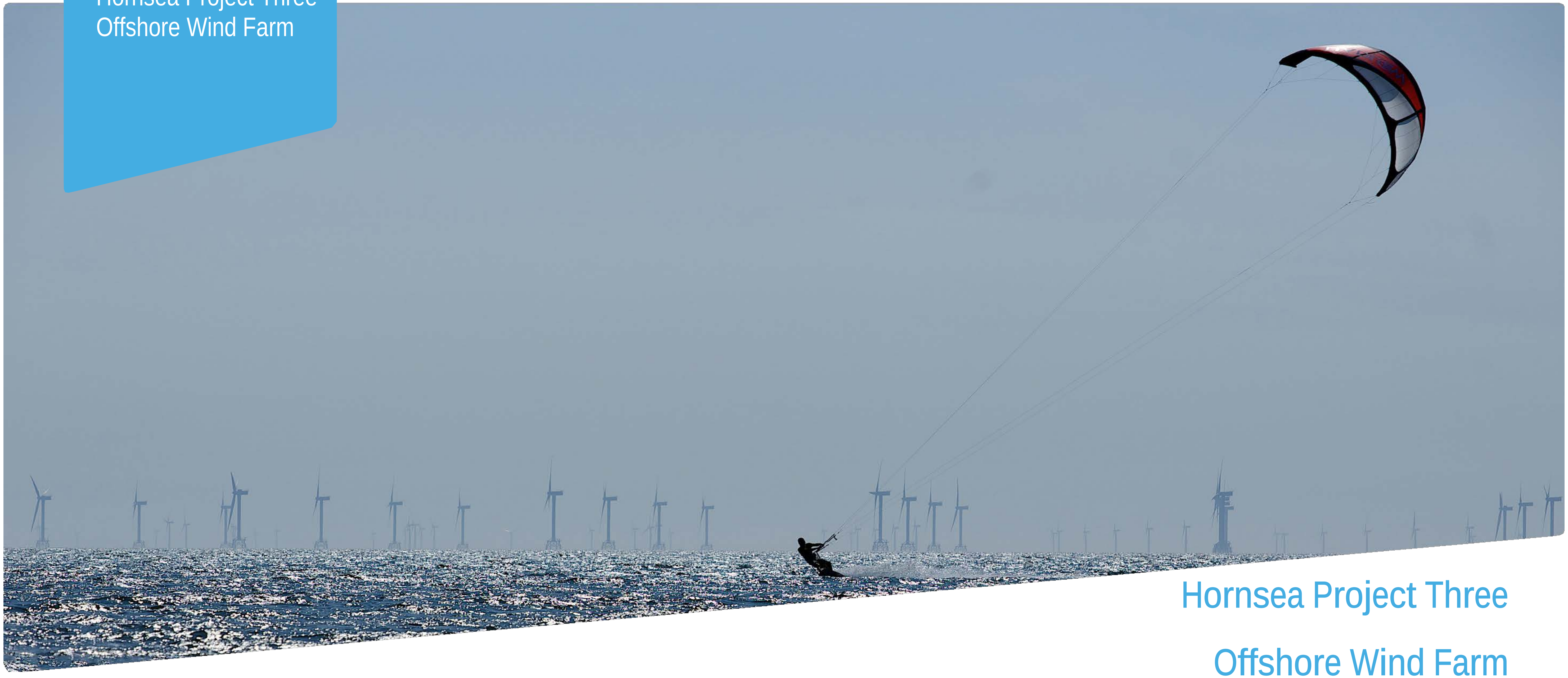
Hornsea Project Three
Offshore Wind Farm



Hornsea Project Three
Offshore Wind Farm

Environmental Statement:
Volume 6, Annex 2.1 – Onshore Infrastructure Flood Risk Assessments

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Date: May 2018

Hornsea 3
Offshore Wind Farm

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Environmental Impact Assessment

Environmental Statement

Volume 6

Annex 2. 1 – Onshore Infrastructure Flood Risk Assessments

Liability

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Front cover picture: Kite surfer near a UK offshore wind farm © Orsted Project Three (UK) Ltd., 2018

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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	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.

Term	Definition
Greenfield Runoff Rate	Rates of surface water runoff 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.
Onshore infrastructure	For the purpose of the site-specific Flood Risk Assessment this includes the Hornsea Three onshore cable corridor, HVAC booster station and HVDC converter/HVAC substation.
Obar	Mean annual maximum flow rate is the value of the average flood event recorded in a river. This flow rate is used to provide a measure of the greenfield runoff performance of a site in its natural state to enable flow rate criteria to be set for post development surface water discharges for various return periods.
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 runoff	Surface water runoff is flow of water that occurs when excess storm water, meltwater, or other sources of water flows over a surface.
Sustainable urban drainage systems	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	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.

Term	Definition
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
bgl	Below ground level
BGS	British Geology Survey
DCO	Development Consent Order
EA	Environment Agency
FRA	Flood Risk Assessment
HDD	Horizontal Directional Drilling
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
IDB	Internal Drainage Board
LDP	Local Development Plan
NPPF	National Planning Policy Framework
NPPG	National Planning Practice Guidance
NPS	National Policy Statement
PPG	Planning Practice Guidance
SFRA	Strategic Flood Risk Assessment
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)
l/s	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 Hornsea Three onshore cable corridor, HVAC booster station and HVDC converter/HVAC substation (hereafter referred to as 'onshore infrastructure').

1.1.1.2 The FRA has 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, a summary of each is presented in Section 3. The policies cover the requirements in respect to Nationally Significant Infrastructure Projects.

1.1.1.3 The FRA supports 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 an annex to 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 Methodology

1.2.1.1 The proposed study area for each of the FRAs follows the Hornsea Three hydrology and flood risk study area as defined in volume 3, chapter 2: Hydrology and Flood Risk. It includes a 1 km buffer around the onshore HVAC booster station area and onshore HVDC converter/HVAC substation area, and a 250 m buffer around the Hornsea Three onshore cable corridor.

1.2.1.2 The buffers applied are considered appropriate for data collection taking into account the nature of Hornsea Three and likely zone of influence on hydrological receptors.

1.2.1.3 In order to achieve the objectives outlined within 1.1.1.7, a staged approach was adopted in undertaking the FRA in accordance with NPS (EN-1), the NPPF and PPG. Initially, screening studies have been undertaken utilising publicly 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 areas and elsewhere in the Hornsea Three 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 aims of the assessment are:

- 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 areas; and
- To identify any impact of the Hornsea Three onshore infrastructure on flood risk elsewhere.

1.3 Report structure

1.3.1.1 This report has the following structure:

- Section 2 identifies the sources of information that have been consulted in preparation of the FRA;
- Section 3 sets out relevant legislation, guidance and local planning policy;
- Section 4 provides the development specific FRA for the proposed onshore HVAC booster station area;
- Section 5 provides the development specific FRA for the proposed onshore HVDC converter/HVAC substation area; and
- Section 6 provides the development specific FRA for the proposed Hornsea Three onshore cable corridor.

1.3.1.2 A hydrological review of the onshore HVAC booster station, HVDC converter/HVAC substation areas and Hornsea Three onshore cable corridor; requirements of 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 are presented below.

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 environments, 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 (EA).	EA data holdings, customer service and engagement team.	Current flood risk, local flood defences, flood levels, supplementary geology and groundwater information.
Groundsure.	Enviro Insight and Geo Insight.	Classification of the underlying geology and hydrogeology. Flood risk from groundwater and surface water.
Internal Drainage Board (IDB).	Norfolk Rivers IDB.	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.
Planning Policy.	NPPF. PPG.	FRA and Planning Guidance. Flood zoning as used by the EA in England.
	NPS EN-1 Section 5.7.	NPS EN-1(5.7.6) refers applicants to this Practice Guide.
	The Department for Environment Food and Rural Affairs (Defra) Sustainable Drainage Systems Non-statutory technical standards for sustainable drainage systems (March 2015).	Surface water runoff standards.
	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 including historical flooding locations. Any relevant flood modelling completed.
	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, 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 LPAs 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 LPA.

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, LPAs 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 the suitability of sites in Flood Zone 3 be considered, taking into account the flood risk vulnerability of 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 ha or greater in Flood Zone 1. Flood Zones are defined as:

- *Flood Zone 1* - Land having a less than 1 in 1,000 annual probability of river or sea flooding;
- *Flood Zone 2* - 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; and
- *Flood Zone 3* - 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.

3.1.3.3 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 likely to be affected by climate change;
- Site-specific flood risk – what are the main sources of flooding, what is the probability of 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 Non-statutory technical standards for sustainable drainage systems (March 2015)

3.1.4.1 This document sets out non-statutory technical standards for sustainable drainage systems, which should be used in conjunction with the NPPF and PPG. The standards relevant for Hornsea Three are presented below:

"Peak flow control

S2 - For greenfield developments, the peak runoff rate from the development to any highway drain, sewer or surface water body for the 1 in 1 year rainfall event and the 1 in 100 year rainfall event should never exceed the peak greenfield runoff rate for the same event.

Volume control

S4 - Where reasonably practicable, for greenfield development, the runoff volume from the development to any highway drain, sewer or surface water body in the 1 in 100 year, 6 hour rainfall event should never exceed the greenfield runoff volume for the same event.

S6 - Where it is not reasonably practicable to constrain the volume of runoff to any drain, sewer or surface water body in accordance with S4, the runoff volume must be discharged at a rate that does not adversely affect flood risk.

Flood risk within the development

S7 - The drainage system must be designed so that, unless an area is designated to hold and/or convey water as part of the design, flooding does not occur on any part of the site for a 1 in 30 year rainfall event.

S8 - The drainage system must be designed so that, unless an area is designated to hold and/or convey water as part of the design, flooding does not occur during a 1 in 100 year rainfall event in any part of: a building (including a basement); or in any utility plant susceptible to water (e.g. pumping station or electricity substation) within the development.

S9 - The design of the site must ensure that, so far as is reasonably practicable, flows resulting from rainfall in excess of a 1 in 100 year rainfall event are managed in exceedance routes that minimise the risks to people and property."

3.1.5 Climate change

3.1.5.1 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.

3.1.5.2 In February 2016, the EA 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 of peak rainfall intensity (Table 3.1) to understand the range of impacts. The allowances (upper end and central) are based on emission percentiles. The central allowance is based on the 50th percentile, whilst 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).

Allowance Category (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%

3.1.5.3 The peak river flow allowance shows the anticipated changes to peak flow within the river systems in the Anglian district caused by climate change. Table 3.2 presents the anticipated peak river flow change associated with the impacts of climate change.

Table 3.2: Peak river flow allowances by river basin district (use 1961 to 1990 baseline).

River Basin District	Allowance Category	Total potential change anticipated for the '2020s' (2015 to 2039)	Total potential change anticipated for the '2050s' (2040 to 2069)	Total potential change anticipated for the '2080s' (2070 to 2115)
Anglian	Upper end	25%	35%	65%
	Higher central	15%	20%	35%
	Central	10%	15%	25%

3.1.5.4 The EA expect sea level rise to increase the rate of coastal erosion. Table 3.3 presents the anticipated sea level rise for given time frames associated with climate change.

Table 3.3: Sea level allowance for each epoch (mm) per year (use 1990 baseline).

Area of England	1990 to 2025	2026 to 2055	2056 to 2085	2086 to 2115	Cumulative rise 1990 to 2115 (metres)
East, east midlands, London, south east	4mm (140 mm)	8.5 (255 mm)	12 (360 mm)	15 (450 mm)	1.21 m

3.1.5.5 As a Lead Local Flood Authority (LLFA), Norfolk County Council refer all developers to the Flood risk assessment: climate change allowances guidance for all developments.

3.1.5.6 In line with the EA's Flood risk assessments: climate change allowance guidance, 20% and 40% has been added to all attenuation/runoff calculations for the Hornsea Three onshore infrastructure to account for climate change (assuming a 1 in 100 year rainfall event).

4. Onshore HVAC Booster Station Area Flood Risk Assessment

4.1 Site setting

4.1.1 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 area is bounded by woodland to the north and east, with agricultural land to the south and east. Access is gained via Sweetbriar Lane.

4.1.2 Existing use

4.1.2.1 The area 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 use

4.1.3.1 It is proposed that a HVAC booster station will be constructed as part of Hornsea Three (as described in volume 1, chapter 3: Project Description). The onshore HVAC booster station and associated permanent infrastructure will occupy a site of up to 3.04 ha, including some land which may be used for landscaping. The onshore HVAC booster station is expected to have an operational life of 35 years. Indicative layouts are presented in volume 1, chapter 3: Project Description. For the purpose of this FRA, the maximum design scenarios are identified in volume 3, chapter 2 Hydrology and Flood Risk and are summarised below:

- The HVAC booster station site area (including all above ground permanent infrastructure, internal circulation roads, fencing, buildings and landscaping): 30,407 m^2, of which:
  - Approximately 10,000 m^2 comprises low permeability hardstanding/surfacing;
  - Approximately 20,400 m^2 comprises above ground permanent infrastructure, gravelled areas, landscaping etc.

4.1.4 Flood Risk Assessment

Hydrological overview

4.1.4.1 The location of EA designated main rivers and ordinary watercourses within the Hornsea Three hydrology and flood risk study area are shown on . Main rivers and ordinary watercourses are defined in annex 2.2: Environment Agency and Internal Drainage Board Watercourses and Flood Zones. There are no main rivers in the Hornsea Three hydrology and flood risk study area at the onshore HVAC booster station area, however there are ordinary watercourses to the east and south.

Fluvial and tidal flooding

4.1.4.2 The EA's flood map (Figure 4.1) indicates that the onshore HVAC booster station area 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 EA's flood mapping indicating that the onshore HVAC booster station area is located within Flood Zone 1.

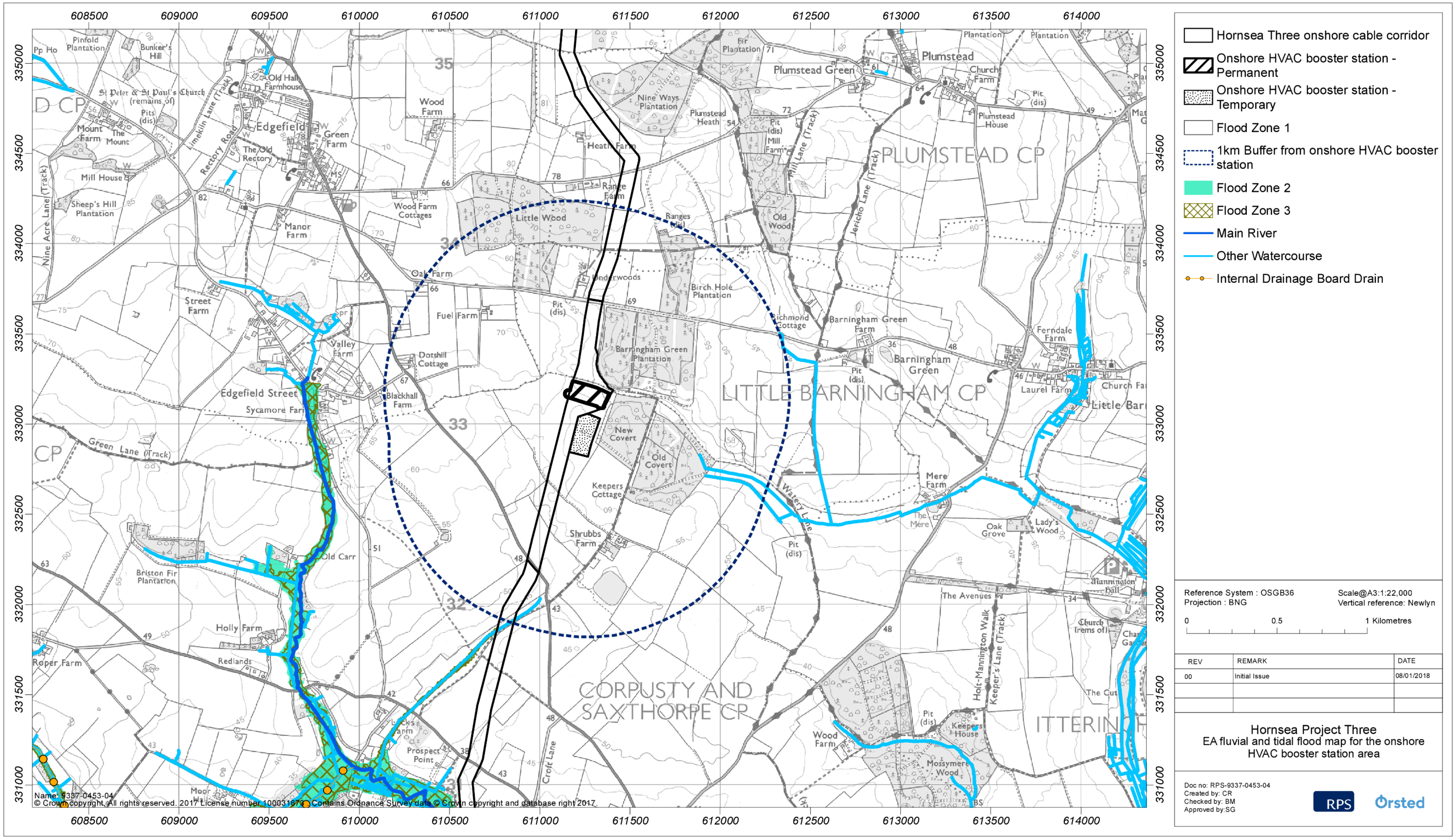

Figure 4.1: EA fluvial and tidal flood map for the onshore HVAC booster station area.

Flooding from rising/high groundwater

4.1.4.4 BGS geology online map (accessed March 2017) indicates that the onshore HVAC booster station 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). Further information on geology and ground conditions can be found in volume 3, chapter 1: Geology and Ground Conditions.

4.1.4.5 The chalks are classified by the EA 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's (2010) SFRA indicates that no groundwater flooding has been reported at the onshore HVAC booster station area.

4.1.4.7 There are no EA-defined categories to assess the potential for groundwater flooding, therefore, the author's professional judgement has been used. Taking into account the geology and hydrogeology of the area and absence of historical groundwater flood events, the potential for groundwater flooding is considered to be low.

Source Protection Zones

4.1.4.8 EA mapping shows the onshore HVAC booster station area is not located within a groundwater Source Protection Zone (see annex 1.2: Abstraction Licences and Source Protection Zones).

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 EA's surface water flood mapping indicates that the majority of the onshore HVAC booster station area is at 'very low' risk of surface water flooding. A localised area along the north eastern corner of the onshore HVAC booster station area 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 onshore HVAC booster station area the majority of surface runoff will either infiltrate into exposed permeable natural surfaces and soils, or be conveyed to the local drainage network.

Reservoir failure assessment

4.1.4.12 EA mapping shows that the onshore HVAC booster station area is not at risk of reservoir flooding.

Flood defence measures

4.1.4.13 EA 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 As the onshore HVAC booster station area 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 onshore HVAC booster station area.

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 DG 5 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 onshore HVAC booster station area 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 onshore HVAC booster station area and the author's professional judgement, the overall risk of flooding via artificial drainage system to the onshore HVAC booster station area has been assessed to be low.

Historic flooding

4.1.4.18 Norfolk County Council, SFRA and Flood Risk Management Strategy (Norfolk County Council, 2010) mapping indicates that the onshore HVAC booster station area has not been affected by historical flooding.

Current flood risk

4.1.4.19 The onshore HVAC booster station area 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 onshore HVAC booster station area is from groundwater.

