0.0	2764
4320 min Winter	2.269	0.0	3532
5760 min Winter	1.769	0.0	4400
7200 min Winter	1.458	0.0	5336
8640 min Winter	1.245	0.0	6240
10080 min Winter	1.089	0.0	7096

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Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
Site Location	GB 621150 304100 TG 21150 04100
C (1km)	-0.024
D1 (1km)	0.291
D2 (1km)	0.351
D3 (1km)	0.244
E (1km)	0.312
F (1km)	2.488
Summer Storms	Yes
Winter Storms	Yes
Cv (Summer)	0.750
Cv (Winter)	0.840
Shortest Storm (mins)	15
Longest Storm (mins)	10080
Climate Change %	+40

Time / Area Diagram

Total Area (ha) 10.000

Time (mins)	Area (ha)	Time (mins)	Area (ha)	Time (mins)	Area (ha)	Time (mins)	Area (ha)	Time (mins)	Area (ha)	Time (mins)	Area (ha)
0-4	1.000	8-12	1.000	16-20	1.000	24-28	1.000	32-36	1.000		
4-8	1.000	12-16	1.000	20-24	1.000	28-32	1.000	36-40	1.000		

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Model Details

Storage is Online Cover Level (m) 10.000

Tank or Pond Structure

Invert Level (m) 8.000

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	5250.0	2.800	5250.0	5.600	5250.0	8.400	5250.0
0.400	5250.0	3.200	5250.0	6.000	5250.0	8.800	5250.0
0.800	5250.0	3.600	5250.0	6.400	5250.0	9.200	5250.0
1.200	5250.0	4.000	5250.0	6.800	5250.0	9.600	5250.0
1.600	5250.0	4.400	5250.0	7.200	5250.0	10.000	5250.0
2.000	5250.0	4.800	5250.0	7.600	5250.0		
2.400	5250.0	5.200	5250.0	8.000	5250.0		

Orifice Outflow Control

Diameter (m) 0.093 Discharge Coefficient 0.600 Invert Level (m) 8.000

Weir Overflow Control

Discharge Coef 0.544 Width (m) 1.000 Invert Level (m) 10.000