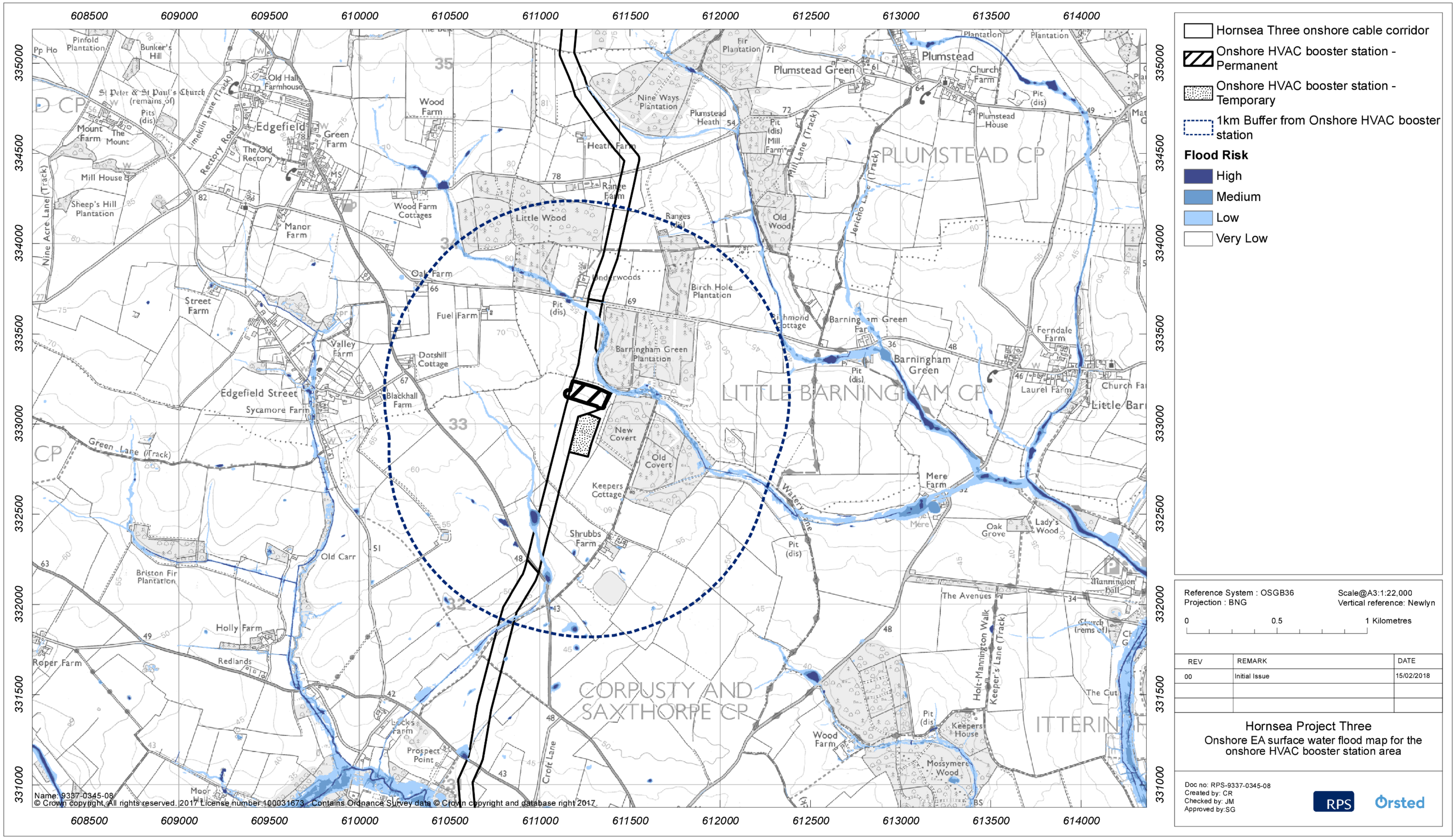

Figure 4.2: Onshore EA surface water flood map for the onshore HVAC booster station area.

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 (Department for Communities and Local Government, 2014), the onshore 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 LPAs 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 Norfolk County Council's 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 area 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 onshore HVAC booster station area 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 onshore HVAC booster station area, 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 HVAC booster station area prior to Hornsea Three while reducing the risk of flooding at the onshore HVAC booster station area 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); and
- 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 onshore HVAC booster station area in line with The SuDS Manual (2015), which indicates that the flow rate discharged from the onshore HVAC booster station area must not exceed that prior to the proposed development for the:

- 1 in 1 year event;
- Greenfield runoff rate (Qbar);
- 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 (National SuDS Working Group, 2004) and the Non-statutory technical standards for sustainable drainage systems (Defra, 2015). The EA/Defra recommended methodology for sites with an area up to 50 ha, is the Institute of Hydrology Report 124 method (Institute of Hydrology, 1994). The runoff rates were calculated using the MicroDrainage software suite and are present within Table 4.2.

4.3.4 Greenfield runoff rate characteristics

4.3.4.1 The proposed land use is an onshore HVAC booster station with an operational life of 35 years. The greenfield runoff 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: 10,000 m^2;
- Standard-period Average Annual Rainfall: 605 mm/year;
- Soil: 0.400 (global soil index); and
- Region No: 5 (catchment based on Flood Studies Report Figure I.2.4.).

Table 4.2: Greenfield runoff characteristics.

Annual Probability (Return Period, years)	Current (Greenfield) Runoff (l/s)
100% (1)	2.50
Qbar	2.90
3.33% (30)	6.90
1% (100)	10.20
1% + 20% Climate Change	12.24
1% + 40% Climate Change	14.28

4.3.5 Attenuation requirements

4.3.5.1 The attenuation volume required to restrict the surface water runoff rate from low permeable surfacing to 2.50 l/s the existing 1 in 1 year rate for a 1 in 100-year rainfall event plus climate change (40%) has been determined using the industry standard MicroDrainage software suite incorporating the following parameters:

- Impermeable Area: approximately 10,000 m^2;
- 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: 2.50 l/s; and
- Assuming no infiltration losses.

4.3.5.2 The system was modelled within MicroDrainage as a tank/pond with controlled discharge via an orifice outflow control. The MicroDrainage calculation sheets are included within section A.7.

4.3.5.3 The attenuation volume required to restrict runoff from a 1 in 100-year storm event, plus a 40% allowance for climate change, to 2.50 l/s, is approximately 1,050 m^3 for the onshore HVAC booster station area. Appendix A, section A.10 illustrates the outline drainage strategy for the onshore HVAC booster station and demonstrates that the required attenuation volume can be practicably provided within the onshore HVAC booster station area.

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 PPG ID7 has been undertaken for the onshore HVAC booster station area, located 2.7 km north of the village Saxthorpe.

4.4.2 Flood risk

4.4.2.1 In accordance with the guidance on development and flood risk (PGG: ID7 Flood risk and coastal change) the FRA provides a response to the aims set out in 1.1.1.5:

- EA 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%)).
- There is no historical evidence of flooding at the onshore HVAC booster station area.
- The onshore HVAC booster station area is located within a flat lying and primarily agricultural landscape, indicating that the potential surface water flood risk to the onshore HVAC booster station area 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.
- The onshore HVAC booster station area has been assessed to be at low to medium risk of groundwater flooding.
- The risk of flooding from infrastructure failure including adopted sewers is considered to be low.
- The onshore HVAC booster station area is not at risk of flooding from a reservoir failure.
- The onshore HVAC booster station 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.
- The onshore HVAC booster station is located within EA Flood Zone 1 and SFRA Flood Zone 1. Therefore, there is no requirement for either a Sequential or Exceptions Test.
- There will be an increase in low permeability cover; and surface runoff will need to be controlled at an agreed runoff rate. MicroDrainage calculations indicate that the overall attenuation requirement for the 10,000 m^2 impermeable development area assuming no loss via infiltration is 1,019 m^3 for the 1 in 100 year storm event plus 40% allowance for climate change.

4.4.3 Conclusion

4.4.3.1 This FRA and supporting documentation shows that the onshore HVAC booster station at this location meets the requirements of NPS EN-1 and the NPPF.

5. Onshore HVDC Converter/HVAC Substation Area Flood Risk Assessment

5.1 Site setting

5.1.1 Location

5.1.1.1 The proposed onshore HVDC converter/HVAC substation area is located at National Grid Reference TG 21000 03541 approximately 5.6 km south west of Norwich City Centre (Figure 5.1). The onshore HVDC converter/HVAC substation area 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 onshore HVDC converter/HVAC substation area is gained via Main Road (B113).

5.1.2 Existing use

5.1.2.1 The onshore HVDC converter/HVAC substation area contains no buildings, structures or development and its topography slopes from the east to the west. It is currently used for agricultural purposes with enclosed fields separated by hedges.

5.1.3 Proposed use

5.1.3.1 It is proposed that a HVDC converter/HVAC substation will be constructed as part of Hornsea Three (as described in volume 1, chapter 3: Project Description). 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 The onshore HVDC converter/HVAC substation and associated permanent infrastructure will occupy an area up to 14.9 ha. The onshore HVDC converter/HVAC substation is expected to have an operational life of 35 years. For the purpose of this FRA, the maximum design scenarios are identified in volume 3, chapter 2: Hydrology and Flood Risk and are summarised below:

- The HVDC converter/HVAC substation site area (including all above ground permanent infrastructure, internal circulation roads, fencing, buildings and landscaping): 149,302 m^2, of which:
  - Approximately 60,000 m^2 comprises above ground permanent infrastructure, internal circulation roads, fencing, buildings; and
  - Approximately 80,900 m^2 comprises permeable surfacing, including ground permanent infrastructure, gravelled areas, landscaping etc.

5.1.4 Flood Risk Assessment

Hydrological Overview

5.1.4.1 The location of EA designated main rivers and ordinary watercourses within the Hornsea Three hydrology and flood risk study area are shown on Figure 5.1. There are no main rivers in the Hornsea Three hydrology and flood risk study area at the onshore HVDC converter/HVAC substation, however there are several ordinary watercourses.

Fluvial and tidal flooding

5.1.4.2 The EA's flood map (Figure 5.1) indicates that the onshore HVDC converter/HVAC substation area 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 EA's flood mapping indicating that the onshore HVDC converter/HVAC substation area is located within Flood Zone 1.

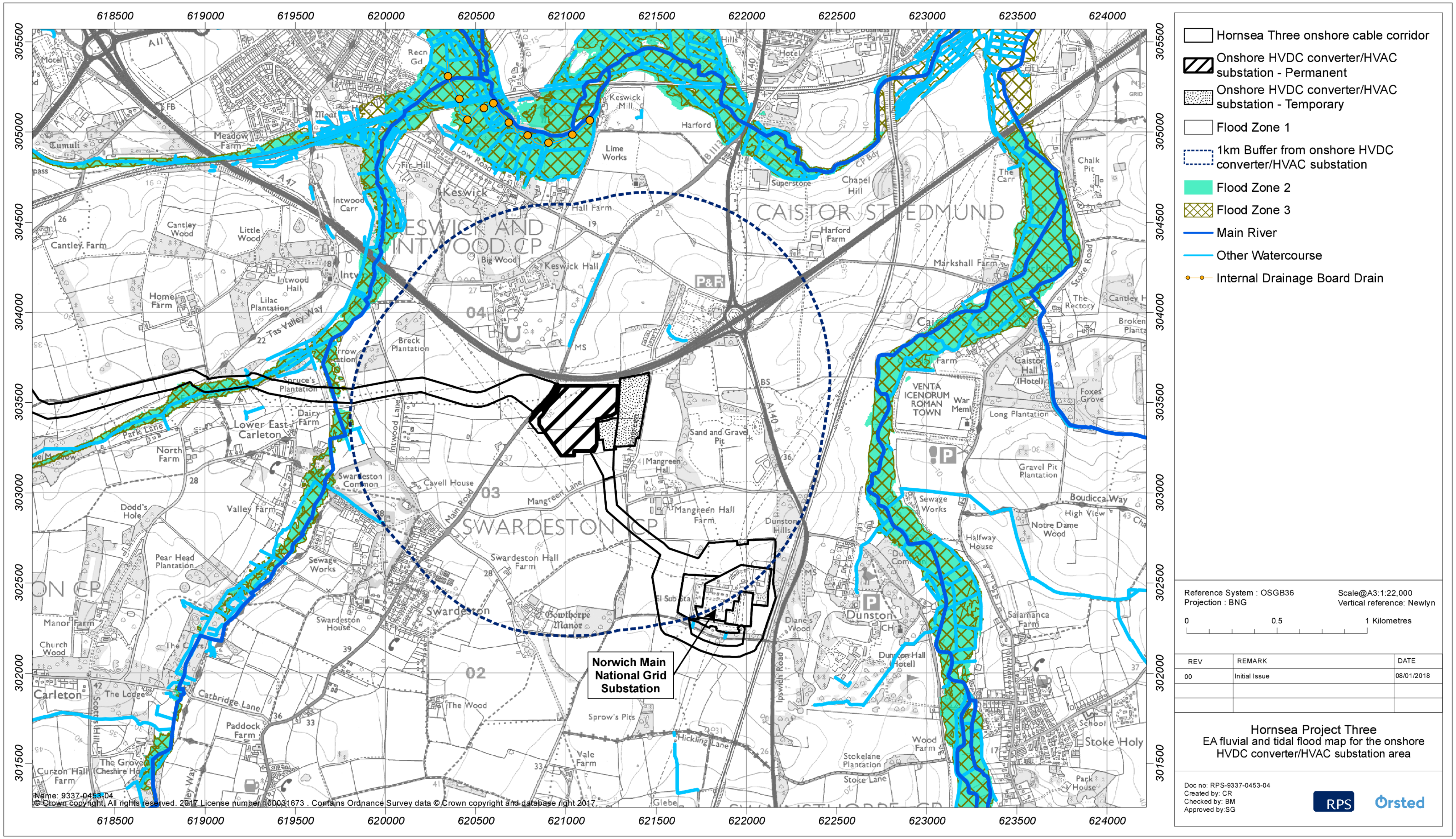

Figure 5.1: EA fluvial and tidal flood map for the onshore HVDC converter/HVAC substation area.

Flooding from rising/high groundwater

5.1.4.4 BGS geology online map (accessed March 2017) indicates that the onshore HVDC converter/HVAC substation area 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 EA 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. This takes into account underlying granular geological characteristics, and absence of historical groundwater flood events.

Source Protection Zones

5.1.4.8 EA mapping shows the onshore HVDC converter/HVAC substation area is not located within a groundwater Source Protection Zone (see annex 1.2: Abstraction Licences and Source Protection Zones)

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 EA'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 onshore HVDC converter/HVAC substation area 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 EA mapping shows that the onshore HVDC converter/HVAC substation area is not at risk of reservoir flooding.

Flood defence measures

5.1.4.13 EA and SFRA mapping indicates that there are no flood defences within the immediate vicinity of the onshore HVDC converter/HVAC substation area.

Sewer/water main failure assessment

5.1.4.14 As the onshore HVDC converter/HVAC substation area 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 onshore HVDC converter/HVAC substation area the overall risk of flooding via artificial drainage system to the onshore HVDC converter/HVAC substation area has been assessed to be low.

Historic flooding

5.1.4.18 Norfolk County Council, SFRA and Flood Risk Management Strategy (Norfolk County Council, 2010) mapping indicates that the onshore HVDC converter/HVAC substation area has not been affected by historical flooding.

Current flood risk

5.1.4.19 The onshore HVDC converter/HVAC substation area 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 onshore HVDC converter/HVAC substation area is from groundwater sources.

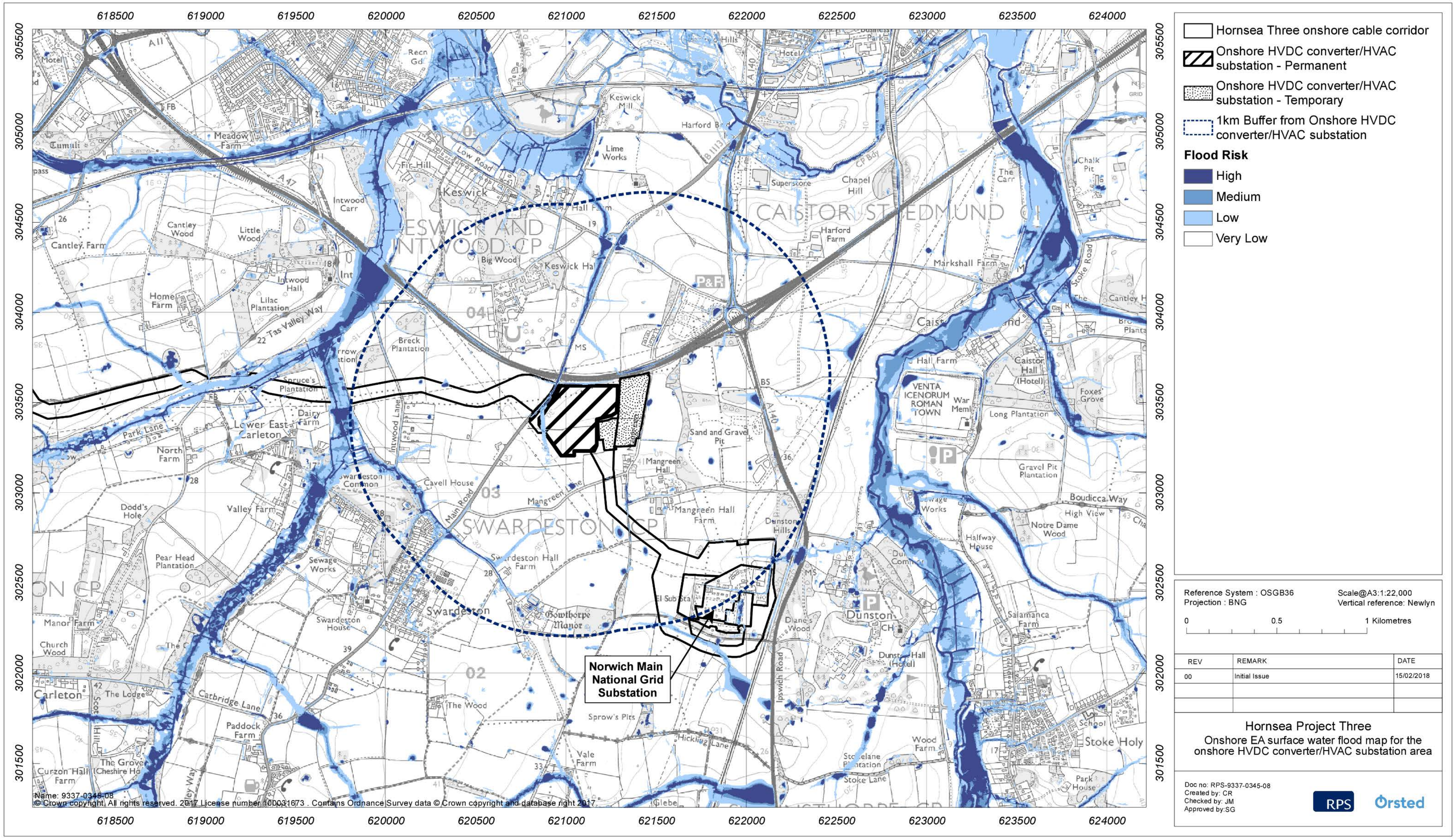

Figure 5.2: Onshore EA surface water flood map for the onshore HVDC converter/HVAC substation area.

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 (Department for Communities and Local Government, 2014), the onshore HVDC converter/HVAC substation is 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 LPAs allocating land in 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 Norfolk County Council SFRA flood mapping shows that the onshore HVDC converter/HVAC substation area 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 onshore HVDC converter/HVAC substation area 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, 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); and
- 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 onshore HVDC converter/HVAC substation area in line with The SuDS Manual (2015), which indicates that the flow rate discharged from the onshore HVDC converter/HVAC substation area must not exceed that prior to Hornsea Three for the:

- 1 in 1 year event;
- Qbar;
- 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 (National SuDS Working Group, 2004) and the Non-statutory technical standards for sustainable drainage systems (Defra, 2015). The EA/Defra recommended methodology for sites up to 50 ha, in area is the Institute of Hydrology Report 124 method (Institute of Hydrology, 1994). The runoff rates were calculated using the MicroDrainage software suite and are present within Table 5.2.

5.3.4 Greenfield runoff rate characteristics

5.3.4.1 The proposed land use (as noted in Section 3.3) is an onshore HVDC converter/HVAC substation with an operational life of 35 years. The greenfield runoff rates are based on the current site baseline, assumed to be 100% permeable surfacing.

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

- Area: 60,000 m^2;
- Standard-period Average Annual Rainfall: 605 mm/year;
- Soil: 0.400; and
- Region No: 5.

Table 5.2: Greenfield runoff characteristics.

Annual Probability (Return Period, years)	Greenfield Runoff (l/s)
100% (1)	15.00
Qbar	17.20
3.33% (30)	41.30
1% (100)	61.30
1% + 20% Climate Change	73.56
1% + 40% Climate Change	85.82

5.3.5 Attenuation requirements

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

- Impermeable area: approximately 60,000 m^2 (assumed 100% impermeable area);
- 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: 15.00 l/s; and
- Assuming no infiltration losses.

5.3.5.2 The system was modelled within MicroDrainage as a tank/pond with controlled discharge via an orifice outflow control. The MicroDrainage calculation sheets are included within section B.7.

5.3.5.3 The attenuation volume required to restrict runoff from a 1 in 100 year storm event, plus a 40% allowance for climate change, to the 1 in 1 year (100% annual probability) current runoff rate of 15.00 l/s, has been determined to be approximately 7,500 m^3 for the onshore HVDC converter/HVAC substation area. Appendix B, section B.11, illustrates the outline drainage strategy for the onshore HVDC converter/HVAC substation and demonstrates that the required attenuation volume can be practicably provided within the HVDC converter/HVAC substation area.

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 onshore HVDC converter/HVAC substation area, located approximately 5.6 km south west of Norwich City Centre.

5.4.2 Flood risk

5.4.2.1 In accordance with the guidance on development and flood risk (PGG: ID7 Flood risk and coastal change) the FRA provides a response to the aims set out in 1.1.1.5:

- EA 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%)).
- There is no historical evidence of flooding at the onshore HVDC converter/HVAC substation area.
- The onshore HVDC converter/HVAC substation area 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 EA surface water flood map indicates that localised areas within the northern and western extent of the onshore HVDC converter/HVAC substation area are at low risk of surface water flooding.
- The onshore HVDC converter/HVAC substation area has been assessed to be at low to medium risk of groundwater flooding.
- The risk of flooding from infrastructure failure including flood defences and adopted sewers is considered to be low.
- The onshore HVDC converter/HVAC substation area is not at risk of flooding from a reservoir failure.
- The onshore HVDC converter/HVAC substation 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.
- The onshore HVDC converter/HVAC substation is located within EA Flood Zone 1 and SFRA Flood Zone 1 therefore there is no requirement for either a Sequential or Exception Test.
- There will be an increase in low permeability cover; and surface runoff will need to be controlled at an agreed runoff rate. MicroDrainage calculations indicate that the overall attenuation requirement for the 60,000 m^2 development assuming no loss via infiltration is 7,500 m^3 for the 1 in 100 year storm event plus a 40% allowance for climate change.

5.4.3 Conclusion

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

6. Hornsea Three Onshore Cable Corridor Flood Risk Assessment

6.1 Methodology

6.1.1.1 The approach to the Hornsea Three onshore cable corridor FRA was discussed and agreed with Norfolk County Council (acting as LLFA for the Hornsea Three hydrology and flood risk study area) during a meeting in November 2017. The FRA focused on areas where the Hornsea Three onshore cable corridor crosses land assessed as Flood Zone 2 and 3, medium to high risk of flooding.

6.2 Site setting

6.2.1 Location

6.2.1.1 The proposed Hornsea Three onshore cable corridor runs approximately 55 km from the landfall location to the onshore HVDC converter/HVAC substation south of Norwich City Centre (Figure 6.1). The Hornsea Three onshore cable corridor runs through a predominantly agricultural land uses together with areas of heathland, valley mires and woodland. The landscape is relatively flat lying with elevations reaching 100 m Above Ordinance Datum (AOD) near Sheringham.

6.2.2 Existing use

6.2.2.1 Hornsea Three onshore cable corridor passes through the EA designated Anglian River Basin District which covers 27,890 km^2 from Lincolnshire in the north to Essex in the south. The landscape ranges from gentle chalk and limestone ridges to the extensive lowlands of the fens and East Anglian coastal estuaries and marshes. The river basin district is predominantly rural, with more than half of its land surface (c. 1.5 million ha) used for agriculture and horticulture.

6.2.3 Proposed use

6.2.3.1 The Hornsea Three onshore cable corridor will extend from the landfall at Weybourne to the onshore HVDC converter/HVAC substation to the south of Norwich. For the purpose of this FRA, the maximum design scenarios are identified in volume 3, chapter 2: Hydrology and Flood Risk and are summarised below:

- Onshore cable corridor (approximately 80 m wide, comprising 60 m permanent area and 20 m temporary working area);
- Up to six cable trenches, each trench is up to 5 m wide at the ground level;
- Up to 440 jointing bays and 440 link boxes;
- Up to 120 Horizontal Directional Drilling (HDD) locations (per phase) comprising up to 105 minor HDDs and 15 major HDDs) – some of these will be watercourse crossings;
- Up to 15 HDD compounds;
- Up to six crossings of watercourses using open cut techniques;
- Up to five secondary compounds (compounds also at the Hornsea three landfall and at the onshore HVDC converter/HVAC substation);
- Up to 55 storage areas; and
- Up to 66 km of temporary haul road surfaced with aggregate on geotextile.

6.2.3.2 Location of compounds can be seen on Figure 6.1. The location of the HDDs is shown on the crossing schedule which accompanies the DCO application.

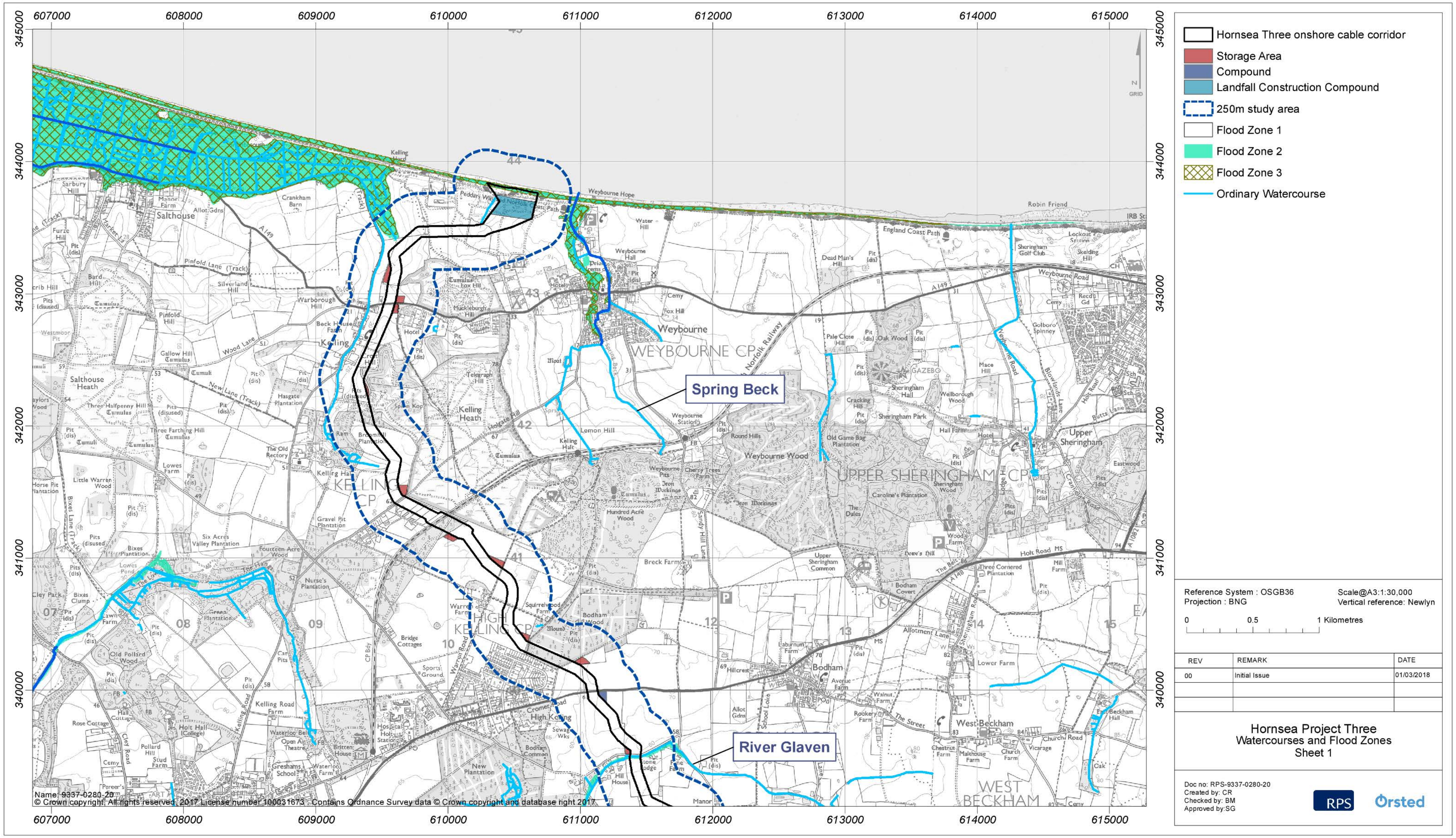

Figure 6.1: Watercourses and Flood Zones.

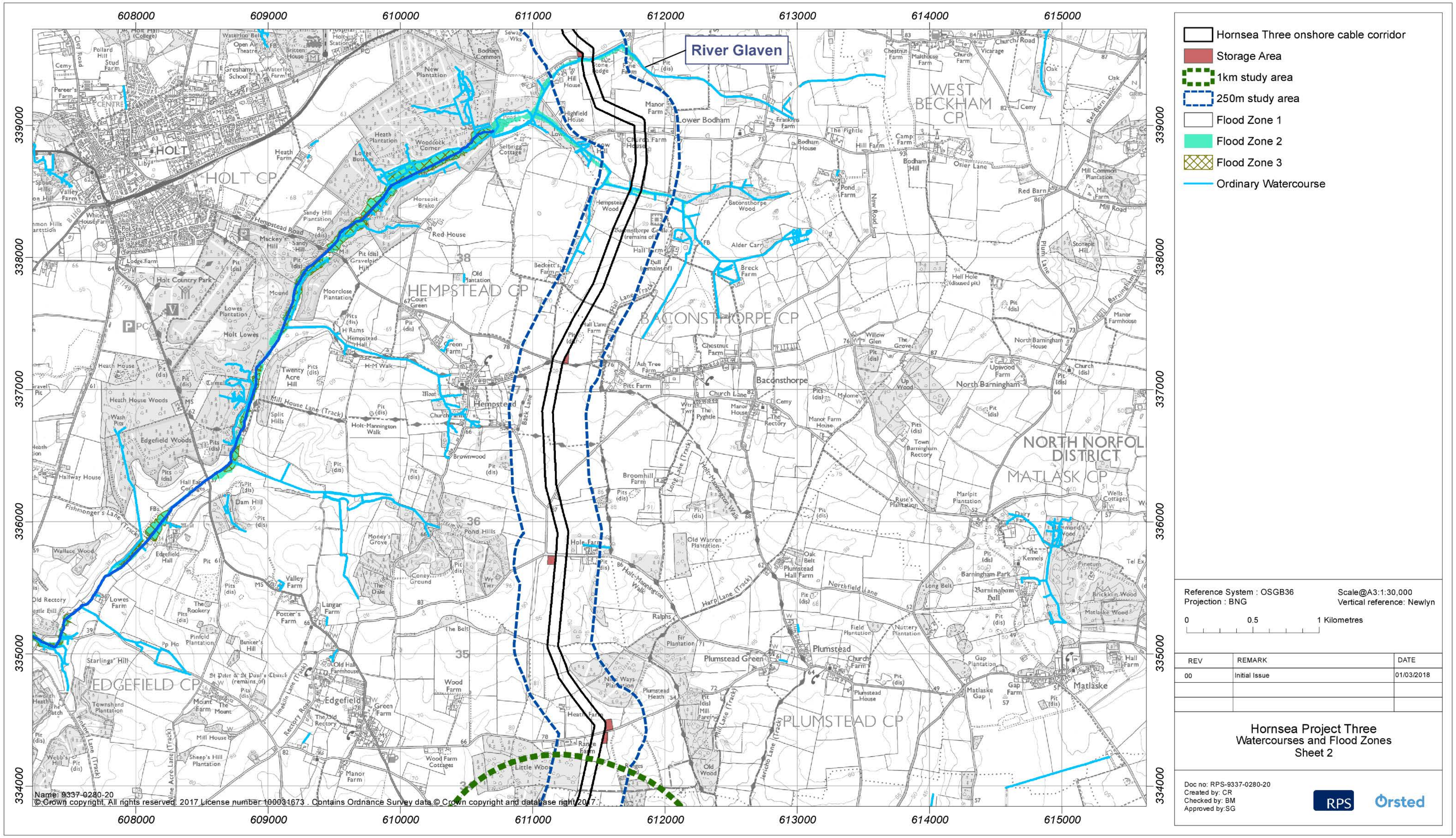

Figure 6.1: Watercourses and Flood Zones.

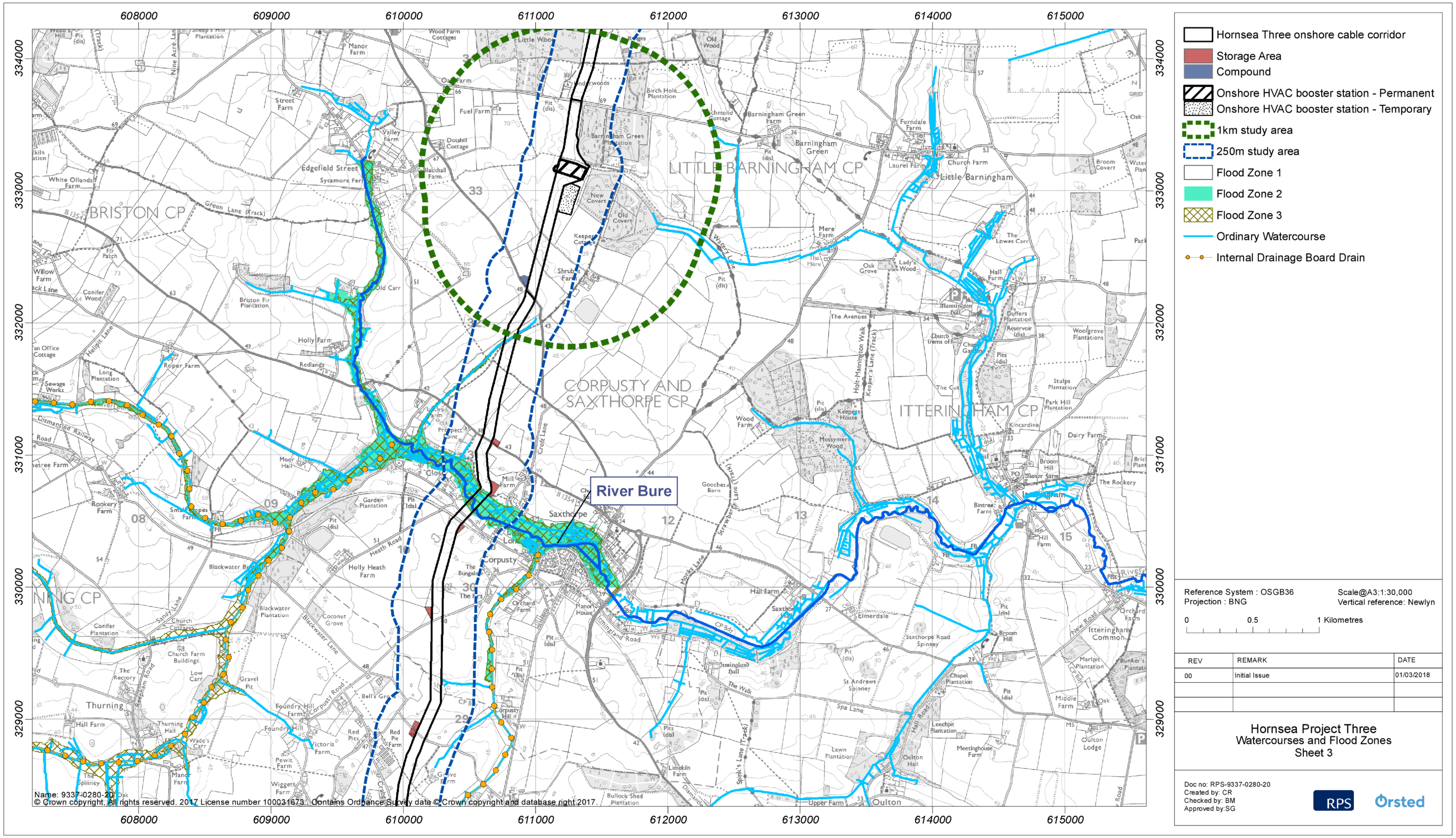

Figure 6.1: Watercourses and Flood Zones.

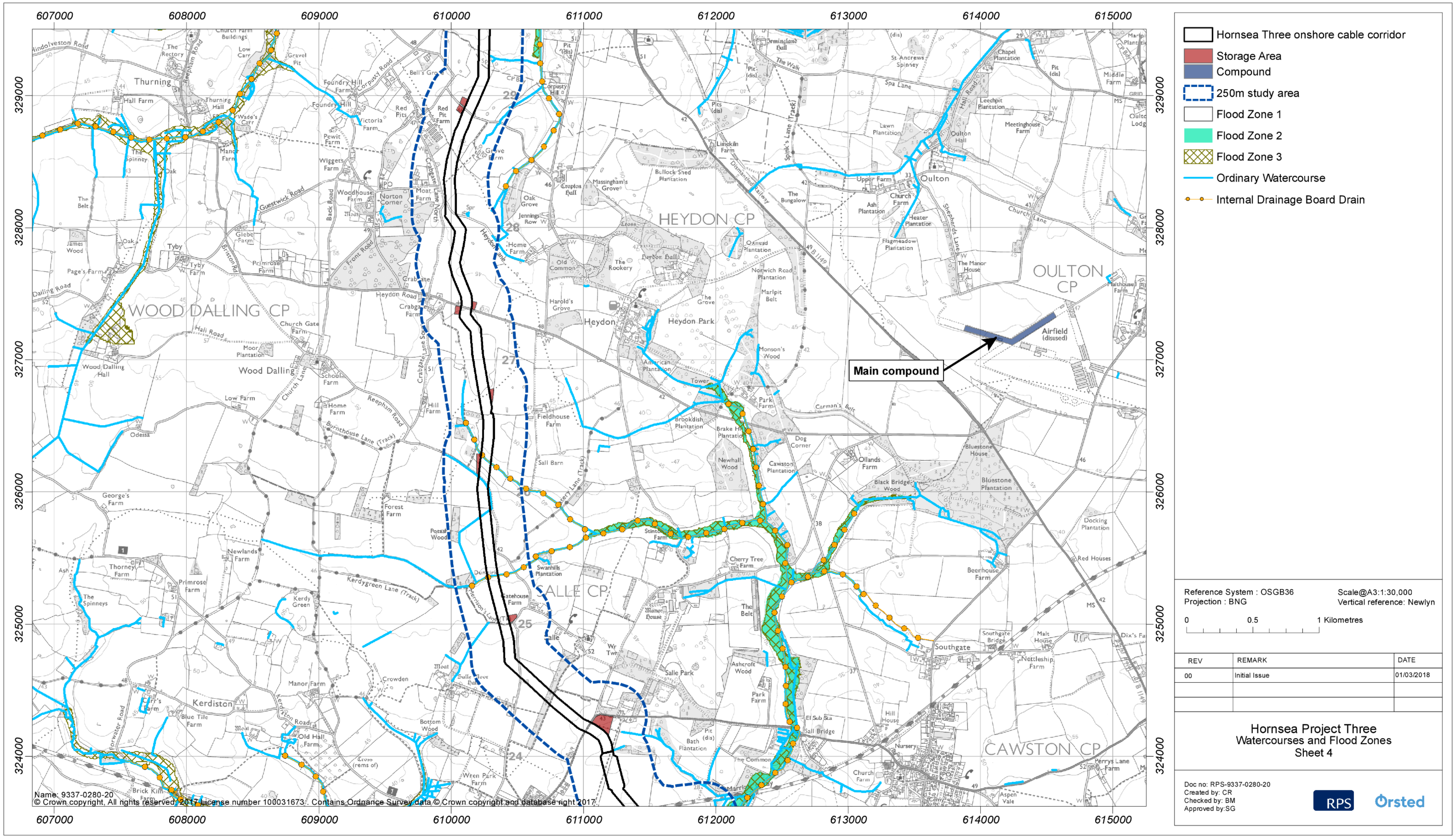

Figure 6.1: Watercourses and Flood Zones.

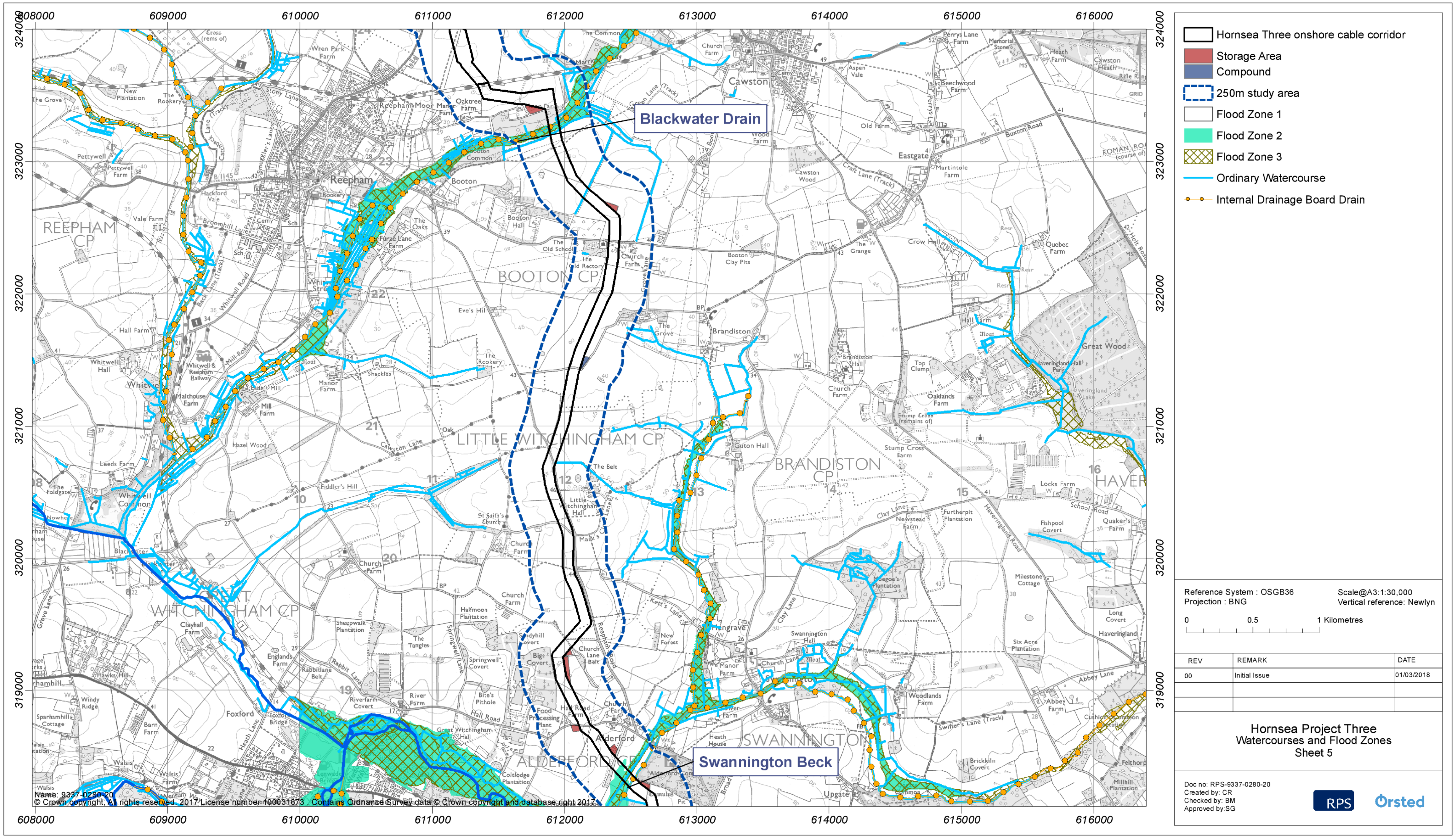

Figure 6.1: Watercourses and Flood Zones.

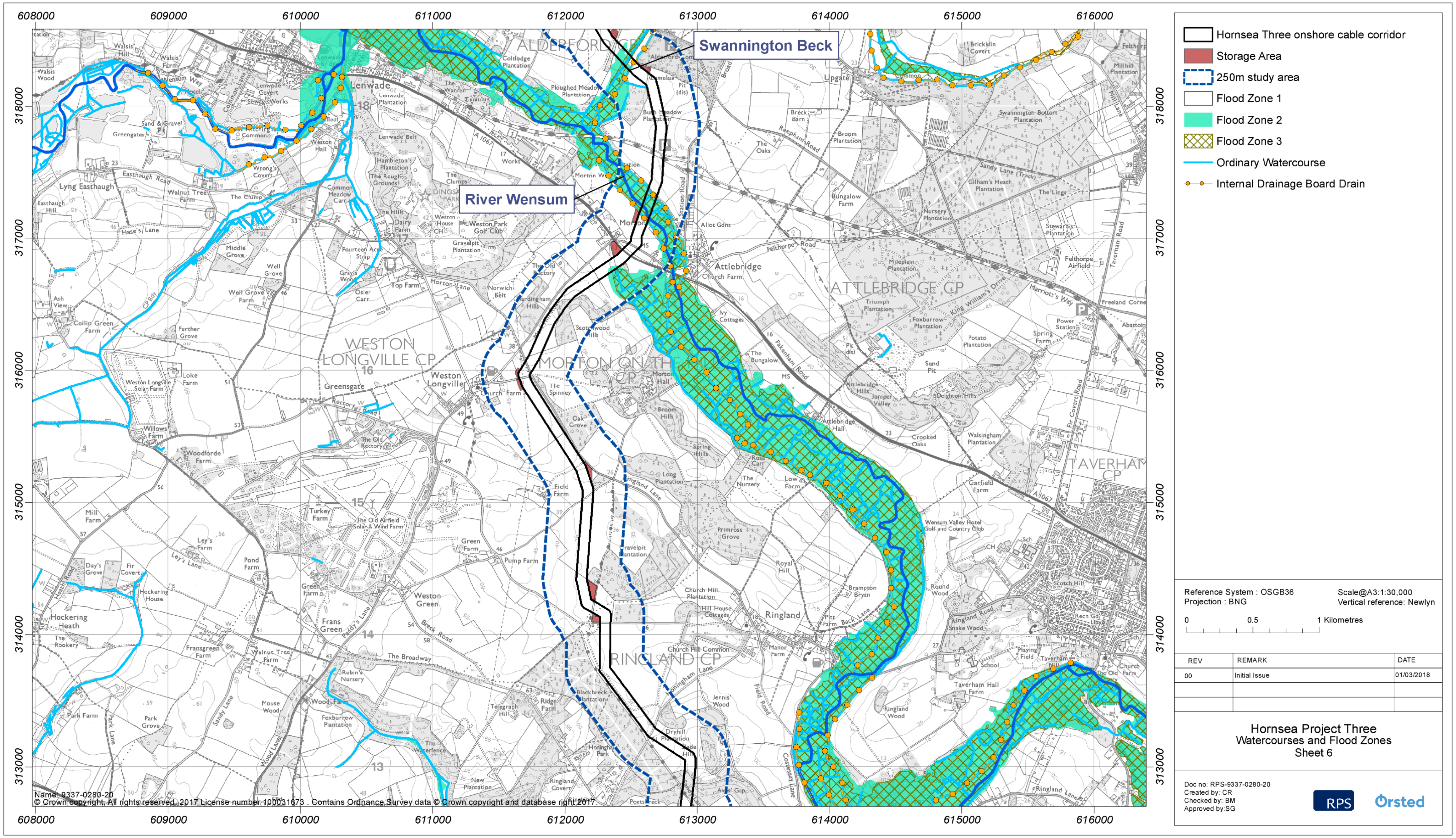

Figure 6.1: Watercourses and Flood Zones.

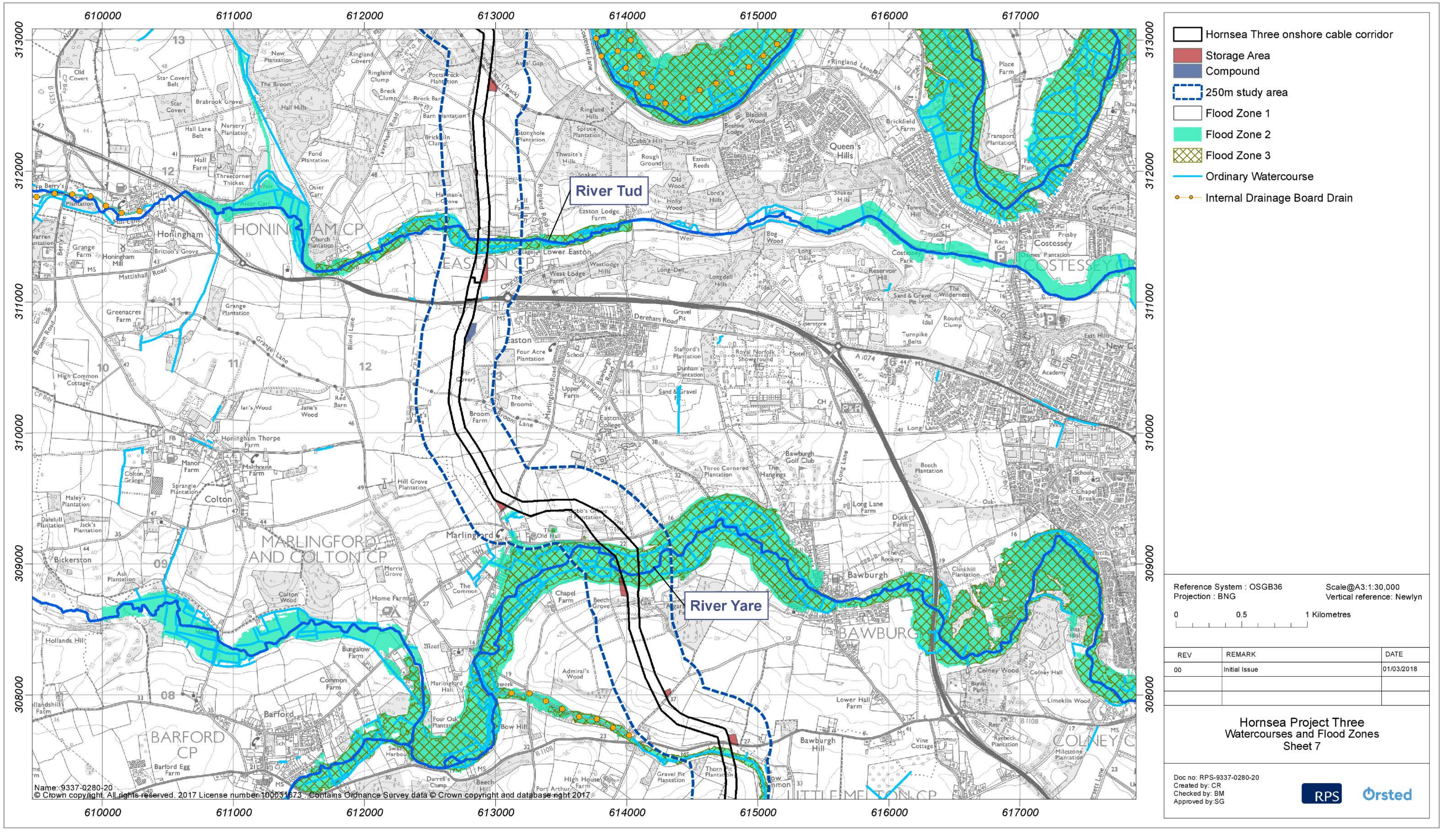

Figure 6.1: Watercourses and Flood Zones.

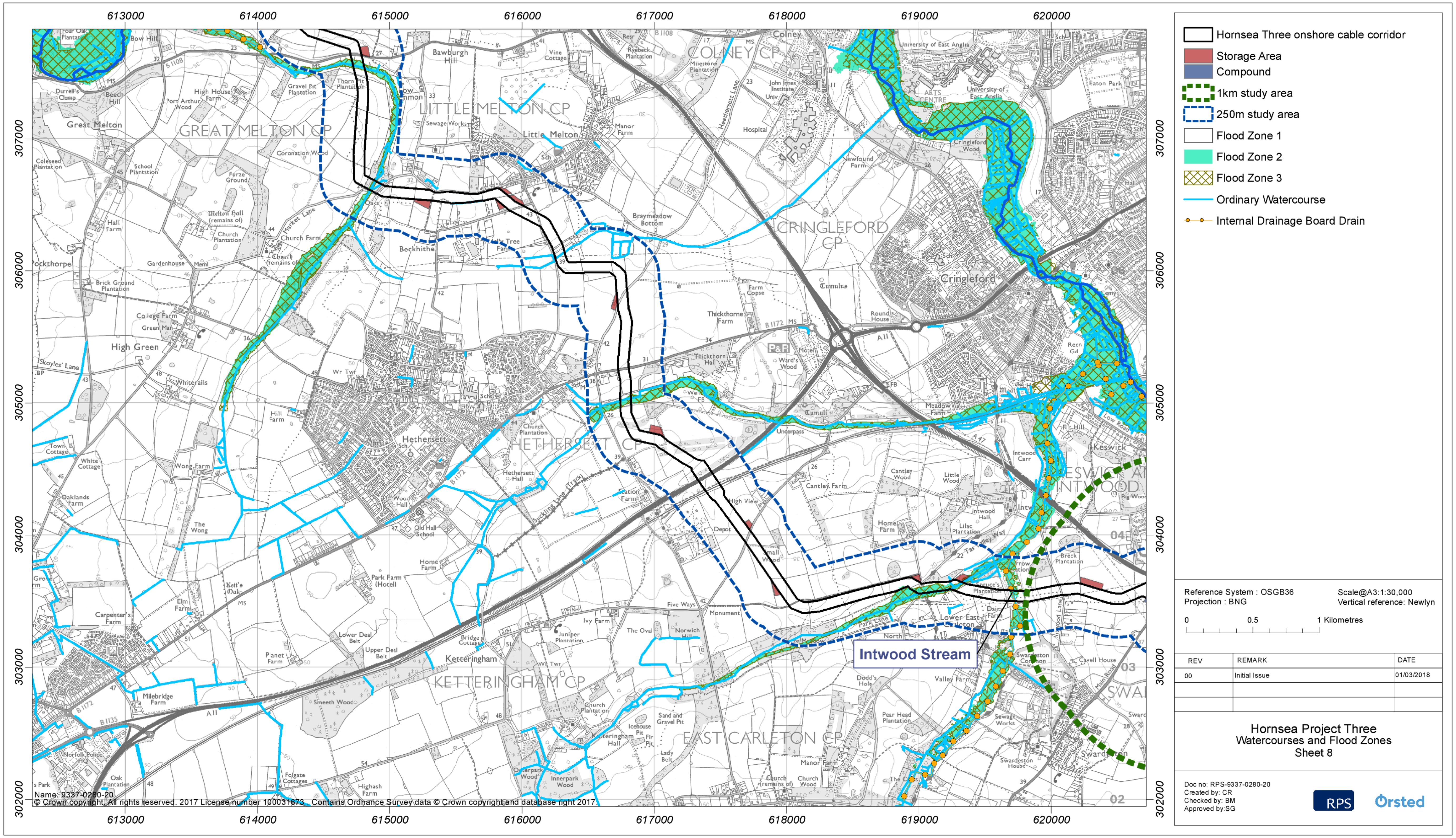

Figure 6.1: Watercourses and Flood Zones.

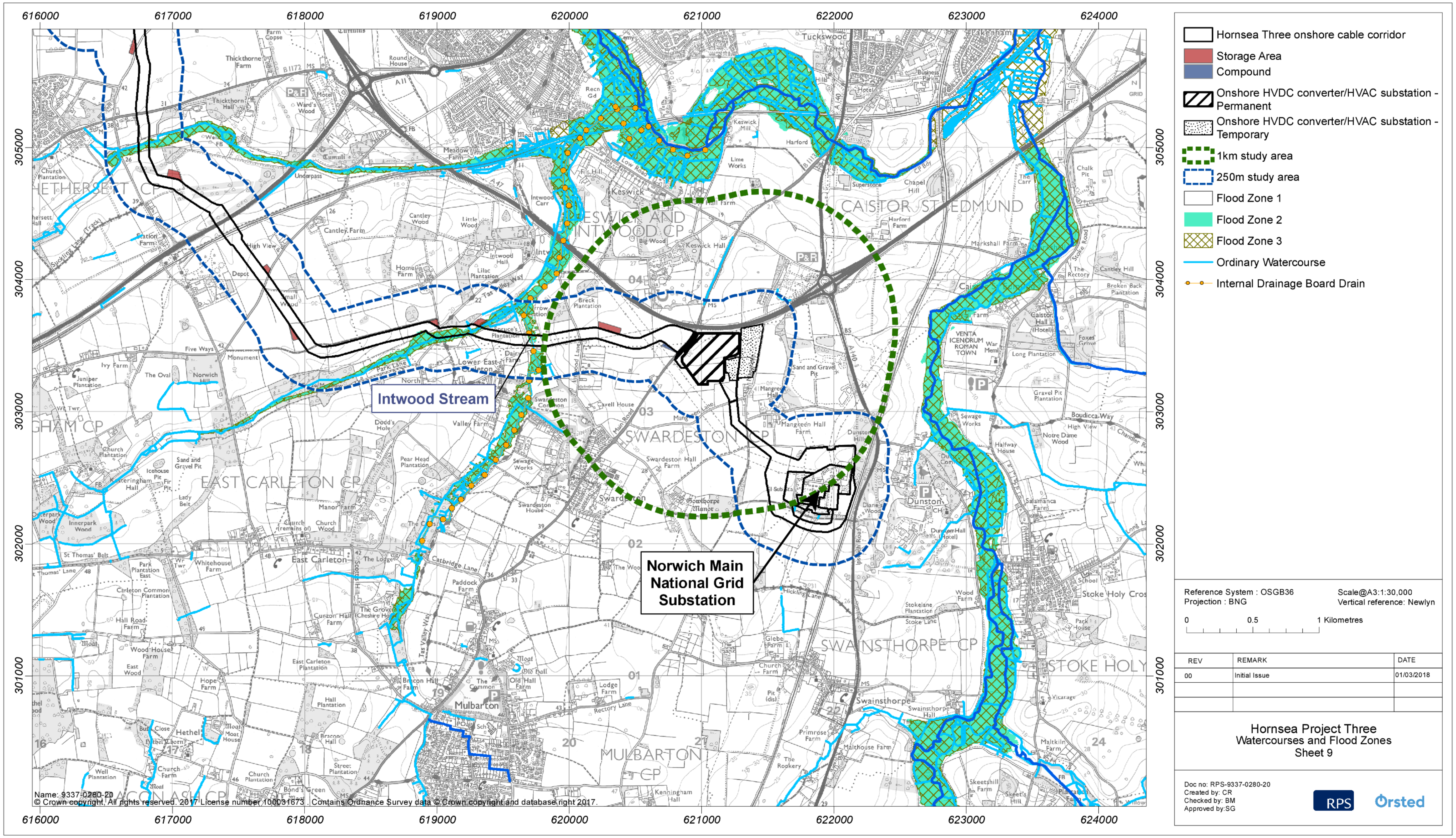

Figure 6.1: Watercourses and Flood Zones.

6.2.4 Flood Risk Assessment

Hydrological overview

6.2.4.1 This section assesses the baseline hydrological characteristics of the Hornsea Three onshore cable corridor. A 250 m buffer was selected for the Hornsea Three onshore cable corridor to identify any potential receptors that might be affected by the Hornsea Three onshore cable corridor. The 250 m buffer is considered an appropriate buffer to identify changes in flood risk in the surrounding area.

6.2.4.2 The Hornsea Three onshore cable corridor crosses a number of catchments associated with EA designated main rivers and ordinary watercourses. The Hornsea Three onshore cable corridor also passes through an IDB area managed by Norfolk Rivers IDB. The Board's drainage and water level management infrastructure consists of a number of watercourses, of varying sizes, which all discharge by gravity into EA designated main rivers. The IDB maintains only the most critical ordinary watercourses (i.e. that are not main rivers), which equates to around 25% of the total length of ordinary watercourses in the IDB district.

6.2.4.3 This section will focus on areas where the Hornsea Three onshore cable corridor crosses areas designated within Flood Zone 2 and 3. The areas which are assessed within the sections are outlined below.

Fluvial flood risk

6.2.4.4 The EA Flood Map for Planners indicates that the majority of the Hornsea Three onshore cable corridor is located in areas defined as Flood Zone 1 (land assessed as having a less than 1 in 1,000 annual probability of river or sea flooding (<0.1%)). Localised areas along the Hornsea Three onshore cable corridor associated with main rivers and ordinary watercourses including, the unnamed stream near Salle, Blackwater Drain, Swannington Beck, River Wensum, River Tud, River Yare, unnamed tributary of the River Yare at Little Melton and Intwood Stream are shown to be within Flood Zone 3. Full details of the areas within Flood Zones 2 and 3 associated with each watercourse are outlined below and in Table 6.1.

River Glaven (Gunthorpe Stream)

6.2.4.5 An area approximately 1.46 ha either side of Gunthorpe Stream is designated as being within Flood Zone 2, designated as at medium risk of fluvial flooding.

River Bure

6.2.4.6 An area equalling approximately 12.29 ha either side of the River Bure is designated as being within Flood Zone 2 and at medium risk of fluvial flooding. A smaller area equalling 10.40 ha, either side of the River Bure is designated being within Flood Zone 3 at high risk of fluvial flooding. Smaller field drains are present north of the River Bure which may contribute to the flood risk within the area.

Blackwater Drain

6.2.4.7 An area equalling approximately 4.65 ha either side of Black Water Drain is designated as being within Flood Zone 2. A smaller area equalling approximately 3.92 ha is designated as being within Flood Zone 3.

Swannington Beck

6.2.4.8 A localised area along the banks of the field drain north of Swannington Beck is designated as being within Flood Zone 2 and 3, at high risk of fluvial flooding. An area approximately 2.96 ha along Swannington Beck is designated as being within Flood Zone 3.

River Wensum

6.2.4.9 The land immediately adjacent to the River Wensum within the Hornsea Three hydrology and flood risk study area is designated as Flood Zone 3, at high risk of fluvial flooding with the area equalling 11.75 ha. To the south west of the Hornsea Three hydrology and flood risk study area, south of Fakenham Road, outside of the IDB boundary, the area around the drainage dykes is also classified as in Flood Zones 3 and 2.

River Tud

6.2.4.10 The land to the south of the River Tud is designated as Flood Zone 2 (approximate area 8.15 ha) and 3 (approximate area 6.82 ha), at high risk of fluvial flooding. The area to the north of the site rises steeply which has contributed to the area being designated as Flood Zone 1.

River Yare

6.2.4.11 The areas north and south of the River Yare are designated as Flood Zone 2 and 3, at high risk of fluvial flooding. The approximate area within Flood Zone 3 equals 20.35 ha. The area at risk of flooding mirrors the area of the IDB boundary but generally extends approximately 30 m further from the river.

Intwood Stream

6.2.4.12 The majority of the Hornsea Three hydrology and flood risk study area at the Intwood Stream crossing point is within Flood Zone 1. A small area (3.69 ha) associated with flat lying ground is within Flood Zone 3 at high risk of fluvial flooding. An area associated with the unnamed stream to the west of Intwood Stream is designated as Flood Zone 2 and 3.

Tidal flood risk

6.2.4.13 Flooding from tidal sources occur when water levels from the sea (i.e. tidal surge) raise above ground levels / flood defences within coastal areas.

6.2.4.14 By virtue of ground elevation, the onshore landfall site is located within Flood Zone 1. The intertidal zone associated with Weybourne Beach is located within Flood Zone 2 and 3.

6.2.4.15 Due to the land characteristics and topography of the areas associated with the onshore landfall tidal flooding has not be considered further within this assessment. Mitigation measures and management strategies to address onshore and intertidal flood risk are presented in the Outline Code of Construction Practice (CoCP) (document reference A8.5).

Table 6.1: Flood zone areas associated with watercourses.

Watercourse	Flood Zone 2 (ha)	Flood Zone 3 (ha)
Blackwater Drain	4.65	3.92
Intwood Stream	4.78	3.69
River Bure	12.29	10.40
River Glaven (Gunthorpe Stream)	1.46	0.00
River Tud	8.15	6.82
River Wensum	13.12	11.75
River Yare	23.20	20.35
Swannington Beck	7.31	2.96

Flooding from rising/high groundwater

6.2.4.16 The majority of the Hornsea Three onshore cable corridor is underlain by superficial deposits predominantly made up of different glacial deposits. In the northern part of the Hornsea Three hydrology and flood risk study area, the valley floors are dominated by Alluvium and Head. Peat is also present near Beach Lane at the Hornsea Three intertidal area (refer to volume 3, chapter 1: Geology and Ground Conditions for further details on superficial and bedrock deposits).

6.2.4.17 The bedrock underlying the northern and central part of the Hornsea Three onshore cable corridoris split between the Lewes Nodular Chalk of the White Chalk Subgroup (in the west) and the Wroxham Crag Formation (in the east). The rest of the Hornsea Three onshore cable corridor is underlain by Lewes Nodular Chalk of the White Chalk Subgroup.

6.2.4.1 In North Norfolk, the chalk aquifer is dominated by groundwater flow via fissures and bedding planes, which tend to be more prevalent in the top 30 to 60 m of the chalk leading to a high flow potential at these depths. Depth to groundwater and groundwater flow direction is heavily influenced by the overlying topography. Seasonal fluctuations in groundwater levels are likely to occur based on the low storage capacity of the chalk with such variation being more prevalent towards the higher topographic areas. The Wroxham Crag Formation is less utilised as a source groundwater due to its unconsolidated nature (i.e. loose material making construction and use of abstraction wells more problematic than the underlying chalk).

6.2.4.2 The chalk is designated as a principal aquifer, which is defined by the BGS 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. In most cases, principal aquifers as aquifers previously designated as major aquifers*".

6.2.4.3 Based on the information outlined above the potential for groundwater flooding is considered to be at low to medium. This is based on the author's professional judgement and takes into account underlying geological characteristics and absence of historical groundwater flood events.

Surface water flooding

6.2.4.4 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.

6.2.4.5 Localised areas along the Hornsea Three onshore cable corridor are defined as being at 'low to high' risk of flooding from surface water. However, the Hornsea Three onshore cable corridor following instillation will not be impacted or cause any adverse effect of surface water flooding.

Reservoir failure assessment

6.2.4.6 Localised areas along the Hornsea Three onshore cable corridor are within an area designated as being within the maximum extent of flooding from a reservoir.

6.2.4.7 However, the EA stipulate that a reservoir dam failure is an unlikely event. All large reservoirs are inspected and supervised by reservoir panel engineers. As the enforcement authority for the Reservoirs Act 1975 in England, the EA ensure that reservoirs are inspected regularly and essential safety work is carried out where required.

6.2.4.8 Taking into account the above, the overall risk of flooding from a reservoir failure has been assessed to be low.

Flood defence measures

6.2.4.9 EA Spatial Flood Defence data indicates a number of flood defences are present along the Hornsea Three hydrology and flood risk study area. The main flood defences are associated with river flood defences along the banks outlined in Table 6.2.

Table 6.2: EA flood defences.

Watercourses	Asset Type	Design Standard (Year)	Condition
River Tud	High Ground (River Channel)	5	3
River Yare	High Ground	5	3
River Bure	High Ground (Maintained Channel Bank)	5	3
River Wensum	High Ground (Main River Channel)	10	3
Intwood Stream	High Ground	0	3

6.2.4.10 The onshore cable corridor will cross main rivers and any ordinary watercourses which incorporate flood defences using HDD. Therefore, the Hornsea Three onshore cable corridor would cause no adverse effects on watercourses, the flood defence function or integrity.

Sewer/water main failure assessment

6.2.4.11 Flooding from sewerage failure occurs when a rainfall event exceeds the maximum capacity of the surrounding network. 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).

6.2.4.12 Sewerage flooding issues may occur along the Hornsea Three onshore cable corridor. However, mitigation measures, as identified in Table 2.17 of volume 3, chapter 2: Hydrology and Flood Risk, limiting the potential impact on the surrounding sewer networks, in turn being at low risk of flooding from this source.

Historic flooding

6.2.4.13 EA historic flood records indicate no historical flood events have occurred within the Hornsea Three hydrology and flood risk study area.

6.3 Flood risk management

6.3.1 Site vulnerability

6.3.1.1 Applying the Flood Risk Vulnerability Classification in Table 2 of the PPG Flood Risk and Coastal Change (Department for Communities and Local Government, 2014), the Hornsea Three onshore cable corridor is classified as "*Essential infrastructure*".

6.3.1.2 Table 3 of the PPG (Table 6.3 of this report) states that "*Essential Infrastructure*" uses are appropriate within Flood Zone 1 and 2, and also in Flood Zone 3, but subject to an Exception test.

Table 6.3: 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.					

6.3.2 Sequential and Exception Tests

6.3.2.1 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.

6.3.2.2 LPAs allocating land in 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.

6.3.2.3 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.

6.3.2.4 The development is for the installation of below ground HVAC/HVDC export cables, and can be classified as "*Essential Infrastructure*". Norfolk County Council SFRA flood mapping shows that the majority of the development is located within Flood Zone 1, with a small percentage (59.89 ha or 1.1%) located within Flood Zone 3. The development is to connect the landfall and onshore HVDC converter/HVAC substation, and therefore is unable to be routed without crossing areas within Flood Zone 3, does not increase flood risk to the surrounding area and has negligible risk of flooding to and from the development. On this basis, the Sequential Test and Exception Test are determined to be passed.

6.4 Flood mitigation measures

6.4.1.1 During construction, site workers will be made aware of areas that are located within Flood Zone 2 and 3, and of the evacuation protocol in the event of a flood. Stockpiled material and construction compounds will be located outside of the floodplain (where possible), minimising loss of floodplain storage area and reducing possibility of silt laden runoff into surrounding watercourses. In accordance with Byelaw 10 (Norfolk Rivers Internal Drainage Board, Development Control Byelaws, March 2013), no materials, Heavy Goods Vehicle's or soil stockpiles will be located within 9 m of the edge of drainage, watercourse and flood risk management features. No work will be carried out within 8 m of non-tidal water bodies unless agreed with the relevant drainage authority, EA or LLFA.

6.4.1.2 The Hornsea Three onshore cable corridor would encounter main rivers, ordinary watercourses, as well as field drains and ditches. Some of the smaller watercourses are likely to be crossed by open-cut techniques (see the Crossing Schedule which accompanies the DCO application). Mitigation measures to minimise any potential adverse effects on surrounding watercourses, increase in flood risk, degradation of agricultural land / designated sites during construction are set out in volume 3, chapter 2: Hydrology and Flood Risk and the Outline CoCP (document reference A8.5) which accompanies the DCO application.

6.4.1.3 HDD will be used to cross main rivers along the Hornsea Three onshore cable corridor. Where required, consent will be sought from local drainage authorities and/or the EA for any works within 8 m of non-tidal water bodies and 9 m from the edge of drainage and flood risk management features.

6.5 Summary and conclusions

6.5.1 Summary

6.5.1.1 A FRA in accordance with section 5.7 of the NPS EN-1, the NPPF and associated PPG ID7 has been undertaken for the proposed Hornsea Three onshore cable corridor extending approximately 55 km from the landfall to the onshore HVDC converter/HVAC substation south of Norwich City Centre.

6.5.2 Flood risk

6.5.2.1 In accordance with the guidance on development and flood risk (PGG: ID7 Flood risk and coastal change) the FRA provides a response to the aims set out in 1.1.1.5:

- EA mapping shows that the majority of 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%)). Localised areas associated with main rivers and ordinary watercourses are designated as being within Flood Zone 2 and 3.
- There is no historical evidence of flooding within the Hornsea Three hydrology and flood risk study area for the onshore cable corridor.
- The Hornsea Three onshore cable corridor 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 EA surface water flood map indicates that localised areas within the along the route are at 'low to high' risk of surface water flooding.
- The Hornsea Three onshore cable corridor has been assessed to be at low to medium risk of groundwater flooding.
- The risk of flooding from infrastructure failure including flood defences and adopted sewers is considered to be low.
- The Hornsea Three onshore cable corridor is not at risk of flooding from a reservoir failure.
- The proposed Hornsea Three onshore cable corridor 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, subject to an Exception Test.
- The Hornsea Three onshore cable corridor is to connect the landfall and onshore HVDC converter/HVAC substation, and therefore is unable to be routed without crossing areas within Flood Zone 3, does not increase flood risk to the surrounding area and has negligible risk of flooding on the development. On this basis, the Sequential Test and Exception Test are determined to be passed.
- Proposed mitigation measures will reduce any adverse impacts caused by the installation of the Hornsea Three onshore cable corridor, meaning there will be a negligible impact to the existing hydrology and flood risk to the area and designated sites.
- Following the installation of Hornsea Three onshore cable corridor, it is anticipated that it will have no adverse effects/impacts on all sources of flooding and the hydrological characteristics of the area. The Hornsea Three onshore cable corridor has therefore, been designated as at low risk of flooding from all sources.

6.5.3 Conclusion

6.5.3.1 This FRA and supporting documentation shows that the Hornsea Three onshore cable corridor meets the requirements of NPS EN-1 and the NPPF.

7. References

British Geological Survey (2017) Geology of Britain Viewer. Available online: http://mapapps.bgs.ac.uk/geologyofbritain/home.

Broadland District Council, Norwich City Council, South Norfolk Council and Norfolk County Council (2014) Joint Core Strategy for Broadland, Norwich and South Norfolk. Available online: https://www.south-norfolk.gov.uk/sites/default/files/JCS_Adopted_Version_Jan_2014.pdf.

CIRIA (2001) Report C532 Control of water pollution from construction sites. London, CIRIA.

CIRIA (2015) Report C741 Environmental good practice on site guide. 4th ed. London, CIRIA.

CIRIA (2015) Report C753 The SuDS manual. London, CIRIA.

Department for Communities and Local Government (2012) National planning policy framework. London, Communities and Local Government.

Department for Communities and Local Government (2014) Flood risk and coastal change. Available online: https://www.gov.uk/guidance/flood-risk-and-coastal-change.

Department for Environment Food and Rural Affairs (2011) National Standards for sustainable drainage systems. Designing, constructing, operating and maintaining drainage for surface runoff. London, Department for Environment Food and Rural Affairs.

Department for Environment, Food and Rural Affairs (2015) Sustainable Drainage Systems: Non-statutory technical standards for sustainable drainage systems. Available online: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/415773/sustainable-drainage-technical-standards.pdf [Accessed 18 December 2017]

Department of Energy and Climate Change (2011) Overarching national policy statement for energy (EN-1) London: Stationery Office.

Environment Agency (2009) Fluvial Design Guide. Available online: http://evidence.environment-agency.gov.uk/FCERM/en/FluvialDesignGuide.aspx.

Environment Agency (2017) Flood risk assessments: climate change allowances. Available online: https://consult.environment-agency.gov.uk/engagement/bostonbarriertwao/results/appendix-9---flood-risk-assessments-climate-change-allowances_20170203.pdf [Accessed on 18 December 2017].

Environment Agency, Defra (2006) Flood and Coastal Defence Appraisal Guidance FCDPAG4. Bristol, Environment Agency.

Groundsure (2017) Groundsure Enviro Insight. s.l., Groundsure.

Groundsure (2017) Groundsure Geo Insight. s.l., Groundsure.

Institute of Hydrology (1994) Flood estimation for small catchments. Report 124. Natural Environment Research Council

Millard Consulting (2007) Partnership of Norfolk District Councils, Strategic Flood Risk Assessment. South Norfolk District Council Area.

Murphy, J., Sexton, D., Jenkins, G., Boorman, P., Booth, B., Brown, K., Clark, R., Collins, M., Harris, G., Kendon, L. (2010) UK Climate Projections science report: Climate change projections. Version 3. Met Office Hadley Centre, Exeter.

National SuDS Working Group (2004) Interim Code of Practice for Sustainable Drainage Systems. Available online: http://www.susdrain.org/files/resources/other-guidance/nswg_icop_for_suds_0704.pdf [Accessed 18 December 2017].

Norfolk County Council (2010) 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. Norwich, Norfolk County Council.

Norfolk County Council (2015) Norfolk Local Flood Risk Management Strategy. Available online: https://www.norfolk.gov.uk/what-we-do-and-how-we-work/policy-performance-and-partnerships/policies-and-strategies/flood-and-water-management-policies/local-flood-risk-management-strategy.

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 Outline Surface Water Drainage Strategy for the Onshore HVAC Booster Station

A.1 Introduction

A.1.1.1 This Outline Surface Water Drainage Strategy was produced to support the FRA for the onshore HVAC booster station. The outline strategy is based on an indicative layout of the onshore HVAC booster station and will be developed in detail post consent.

A.2 Site information

A.2.1.1 The onshore HVAC booster station area is located 2.5 km east of the village of Edgefield. It is rectangular in shape occupying a total area of approximately 3.04 ha. Access to the onshore HVAC booster station area is currently provided via a network of farm tracks, off B1149.

A.2.1.2 No topographical survey was undertaken for the onshore HVAC booster station area. However, based on available online OS maps, the onshore HVAC booster station area has an average slope of 8% with a steady fall towards the north east. Ground levels south west and north east of the onshore HVAC booster station area are approximately 59.5m AOD and 48.5m AOD respectively.

A.2.1.3 The onshore HVAC booster station area is currently used for agricultural purposes and fully permeable. The proposed development will create a total impermeable area of 1 ha. The remaining 2.04 ha will be permeable, consisting of free draining surface chippings and landscaping.

A.2.1.4 The Qbar for the onshore HVAC booster station boundary was calculated using the Interim Code of Practice (ICP) for SuDS method. The results, attached in section A.8, shows that the Qbar based on an overall impermeable area of 1 ha is 2.5 l/s.

A.3 Policy

A.3.1.1 The NPPF requires that proposed development should not increase flood risk. Surface water runoff from the development site should not exceed that generated from the existing application site.

A.3.1.2 The National Planning Practice Guidance (NPPG) meanwhile outlines the hierarchy to be investigated by the developer when considering surface water drainage strategy. The following drainage options are to be investigated following order of priority:

1. Discharge rainwater into ground via infiltration;
2. Discharge rainwater direct to a watercourse;
3. Discharge rainwater to a surface water sewer/drain; and
4. Discharge rainwater to the combined sewer.

A.4 Surface water drainage hierarchy

A.4.1.1 The NPPF requires that proposed development should not increase flood risk. Surface water runoff from the development site should not exceed that generated from the existing application site.

A.4.1.2 Based on the NPPG, all of the drainage options are examined in detail in order to assess the feasibility of using a combination of SuDS as part of the onshore HVAC booster station.

Discharge rainwater into ground via infiltration

A.4.1.3 No soil infiltration testing was undertaken on the onshore HVAC booster station area at the time of writing due to access restrictions. Reference to the BGS online mapping (1:50,000) indicates that the onshore HVAC booster station area is underlain by superficial deposits from Briton's Lane Sand and Gravel Member. The onshore HVAC booster station area is shown to be underlain by bedrock deposits from the Lewes Nodular Chalk Formation which comprised of rock.

A.4.1.4 Reference to BGS borehole records indicates a borehole log on site (BGS reference: TG13SW5). The borehole scans shows that the onshore HVAC booster station area is underlined by sandy subsoil up to 6m below ground level (bgl) and sand between 6m and 15m bgl and clay between 15m and 24m bgl.

A.4.1.5 Due to the presence of clay, the discharge of surface water runoff into the ground via infiltration is considered not feasible.

Discharge rainwater direct to a watercourse

A.4.1.6 There are two unnamed watercourses located approximately 0.5 km from the onshore HVAC booster station western boundary and 1 km from the eastern boundary.

A.4.1.7 Surface terrain models obtained from LiDAR confirmed the presence of a ditch passing through a wooded area to the north east of the onshore HVAC booster station. This appears to connect into the unnamed ditch situated east of the onshore HVAC booster station. Figure 7.1 below illustrates the location of the ditch from the onshore HVAC booster station.

A.4.1.8 The ditch has a level of approximately 48.7m AOD - 47.7m AOD which is reflective of the topography of the onshore HVAC booster station area which fall towards the north east.

A.4.1.9 On this basis, the possibility to discharge surface water runoff generated from the onshore HVAC booster station area to the ditch will be considered.

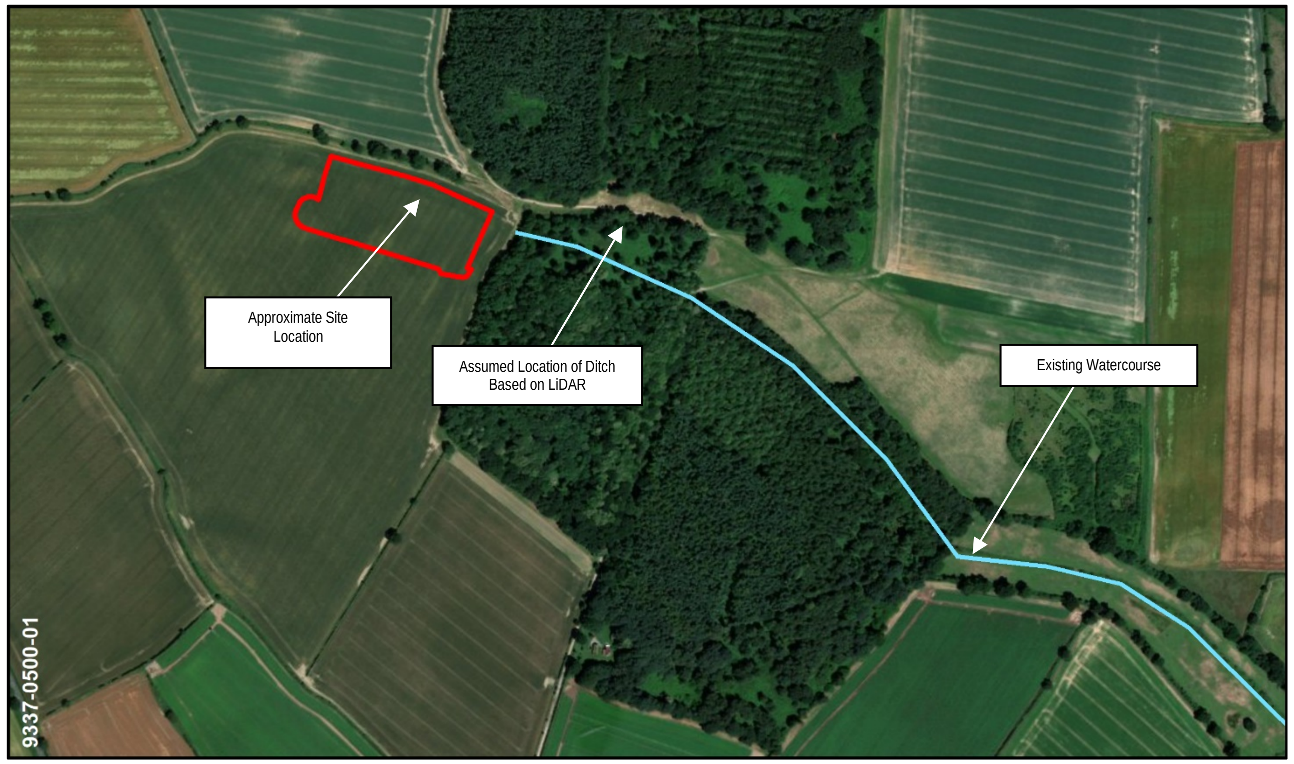

Figure A.1: Indicative Location of Ditch.

Discharge rainwater to a surface water sewer

A.4.1.10 No sewer records were made available.

A.4.1.11 As the onshore HVAC booster station area is currently greenfield and located 1 km north east of the B1149, it is highly likely that there are no public sewers present on the onshore HVAC booster station area. If there are sewers located beyond the onshore HVAC booster station boundary, it is possible that these sewers are used to drain surface water runoff generated from the B1149 and associated highways.

Discharge rainwater to the combined sewer

A.4.1.12 No sewer records were made available.

A.5 Proposed surface water drainage strategy

A.5.1.1 The proposed surface water drainage design parameters are as follows:

- The proposed drainage system is to be designed so that no flooding will occur during a 1 in 100 year rainfall event + 40% climate change will effect in any part of the onshore HVAC booster station area;
- Surface water runoff generated by the onshore HVAC booster station area is to discharge into the existing drain running along the onshore HVAC booster station's northern boundary;
- The discharge rate into the existing drain is to be limited to Qbar 1 in 1 year; and
- Surface water runoff generated on areas where there is a possibility of contaminants will be treated prior to discharge.

A.5.1.2 Surface water runoff within the onshore HVAC booster station area will be generated by the access road, the HVAC booster station and its associated concrete plinths.

A.5.1.3 It is proposed that surface water runoff generated on the access road will flow into the filter drain. The filter drain, to be located directly adjacent to the access road will be wrapped with impermeable geotextile membrane to avoid ingress and egress of water. Surface water runoff within the filter drain will then be conveyed forward, towards underground storage tanks.

A.5.1.4 Surface water runoff generated from the roof of the onshore HVAC booster station meanwhile will be collected and conveyed towards the Geocellular Storage Crates for attenuation.

A.5.1.5 Surface water runoff generated from areas where oil/fuel may be present (i.e. concrete bunds), will be passed through an Oil Water Separator prior to attenuation.

A.5.1.6 Surface water runoff will eventually discharge into the existing ditch, located north east of HVAC booster station area boundary. The discharge rate will be limited to Qbar 1 in 1 year of 2.5 l/s. The rate will be restricted via Hydro-Brake® Optimum® flow control system or other similar approved system.

A.6 Surface water drainage modelling

A.6.1.1 The attenuation features for the surface water drainage system has been sized using MicroDrainage® to prevent flooding of the onshore HVAC booster station area and surrounding areas. The modelling summary for the onshore HVAC booster station area attached in section A.9, shows that in order to attenuate surface water runoff generated for rainfall event up to 1 in 100 year with 40% climate change effect the Geocellular Storage Crates would need to provide a total of 1,050 m^3 of storage, which could have an area of 700 m^2 and a depth of 1.5 m.

A.6.1.2 Section A.10 illustrates the outline drainage strategy for the onshore HVAC booster station and demonstrates that the required attenuation volume can be practicably provided within the onshore HVAC booster station area.

A.7 MicroDrainage calculations for onshore HVAC booster station

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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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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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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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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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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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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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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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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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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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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

A.8 Greenfield Qbar runoff calculations

ICP SUDS Mean Annual Flood

Input

Return Period (years)	1	SAAR (mm)	605	Urban	0.000
Area (ha)	1.000	Soil	0.400	Region Number	Region 5

Results l/s

QBAR Rural	2.9
QBAR Urban	2.9
Q1 year	2.5
Q1 year	2.5
Q30 years	6.9
Q100 years	10.2

A.9 Modelling summary

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

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
15 min Summer	51.900	0.400	2.0	280.2	O K
30 min Summer	52.026	0.526	2.0	368.2	O K
60 min Summer	52.156	0.656	2.0	459.2	O K
120 min Summer	52.318	0.818	2.0	572.3	O K
180 min Summer	52.424	0.924	2.0	647.1	O K
240 min Summer	52.502	1.002	2.1	701.6	O K
360 min Summer	52.607	1.107	2.2	774.7	O K
480 min Summer	52.670	1.170	2.2	819.2	O K
600 min Summer	52.712	1.212	2.3	848.1	O K
720 min Summer	52.739	1.239	2.3	867.4	O K
960 min Summer	52.769	1.269	2.3	888.4	O K
1440 min Summer	52.778	1.278	2.3	894.8	O K
2160 min Summer	52.745	1.245	2.3	871.5	O K
2880 min Summer	52.695	1.195	2.3	836.4	O K
4320 min Summer	52.609	1.109	2.2	776.3	O K
5760 min Summer	52.545	1.045	2.1	731.4	O K
7200 min Summer	52.499	0.999	2.1	699.5	O K
8640 min Summer	52.464	0.964	2.0	675.0	O K
10080 min Summer	52.437	0.937	2.0	656.1	O K
15 min Winter	51.949	0.449	2.0	314.1	O K
30 min Winter	52.090	0.590	2.0	412.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	150.640	0.0	173.6	27
30 min Summer	99.120	0.0	171.2	42
60 min Summer	62.020	0.0	330.7	72
120 min Summer	38.938	0.0	314.9	132
180 min Summer	29.560	0.0	312.7	190
240 min Summer	24.201	0.0	317.8	250
360 min Summer	18.056	0.0	333.3	370
480 min Summer	14.508	0.0	342.3	490
600 min Summer	12.172	0.0	347.5	608
720 min Summer	10.508	0.0	350.5	728
960 min Summer	8.281	0.0	352.4	966
1440 min Summer	5.852	0.0	347.9	1444
2160 min Summer	4.103	0.0	666.0	2160
2880 min Summer	3.187	0.0	658.2	2796
4320 min Summer	2.237	0.0	627.7	3420
5760 min Summer	1.749	0.0	1224.6	4168
7200 min Summer	1.457	0.0	1196.5	4984
8640 min Summer	1.263	0.0	1140.5	5872
10080 min Summer	1.125	0.0	1082.0	6664
15 min Winter	150.640	0.0	174.4	27
30 min Winter	99.120	0.0	165.5	41

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

Storm Event	Max Level (m)	Max Depth (m)	Max Control (l/s)	Max Volume (m³)	Status
60 min Winter	52.236	0.736	2.0	514.9	O K
120 min Winter	52.417	0.917	2.0	642.1	O K
180 min Winter	52.538	1.038	2.1	726.5	O K
240 min Winter	52.626	1.126	2.2	788.1	O K
360 min Winter	52.745	1.245	2.3	871.5	O K
480 min Winter	52.818	1.318	2.4	922.8	O K
600 min Winter	52.866	1.366	2.4	956.5	O K
720 min Winter	52.899	1.399	2.4	979.5	O K
960 min Winter	52.937	1.437	2.4	1005.9	O K
1440 min Winter	52.955	1.455	2.5	1018.7	O K
2160 min Winter	52.930	1.430	2.4	1000.9	O K
2880 min Winter	52.885	1.385	2.4	969.7	O K
4320 min Winter	52.782	1.282	2.3	897.2	O K
5760 min Winter	52.706	1.206	2.3	844.3	O K
7200 min Winter	52.646	1.146	2.2	802.2	O K
8640 min Winter	52.596	1.096	2.2	767.2	O K
10080 min Winter	52.554	1.054	2.1	738.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
60 min Winter	62.020	0.0	322.6	70
120 min Winter	38.938	0.0	313.7	130
180 min Winter	29.560	0.0	322.6	188
240 min Winter	24.201	0.0	336.0	246
360 min Winter	18.056	0.0	352.8	364
480 min Winter	14.508	0.0	361.9	482
600 min Winter	12.172	0.0	367.0	600
720 min Winter	10.508	0.0	369.8	718
960 min Winter	8.281	0.0	371.2	952
1440 min Winter	5.852	0.0	365.1	1416
2160 min Winter	4.103	0.0	706.3	2100
2880 min Winter	3.187	0.0	696.6	2748
4320 min Winter	2.237	0.0	663.0	3640
5760 min Winter	1.749	0.0	1288.1	4440
7200 min Winter	1.457	0.0	1242.8	5344
8640 min Winter	1.263	0.0	1194.6	6312
10080 min Winter	1.125	0.0	1154.5	7256

Rainfall Details

Rainfall Model	FEH	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
FEH Rainfall Version	2013	Cv (Winter)	0.840
Site Location	GB 609251 333774	Shortest Storm (mins)	15
Data Type	Point	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 1.000

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	0.333	4	8	0.333	8	12	0.333

Model Details

Storage is Online Cover Level (m) 53.700

Tank or Pond Structure

Invert Level (m) 51.500

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	700.0	1.500	700.0	2.800	0.0	4.200	0.0
0.200	700.0	1.501	0.0	3.000	0.0	4.400	0.0
0.400	700.0	1.800	0.0	3.001	0.0	4.600	0.0
0.600	700.0	2.000	0.0	3.400	0.0	4.800	0.0
0.800	700.0	2.001	0.0	3.600	0.0	5.000	0.0
1.000	700.0	2.400	0.0	3.800	0.0		
1.001	700.0	2.600	0.0	4.000	0.0		

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SHE-0068-2500-1500-2500
Design Head (m)	1.500
Design Flow (l/s)	2.5
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Application	Surface
Sump Available	Yes
Diameter (mm)	68
Invert Level (m)	51.500
Minimum Outlet Pipe Diameter (mm)	100
Suggested Manhole Diameter (mm)	1200

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.500	2.5
Flush-Flo™	0.300	2.0
Kick-Flo®	0.609	1.7
Mean Flow over Head Range	-	2.0

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	1.7	1.200	2.3	3.000	3.4	7.000	5.1
0.200	2.0	1.400	2.4	3.500	3.7	7.500	5.3
0.300	2.0	1.600	2.6	4.000	3.9	8.000	5.4
0.400	2.0	1.800	2.7	4.500	4.2	8.500	5.6
0.500	1.9	2.000	2.9	5.000	4.4	9.000	5.8
0.600	1.7	2.200	3.0	5.500	4.6	9.500	5.9
0.800	1.9	2.400	3.1	6.000	4.8		
1.000	2.1	2.600	3.2	6.500	4.9		

A.10 Onshore HVAC booster station – proposed drainage layout

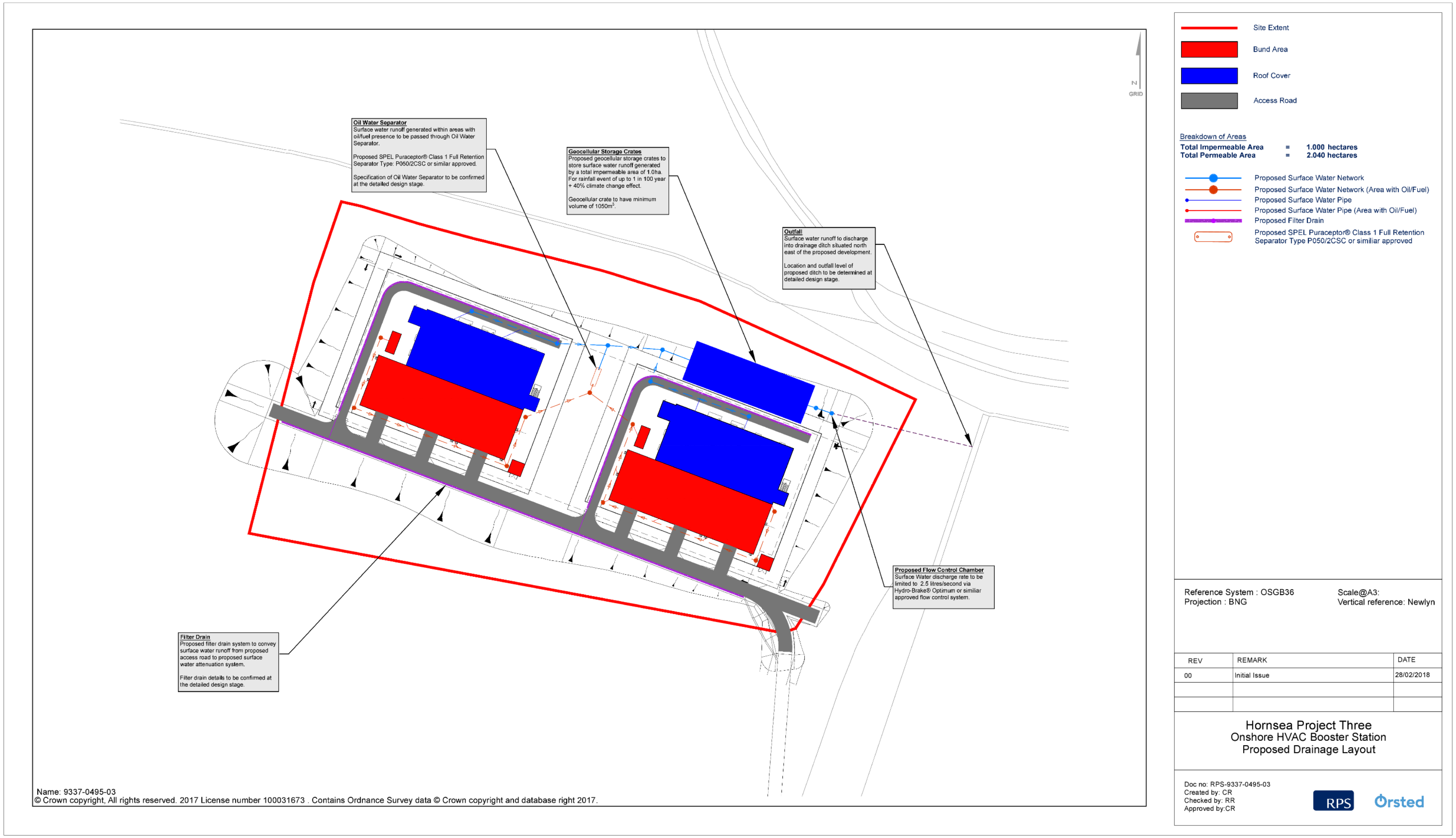

Figure A.2: Onshore HVAC Booster Station – Proposed Drainage Layout.

Appendix B Outline Surface Water Drainage Strategy for the Onshore HVDC Converter/HVAC Substation

B.1 Introduction

B.1.1.1 This Outline Surface Water Drainage Strategy was produced to support the FRA for the onshore HVDC converter/HVAC substation. The strategy is based on an indicative layout for the HDVC converter/HVAC substation and will be developed in detail post consent.

B.2 Site information

B.2.1.1 The onshore HVDC converter/HVAC substation area is located 1 km north west of the existing National Grid Electricity Transmission 400 kV Norwich Main substation. It is irregular in shape occupying a total area of 14.9 ha. Access to the onshore HVDC converter/HVAC substation area is currently provided in the western section of the site via B1113.

B.2.1.2 No topographical survey was undertaken for the onshore HVDC converter/HVAC substation area. However, based on available online OS maps, the onshore HVDC converter/HVAC substation area has an average slope of 4% with a steady fall from south east to the north west. The highest point of the site is approximately 40 m AOD, located in the south east corner.

B.2.1.3 The onshore HVDC converter/HVAC substation area is currently greenfield and fully permeable. The onshore HVDC converter/HVAC substation will create a total impermeable area of 6 ha. The remaining 8.9 ha will be permeable, consisting of free draining surface chippings.

B.2.1.4 The Qbar for the site boundary was calculated using the ICP SuDS method. The results, attached in section B.8, shows that the Qbar based on an overall impermeable area of 5.687 ha is 16.3 l/s.

B.3 Policy

B.3.1.1 The NPPF requires that proposed development should not increase flood risk. Surface water runoff from the development site should not exceed that generated from the existing application site.

B.3.1.2 The NPPG meanwhile outlines the hierarchy to be investigated by the developer when considering surface water drainage strategy. The following drainage options are to be investigated following order of priority:

1. Discharge rainwater into ground via infiltration;
2. Discharge rainwater direct to a watercourse;
3. Discharge rainwater to a surface water sewer/drain; and
4. Discharge rainwater to the combined sewer.

B.4 Surface water drainage hierarchy

B.4.1.1 Based on the NPPG, all of the drainage options are examined in detail in order to assess the feasibility of using a combination of SuDS as part of the onshore HVDC converter/HVAC substation area.

Discharge rainwater into ground via infiltration

B.4.1.2 No soil infiltration testing was undertaken on the onshore HVDC converter/HVAC substation area at the time of writing due to access restrictions. Reference to BGS online mapping (1:50,000) indicates that the onshore HVDC converter/HVAC substation area is underlain by superficial deposits from Lowestoft Formation. This particular deposit forms an extensive sheet of chalky till together with outwash sands and gravels, silts and clays. The onshore HVDC converter/HVAC substation area is shown to be underlain by bedrock deposits from the Lewes Nodular Chalk Formation which is comprised of rock.

B.4.1.3 Reference to BGS borehole records indicates a borehole log on site (BGS reference: TG20SW14). The borehole scans shows that the onshore HVDC converter/HVAC substation area is underlined by boulder clay.

B.4.1.4 Based on the information above, discharge of surface water runoff into ground via infiltration is considered not feasible.

Discharge rainwater direct to a watercourse

B.4.1.5 The River Tas is located approximately 1.25 km away from the onshore HVDC converter/HVAC substation area eastern boundary. The River Yare meanwhile, is approximately 1.5 km from the onshore HVDC converter/HVAC substation area northern boundary.

B.4.1.6 Based on information provided from onshore HVDC converter/HVAC substation area, there are local ditches at the edges of the proposed onshore HVDC converter/HVAC substation area. A deep drain, with depth of up to 1 m, runs along the northern boundary of the development area, separating the onshore HVDC converter/HVAC substation area from the A47 dual carriageway. It is believed that the drain is used to intercept overland surface water runoff generated on onshore HVDC converter/HVAC substation area from overflowing offsite, into the A47.

B.4.1.7 On this basis, the possibility to discharge surface water runoff generated from the onshore HVDC converter/HVAC substation area to the deep drain will be considered.

Discharge rainwater to a surface water sewer

B.4.1.8 No sewer records were made available.

B.4.1.9 As the onshore HVDC converter/HVAC substation area is currently greenfield and located along the A47, it is highly likely that there are no public sewers presence on site. If there are sewers located beyond the onshore HVDC converter/HVAC substation area boundary, it is possible that these sewers are used to drain surface water runoff generated from the A47 and associated highways.

Discharge rainwater to the combined sewer

B.4.1.10 No sewer records were made available.

B.5 Proposed surface water drainage strategy

B.5.1.1 The proposed surface water drainage design parameters are as follows:

- The proposed drainage system is to be designed so that no flooding will occur during a 1 in 100 year rainfall event + 40% climate change will effect in any part of the onshore HVDC converter/HVAC substation area;
- Surface water runoff generated by the proposed development is to discharge into the existing drain running along the onshore HVDC converter/HVAC substation area's northern boundary;
- The discharge rate into the existing drain to be limited to Qbar; and
- Surface water runoff generated on areas where there is a possibility of contaminants will be treated prior to discharge.

B.5.1.2 Surface water runoff within the proposed development will be generated by three different areas – the access road, the roof of the substations and the associated substations concrete bunds.

B.5.1.3 As the onshore HVDC converter/HVAC substation area is extensive, the proposed drainage strategy will look to divide the site into two – the southern and northern catchment. The southern catchment will have a total impermeable area of 3 ha and the northern catchment 3 ha.

B.5.1.4 Surface water runoff generated will be collected and conveyed towards Geocellular Storage Crates for attenuation. Surface water runoff generated from areas where oil/fuel may be present (i.e. concrete bunds), will be passed through an Oil Water Separator prior to attenuation.

B.5.1.5 Surface water runoff will eventually discharge into the deep drain running through the onshore HVDC converter/HVAC substation area's northern boundary. The discharge rate will be limited to Qbar 1 in 1 year of 15 l/s. In order to achieve this, discharge rate from the southern and northern catchment will be limited to 7.5 l/s each. Due to the depth of the proposed Geocellular Storage Crates, pumps would be utilised to limit the discharge rates.

B.6 Surface water drainage modelling

B.6.1.1 The attenuation features for the surface water drainage system has been sized using MicroDrainage® to prevent flooding of the site and surrounding areas. The modelling summary for both catchment areas in sections B.9 and B.10, shows that in order for the proposed attenuation systems to attenuate surface water runoff generated for rainfall event up to 1 in 100 year with 40% climate change effect the Geocellular Storage Crates would need to provide a total 7,500 m^3 of storage for both catchments which could have an area of 1,500 m^2 and a depth of 2.5 m.

B.6.1.2 Section B.11 illustrates the outline drainage strategy for the onshore HVDC converter/HVAC substation and demonstrates that the required attenuation volume can be practicably provided within the onshore HVDC converter/HVAC substation area.

B.7 MicroDrainage calculations for onshore HVDC converter/HVAC substation

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Micro Drainage	Source Control 2017.1.2	

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	8.774	0.774	20.3	0.0	20.3	4447.7	O K
30 min Summer	8.876	0.876	21.7	0.0	21.7	5037.0	O K
60 min Summer	8.990	0.990	23.1	0.0	23.1	5695.1	O K
120 min Summer	9.116	1.116	24.6	0.0	24.6	6418.2	O K
180 min Summer	9.194	1.194	25.5	0.0	25.5	6864.2	O K
240 min Summer	9.250	1.250	26.1	0.0	26.1	7185.3	O K
360 min Summer	9.328	1.328	27.0	0.0	27.0	7634.5	O K
480 min Summer	9.381	1.381	27.5	0.0	27.5	7941.0	O K
600 min Summer	9.420	1.420	27.9	0.0	27.9	8164.7	O K
720 min Summer	9.449	1.449	28.2	0.0	28.2	8333.6	O K
960 min Summer	9.517	1.517	28.9	0.0	28.9	8720.0	O K
1440 min Summer	9.595	1.595	29.7	0.0	29.7	9173.2	O K
2160 min Summer	9.642	1.642	30.1	0.0	30.1	9438.8	O K
2880 min Summer	9.656	1.656	30.3	0.0	30.3	9522.6	O K
4320 min Summer	9.586	1.586	29.6	0.0	29.6	9119.5	O K
5760 min Summer	9.521	1.521	29.0	0.0	29.0	8747.9	O K
7200 min Summer	9.459	1.459	28.3	0.0	28.3	8387.0	O K
8640 min Summer	9.398	1.398	27.7	0.0	27.7	8041.1	O K
10080 min Summer	9.341	1.341	27.1	0.0	27.1	7712.6	O K
15 min Winter	8.867	0.867	21.6	0.0	21.6	4985.9	O K
30 min Winter	8.982	0.982	23.0	0.0	23.0	5647.1	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)
15 min Summer	188.954	0.0	1539.9	0.0	117
30 min Summer	107.076	0.0	1651.1	0.0	130
60 min Summer	60.677	0.0	3244.0	0.0	158
120 min Summer	34.384	0.0	3485.5	0.0	214
180 min Summer	24.664	0.0	3620.6	0.0	270
240 min Summer	19.485	0.0	3710.3	0.0	328
360 min Summer	13.977	0.0	3821.1	0.0	440
480 min Summer	11.042	0.0	3882.0	0.0	554
600 min Summer	9.196	0.0	3913.9	0.0	668
720 min Summer	7.920	0.0	3926.5	0.0	782
960 min Summer	6.366	0.0	3953.7	0.0	1010
1440 min Summer	4.679	0.0	3886.9	0.0	1470
2160 min Summer	3.439	0.0	7734.9	0.0	2160
2880 min Summer	2.764	0.0	7706.5	0.0	2484
4320 min Summer	1.945	0.0	7097.2	0.0	3204
5760 min Summer	1.516	0.0	12667.9	0.0	4008
7200 min Summer	1.250	0.0	12518.8	0.0	4832
8640 min Summer	1.067	0.0	12184.3	0.0	5640
10080 min Summer	0.934	0.0	11678.9	0.0	6464
15 min Winter	188.954	0.0	1647.4	0.0	117
30 min Winter	107.076	0.0	1764.5	0.0	130

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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
60 min Winter	9.111	1.111	24.6	0.0	24.6	6386.4	O K
120 min Winter	9.252	1.252	26.2	0.0	26.2	7200.6	O K
180 min Winter	9.340	1.340	27.1	0.0	27.1	7704.5	O K
240 min Winter	9.403	1.403	27.8	0.0	27.8	8068.9	O K
360 min Winter	9.492	1.492	28.7	0.0	28.7	8581.4	O K
480 min Winter	9.554	1.554	29.3	0.0	29.3	8934.5	O K
600 min Winter	9.599	1.599	29.7	0.0	29.7	9195.0	O K
720 min Winter	9.634	1.634	30.0	0.0	30.0	9394.1	O K
960 min Winter	9.713	1.713	30.8	0.0	30.8	9848.0	Flood Risk
1440 min Winter	9.808	1.808	31.7	0.0	31.7	10398.6	Flood Risk
2160 min Winter	9.872	1.872	32.2	0.0	32.2	10762.8	Flood Risk
2880 min Winter	9.888	1.888	32.4	0.0	32.4	10854.0	Flood Risk
4320 min Winter	9.793	1.793	31.5	0.0	31.5	10311.9	Flood Risk
5760 min Winter	9.708	1.708	30.7	0.0	30.7	9818.6	Flood Risk
7200 min Winter	9.622	1.622	29.9	0.0	29.9	9325.4	O K
8640 min Winter	9.539	1.539	29.1	0.0	29.1	8847.2	O K
10080 min Winter	9.459	1.459	28.3	0.0	28.3	8391.8	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)
60 min Winter	60.677	0.0	3487.4	0.0	158
120 min Winter	34.384	0.0	3741.6	0.0	212
180 min Winter	24.664	0.0	3883.9	0.0	268
240 min Winter	19.485	0.0	3978.1	0.0	324
360 min Winter	13.977	0.0	4094.4	0.0	436
480 min Winter	11.042	0.0	4158.1	0.0	546
600 min Winter	9.196	0.0	4191.2	0.0	658
720 min Winter	7.920	0.0	4204.0	0.0	770
960 min Winter	6.366	0.0	4231.8	0.0	996
1440 min Winter	4.679	0.0	4160.1	0.0	1446
2160 min Winter	3.439	0.0	8337.1	0.0	2112
2880 min Winter	2.764	0.0	8297.8	0.0	2740
4320 min Winter	1.945	0.0	7640.5	0.0	3388
5760 min Winter	1.516	0.0	13881.2	0.0	4304
7200 min Winter	1.250	0.0	13676.1	0.0	5208
8640 min Winter	1.067	0.0	13281.5	0.0	6104
10080 min Winter	0.934	0.0	12714.0	0.0	6976

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Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	1999
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) 12.800

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.500	28	32	0.500	56	60	0.500	84	88	0.500
4	8	0.500	32	36	0.500	60	64	0.500	88	92	0.500
8	12	0.500	36	40	0.500	64	68	0.500	92	96	0.500
12	16	0.500	40	44	0.500	68	72	0.500	96	100	0.500
16	20	0.500	44	48	0.500	72	76	0.500	100	104	0.300
20	24	0.500	48	52	0.500	76	80	0.500			
24	28	0.500	52	56	0.500	80	84	0.500			

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Suite D10 Josephs Well Leeds LS3 1AB		Micro Drainage
Date 04/12/2017 15:20 File 1 IN 100 YR CC TANK (13...	Designed by angus.kerry Checked by	
Micro Drainage	Source Control 2017.1.2	

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)
0.000	5750.0	0.800	5750.0	1.600	5750.0
0.400	5750.0	1.200	5750.0	2.000	5750.0

Orifice Outflow Control

Diameter (m) 0.107 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

RPS Group PLC		Page 1
Suite D10 Josephs Well Leeds LS3 1AB		Micro Drainage
Date 04/12/2017 15:21	Designed by angus.kerry	
File 1 IN 100 YR CC TANK (13...	Checked by	
Micro Drainage	Source Control 2017.1.2	

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	8.695	0.695	19.1	0.0	19.1	5208.9	O K
30 min Summer	8.787	0.787	20.5	0.0	20.5	5899.6	O K
60 min Summer	8.890	0.890	21.9	0.0	21.9	6673.1	O K
120 min Summer	9.004	1.004	23.3	0.0	23.3	7528.4	O K
180 min Summer	9.075	1.075	24.2	0.0	24.2	8060.7	O K
240 min Summer	9.126	1.126	24.8	0.0	24.8	8447.9	O K
360 min Summer	9.200	1.200	25.6	0.0	25.6	8997.6	O K
480 min Summer	9.251	1.251	26.1	0.0	26.1	9381.5	O K
600 min Summer	9.289	1.289	26.6	0.0	26.6	9669.1	O K
720 min Summer	9.319	1.319	26.9	0.0	26.9	9892.9	O K
960 min Summer	9.387	1.387	27.6	0.0	27.6	10399.6	O K
1440 min Summer	9.472	1.472	28.5	0.0	28.5	11041.0	O K
2160 min Summer	9.536	1.536	29.1	0.0	29.1	11517.4	O K
2880 min Summer	9.559	1.559	29.3	0.0	29.3	11690.8	O K
4320 min Summer	9.502	1.502	28.8	0.0	28.8	11266.9	O K
5760 min Summer	9.453	1.453	28.3	0.0	28.3	10897.4	O K
7200 min Summer	9.406	1.406	27.8	0.0	27.8	10545.0	O K
8640 min Summer	9.360	1.360	27.3	0.0	27.3	10199.6	O K
10080 min Summer	9.315	1.315	26.8	0.0	26.8	9864.5	O K
15 min Winter	8.778	0.778	20.3	0.0	20.3	5838.1	O K
30 min Winter	8.882	0.882	21.7	0.0	21.7	6612.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)
15 min Summer	220.446	0.0	1479.9	0.0	117
30 min Summer	124.922	0.0	1585.3	0.0	131
60 min Summer	70.790	0.0	3181.9	0.0	158
120 min Summer	40.115	0.0	3408.6	0.0	216
180 min Summer	28.775	0.0	3534.3	0.0	272
240 min Summer	22.732	0.0	3617.0	0.0	330
360 min Summer	16.306	0.0	3717.6	0.0	444
480 min Summer	12.882	0.0	3770.9	0.0	558
600 min Summer	10.729	0.0	3796.9	0.0	674
720 min Summer	9.240	0.0	3804.8	0.0	788
960 min Summer	7.427	0.0	3822.8	0.0	1020
1440 min Summer	5.459	0.0	3745.6	0.0	1482
2160 min Summer	4.012	0.0	7671.6	0.0	2176
2880 min Summer	3.225	0.0	7603.9	0.0	2812
4320 min Summer	2.269	0.0	6957.8	0.0	3448
5760 min Summer	1.769	0.0	13276.9	0.0	4192
7200 min Summer	1.458	0.0	12973.2	0.0	4992
8640 min Summer	1.245	0.0	12511.5	0.0	5816
10080 min Summer	1.089	0.0	11908.9	0.0	6640
15 min Winter	220.446	0.0	1582.1	0.0	117
30 min Winter	124.922	0.0	1692.9	0.0	131

RPS Group PLC		Page 2
Suite D10 Josephs Well Leeds LS3 1AB		Micro Drainage
Date 04/12/2017 15:21	Designed by angus.kerry	
File 1 IN 100 YR CC TANK (13...	Checked by	
Micro Drainage	Source Control 2017.1.2	

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
60 min Winter	8.998	0.998	23.2	0.0	23.2	7481.5	O K
120 min Winter	9.126	1.126	24.7	0.0	24.7	8443.4	O K
180 min Winter	9.206	1.206	25.7	0.0	25.7	9043.8	O K
240 min Winter	9.264	1.264	26.3	0.0	26.3	9481.7	O K
360 min Winter	9.348	1.348	27.2	0.0	27.2	10106.3	O K
480 min Winter	9.406	1.406	27.8	0.0	27.8	10545.5	O K
600 min Winter	9.450	1.450	28.2	0.0	28.2	10877.0	O K
720 min Winter	9.485	1.485	28.6	0.0	28.6	11137.1	O K
960 min Winter	9.563	1.563	29.4	0.0	29.4	11724.9	O K
1440 min Winter	9.665	1.665	30.3	0.0	30.3	12484.4	O K
2160 min Winter	9.744	1.744	31.1	0.0	31.1	13081.0	Flood Risk
2880 min Winter	9.779	1.779	31.4	0.0	31.4	13342.3	Flood Risk
4320 min Winter	9.702	1.702	30.7	0.0	30.7	12765.3	Flood Risk
5760 min Winter	9.640	1.640	30.1	0.0	30.1	12303.7	O K
7200 min Winter	9.578	1.578	29.5	0.0	29.5	11831.7	O K
8640 min Winter	9.515	1.515	28.9	0.0	28.9	11359.3	O K
10080 min Winter	9.453	1.453	28.3	0.0	28.3	10896.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Overflow Volume (m³)	Time-Peak (mins)
60 min Winter	70.790	0.0	3412.9	0.0	158
120 min Winter	40.115	0.0	3651.6	0.0	214
180 min Winter	28.775	0.0	3784.1	0.0	270
240 min Winter	22.732	0.0	3871.2	0.0	326
360 min Winter	16.306	0.0	3976.9	0.0	438
480 min Winter	12.882	0.0	4033.0	0.0	550
600 min Winter	10.729	0.0	4060.3	0.0	664
720 min Winter	9.240	0.0	4068.4	0.0	776
960 min Winter	7.427	0.0	4087.2	0.0	1002
1440 min Winter	5.459	0.0	4005.6	0.0	1456
2160 min Winter	4.012	0.0	8244.4	0.0	2136
2880 min Winter	3.225	0.0	8167.3	0.0	2796
4320 min Winter	2.269	0.0	7477.2	0.0	3616
5760 min Winter	1.769	0.0	14438.2	0.0	4456
7200 min Winter	1.458	0.0	14084.8	0.0	5368
8640 min Winter	1.245	0.0	13569.6	0.0	6280
10080 min Winter	1.089	0.0	12911.2	0.0	7176

RPS Group PLC		Page 3
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Micro Drainage	Source Control 2017.1.2	

Rainfall Details

Rainfall Model	FEH
Return Period (years)	100
FEH Rainfall Version	1999
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) 12.800

Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)	Time (mins) From:	To:	Area (ha)
0	4	0.500	28	32	0.500	56	60	0.500	84	88	0.500
4	8	0.500	32	36	0.500	60	64	0.500	88	92	0.500
8	12	0.500	36	40	0.500	64	68	0.500	92	96	0.500
12	16	0.500	40	44	0.500	68	72	0.500	96	100	0.500
16	20	0.500	44	48	0.500	72	76	0.500	100	104	0.300
20	24	0.500	48	52	0.500	76	80	0.500			
24	28	0.500	52	56	0.500	80	84	0.500			

RPS Group PLC		Page 4
Suite D10 Josephs Well Leeds LS3 1AB		
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File 1 IN 100 YR CC TANK (13...	Checked by	
Micro Drainage	Source Control 2017.1.2	

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)
0.000	7500.0	0.800	7500.0	1.600	7500.0
0.400	7500.0	1.200	7500.0	2.000	7500.0

Orifice Outflow Control

Diameter (m) 0.107 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

B.8 Greenfield Qbar Runoff Calculations

ICP SUDS Mean Annual Flood

Input

Return Period (years)	1	Soil	0.400
Area (ha)	6.000	Urban	0.000
SAAR (mm)	605	Region Number	Region 5

Results	**l/s**
QBAR Rural	17.2
QBAR Urban	17.2
Q1 year	15.0
Q1 year	15.0
Q30 years	41.3
Q100 years	61.3

B.9 Modelling summary for onshore HVDC converter/HVAC substation southside

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

Half Drain Time : 5283 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	32.131	0.631	0.0	1.9	1.9	899.1	O K
30 min Summer	32.325	0.825	0.0	2.5	2.5	1176.1	O K
60 min Summer	32.524	1.024	0.0	3.1	3.1	1459.2	O K
120 min Summer	32.734	1.234	0.0	3.7	3.7	1759.1	O K
180 min Summer	32.888	1.388	0.0	4.2	4.2	1978.5	O K
240 min Summer	33.011	1.511	0.0	4.5	4.5	2152.8	O K
360 min Summer	33.195	1.695	0.0	5.1	5.1	2415.1	O K
480 min Summer	33.324	1.824	0.0	5.5	5.5	2599.9	O K
600 min Summer	33.418	1.918	0.0	5.8	5.8	2733.5	O K
720 min Summer	33.488	1.988	0.0	6.0	6.0	2833.3	O K
960 min Summer	33.580	2.080	0.0	6.2	6.2	2963.8	O K
1440 min Summer	33.668	2.168	0.0	6.5	6.5	3089.5	O K
2160 min Summer	33.700	2.200	0.0	6.6	6.6	3134.9	O K
2880 min Summer	33.689	2.189	0.0	6.6	6.6	3119.7	O K
4320 min Summer	33.645	2.145	0.0	6.4	6.4	3056.6	O K
5760 min Summer	33.615	2.115	0.0	6.3	6.3	3014.4	O K
7200 min Summer	33.596	2.096	0.0	6.3	6.3	2986.3	O K
8640 min Summer	33.579	2.079	0.0	6.2	6.2	2962.3	O K
10080 min Summer	33.563	2.063	0.0	6.2	6.2	2939.9	O K
15 min Winter	32.207	0.707	0.0	2.1	2.1	1006.9	O K
30 min Winter	32.424	0.924	0.0	2.8	2.8	1317.2	O K
60 min Winter	32.647	1.147	0.0	3.4	3.4	1634.3	O K
120 min Winter	32.883	1.383	0.0	4.1	4.1	1970.5	O K
180 min Winter	33.055	1.555	0.0	4.7	4.7	2216.5	O K
240 min Winter	33.193	1.693	0.0	5.1	5.1	2411.9	O K
360 min Winter	33.399	1.899	0.0	5.7	5.7	2706.1	O K
480 min Winter	33.545	2.045	0.0	6.1	6.1	2913.6	O K
600 min Winter	33.650	2.150	0.0	6.5	6.5	3063.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	160.105	0.0	148.5	27
30 min Summer	104.820	0.0	193.6	42
60 min Summer	65.150	0.0	442.5	72
120 min Summer	39.418	0.0	530.8	132
180 min Summer	29.668	0.0	593.9	192
240 min Summer	24.302	0.0	642.8	250
360 min Summer	18.312	0.0	713.2	370
480 min Summer	14.897	0.0	759.0	490
600 min Summer	12.624	0.0	788.5	610
720 min Summer	10.987	0.0	807.0	728
960 min Summer	8.749	0.0	821.6	968
1440 min Summer	6.265	0.0	804.6	1446
2160 min Summer	4.431	0.0	1598.1	2164
2880 min Summer	3.457	0.0	1563.7	2880
4320 min Summer	2.435	0.0	1426.5	3596
5760 min Summer	1.904	0.0	2717.6	4320
7200 min Summer	1.580	0.0	2672.4	5112
8640 min Summer	1.360	0.0	2592.6	5888
10080 min Summer	1.201	0.0	2477.5	6752
15 min Winter	160.105	0.0	166.4	27
30 min Winter	104.820	0.0	216.8	42
60 min Winter	65.150	0.0	495.6	72
120 min Winter	39.418	0.0	594.5	130
180 min Winter	29.668	0.0	665.2	188
240 min Winter	24.302	0.0	719.9	248
360 min Winter	18.312	0.0	798.8	366
480 min Winter	14.897	0.0	850.1	484
600 min Winter	12.624	0.0	883.1	600

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

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
720 min Winter	33.729	2.229	0.0	6.7	6.7	3176.3	O K
960 min Winter	33.832	2.332	0.0	7.0	7.0	3323.7	O K
1440 min Winter	33.934	2.434	0.0	7.3	7.3	3467.7	O K
2160 min Winter	33.974	2.474	0.0	7.4	7.4	3525.8	O K
2880 min Winter	33.969	2.469	0.0	7.4	7.4	3518.8	O K
4320 min Winter	33.912	2.412	0.0	7.2	7.2	3437.1	O K
5760 min Winter	33.868	2.368	0.0	7.1	7.1	3374.9	O K
7200 min Winter	33.835	2.335	0.0	7.0	7.0	3327.6	O K
8640 min Winter	33.802	2.302	0.0	6.9	6.9	3280.8	O K
10080 min Winter	33.770	2.270	0.0	6.8	6.8	3235.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
720 min Winter	10.987	0.0	903.9	718
960 min Winter	8.749	0.0	920.2	952
1440 min Winter	6.265	0.0	901.1	1418
2160 min Winter	4.431	0.0	1789.8	2100
2880 min Winter	3.457	0.0	1751.2	2768
4320 min Winter	2.435	0.0	1597.0	3980
5760 min Winter	1.904	0.0	3043.1	4488
7200 min Winter	1.580	0.0	2992.1	5408
8640 min Winter	1.360	0.0	2902.0	6312
10080 min Winter	1.201	0.0	2772.2	7256

Rainfall Details

Rainfall Model	FEH	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
FEH Rainfall Version	2013	Cv (Winter)	0.840
Site Location	GB 621399 303590	Shortest Storm (mins)	15
Data Type	Point	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 3.000

Time From:	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**	**Time From:**	**(mins) To:**	**Area (ha)**
0	4	1.000	4	8	1.000	8	12	1.000

Model Details

Storage is Online Cover Level (m) 35.000

Cellular Storage Structure

Invert Level (m)	31.500	Safety Factor	2.0
Infiltration Coefficient Base (m/hr)	0.00000	Porosity	0.95
Infiltration Coefficient Side (m/hr)	0.00000		

Depth (m)	**Area (m²)**	**Inf. Area (m²)**	**Depth (m)**	**Area (m²)**	**Inf. Area (m²)**
0.000	1500.0	1500.0	2.501	0.0	1500.0
2.500	1500.0	1500.0			

Pump Outflow Control

Invert Level (m) 31.500

Depth (m)	**Flow (l/s)**
2.500	7.5000

B.10 Modelling summary HVDC converter/HVAC substation northside

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

Half Drain Time : 5283 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	32.131	0.631	0.0	1.9	1.9	899.1	O K
30 min Summer	32.325	0.825	0.0	2.5	2.5	1176.1	O K
60 min Summer	32.524	1.024	0.0	3.1	3.1	1459.2	O K
120 min Summer	32.734	1.234	0.0	3.7	3.7	1759.1	O K
180 min Summer	32.888	1.388	0.0	4.2	4.2	1978.5	O K
240 min Summer	33.011	1.511	0.0	4.5	4.5	2152.8	O K
360 min Summer	33.195	1.695	0.0	5.1	5.1	2415.1	O K
480 min Summer	33.324	1.824	0.0	5.5	5.5	2599.9	O K
600 min Summer	33.418	1.918	0.0	5.8	5.8	2733.5	O K
720 min Summer	33.488	1.988	0.0	6.0	6.0	2833.3	O K
960 min Summer	33.580	2.080	0.0	6.2	6.2	2963.8	O K
1440 min Summer	33.668	2.168	0.0	6.5	6.5	3089.5	O K
2160 min Summer	33.700	2.200	0.0	6.6	6.6	3134.9	O K
2880 min Summer	33.689	2.189	0.0	6.6	6.6	3119.7	O K
4320 min Summer	33.645	2.145	0.0	6.4	6.4	3056.6	O K
5760 min Summer	33.615	2.115	0.0	6.3	6.3	3014.4	O K
7200 min Summer	33.596	2.096	0.0	6.3	6.3	2986.3	O K
8640 min Summer	33.579	2.079	0.0	6.2	6.2	2962.3	O K
10080 min Summer	33.563	2.063	0.0	6.2	6.2	2939.9	O K
15 min Winter	32.207	0.707	0.0	2.1	2.1	1006.9	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	160.105	0.0	148.5	27
30 min Summer	104.820	0.0	193.6	42
60 min Summer	65.150	0.0	442.5	72
120 min Summer	39.418	0.0	530.8	132
180 min Summer	29.668	0.0	593.9	192
240 min Summer	24.302	0.0	642.8	250
360 min Summer	18.312	0.0	713.2	370
480 min Summer	14.897	0.0	759.0	490
600 min Summer	12.624	0.0	788.5	610
720 min Summer	10.987	0.0	807.0	728
960 min Summer	8.749	0.0	821.6	968
1440 min Summer	6.265	0.0	804.6	1446
2160 min Summer	4.431	0.0	1598.1	2164
2880 min Summer	3.457	0.0	1563.7	2880
4320 min Summer	2.435	0.0	1426.5	3596
5760 min Summer	1.904	0.0	2717.6	4320
7200 min Summer	1.580	0.0	2672.4	5112
8640 min Summer	1.360	0.0	2592.6	5888
10080 min Summer	1.201	0.0	2477.5	6752
15 min Winter	160.105	0.0	166.4	27

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

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	32.424	0.924	0.0	2.8	2.8	1317.2	O K
60 min Winter	32.647	1.147	0.0	3.4	3.4	1634.3	O K
120 min Winter	32.883	1.383	0.0	4.1	4.1	1970.5	O K
180 min Winter	33.055	1.555	0.0	4.7	4.7	2216.5	O K
240 min Winter	33.193	1.693	0.0	5.1	5.1	2411.9	O K
360 min Winter	33.399	1.899	0.0	5.7	5.7	2706.1	O K
480 min Winter	33.545	2.045	0.0	6.1	6.1	2913.6	O K
600 min Winter	33.650	2.150	0.0	6.5	6.5	3063.9	O K
720 min Winter	33.729	2.229	0.0	6.7	6.7	3176.3	O K
960 min Winter	33.832	2.332	0.0	7.0	7.0	3323.7	O K
1440 min Winter	33.934	2.434	0.0	7.3	7.3	3467.7	O K
2160 min Winter	33.974	2.474	0.0	7.4	7.4	3525.8	O K
2880 min Winter	33.969	2.469	0.0	7.4	7.4	3518.8	O K
4320 min Winter	33.912	2.412	0.0	7.2	7.2	3437.1	O K
5760 min Winter	33.868	2.368	0.0	7.1	7.1	3374.9	O K
7200 min Winter	33.835	2.335	0.0	7.0	7.0	3327.6	O K
8640 min Winter	33.802	2.302	0.0	6.9	6.9	3280.8	O K
10080 min Winter	33.770	2.270	0.0	6.8	6.8	3235.0	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	104.820	0.0	216.8	42
60 min Winter	65.150	0.0	495.6	72
120 min Winter	39.418	0.0	594.5	130
180 min Winter	29.668	0.0	665.2	188
240 min Winter	24.302	0.0	719.9	248
360 min Winter	18.312	0.0	798.8	366
480 min Winter	14.897	0.0	850.1	484
600 min Winter	12.624	0.0	883.1	600
720 min Winter	10.987	0.0	903.9	718
960 min Winter	8.749	0.0	920.2	952
1440 min Winter	6.265	0.0	901.1	1418
2160 min Winter	4.431	0.0	1789.8	2100
2880 min Winter	3.457	0.0	1751.2	2768
4320 min Winter	2.435	0.0	1597.0	3980
5760 min Winter	1.904	0.0	3043.1	4488
7200 min Winter	1.580	0.0	2992.1	5408
8640 min Winter	1.360	0.0	2902.0	6312
10080 min Winter	1.201	0.0	2772.2	7256

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Rainfall Details

Rainfall Model	FEH	Winter Storms	Yes
Return Period (years)	100	Cv (Summer)	0.750
FEH Rainfall Version	2013	Cv (Winter)	0.840
Site Location	GB 621399 303590	Shortest Storm (mins)	15
Data Type	Point	Longest Storm (mins)	10080
Summer Storms	Yes	Climate Change %	+40

Time Area Diagram

Total Area (ha) 3.000

Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)	Time From:	(mins) To:	Area (ha)
0	4	1.000	4	8	1.000	8	12	1.000

Model Details

Storage is Online Cover Level (m) 35.000

Cellular Storage Structure

Invert Level (m) 31.500 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	1500.0	1500.0	2.501	0.0	1500.0
2.500	1500.0	1500.0			

Pump Outflow Control

Invert Level (m) 31.500

Depth (m)	Flow (l/s)
2.500	7.5000

B.11 Onshore HVDC converter/HVAC substation – proposed drainage layout

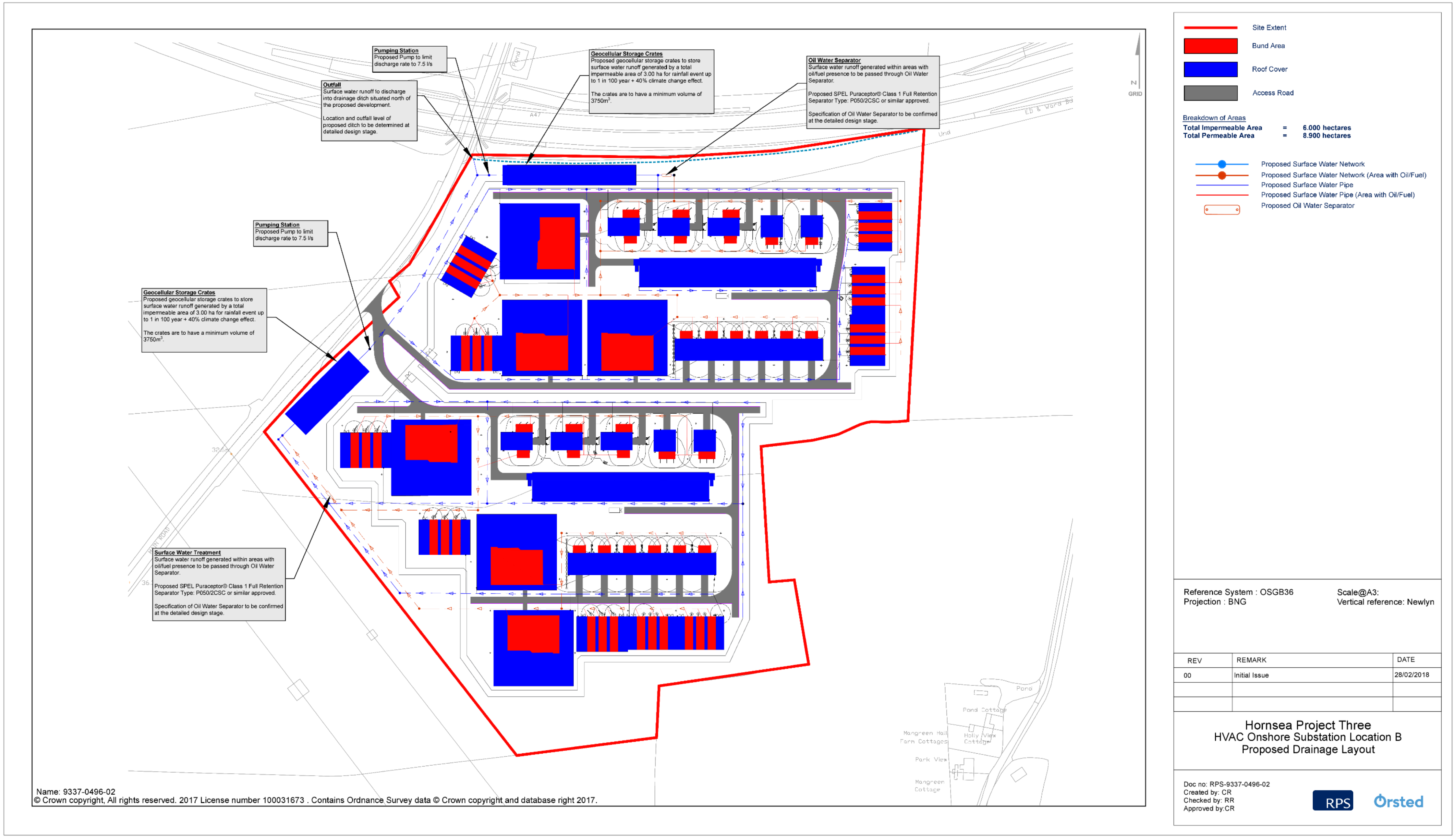

Figure B.1: Onshore HVDC converter/HVAC substation – Proposed Drainage Layout.