FIVE ESTUARIES OFFSHORE WIND FARM

VOLUME 9, REPORT 14.2: OUTLINE MARINE MAMMAL MITIGATION PROTOCOL – UXO (TRACKED)

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In preparation of this document Five Estuaries Wind Farm Ltd has made reasonable efforts to ensure that the content is accurate, up to date and complete for purpose.

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DEFINITION OF ACRONYMS

Term	Definition
ADD	Acoustic Deterrent Device
dB	Decibel
DCO	Development Consent Order
dML	deemed Marine Licence
EIA	Environmental Impact Assessment
ES	Environmental Statement
JNCC	Joint Nature Conservation Committee
kJ	Kilojoules
km	Kilometres
m	Meter
m^3	Meters cubed
m/s	Metres per second
MDS	Maximum Design Scenario
MMMP	Marine Mammal Mitigation Protocol
MMO	Marine Management Organisation
MMOb	Marine Mammal Observer
NAS	Noise Abatement System
OSP	Offshore Substation Platform
OWF	Offshore Wind Farm
PAM	Passive Acoustic Monitoring
PCW	Phocid carnivore in water
PTS	Permanent Threshold Shift
SEL	Sound Exposure Level
SEL_{cum}	Cumulative Sound Exposure Level
SPL_{peak}	Peak Sound Pressure Level
SNCB	Statutory Nature Conservation Bodies
UK	United Kingdom
UXO	Unexploded Ordnance
VE	Five Estuaries
WTG	Wind Turbine Generator

GLOSSARY

Term	Definition
Array Area	The areas where the WTGs will be located. These should be referred to as the northern and southern arrays to differentiate them.
Development Consent Order	An order made under the Planning Act 2008 granting development consent for a Nationally Significant Infrastructure Project (NSIP) from the Secretary of State (SoS) for the Department for Energy Security and Net Zero (DESNZ).
Effect	Term used to express the consequence of an impact. The significance of an effect is determined by correlating the magnitude of the impact in question with the sensitivity of the receptor in question, in accordance with defined significance criteria.
ES	Environmental Statement (the documents that collate the processes and results of the EIA).
Impact	An impact to the receiving environment is defined as any change to its baseline condition, either adverse or beneficial, resulting from the activities associated with the construction, operation and maintenance, or decommissioning of VE.
Magnitude	The extent of any interaction, the likelihood, duration, frequency and reversibility of any potential impact.
Maximum Design Scenario (MDS)	The maximum design parameters of the combined project assets that result in the greatest potential for change in relation to each impact assessed.
Mitigation	Mitigation measures, or commitments, are commitments made by VE to reduce and/or eliminate the potential for significant effects to arise as a result of VE.
Peak Sound Pressure Level	Characterised as a transient sound from impulsive noise sources, it is the maximum change in positive pressure as the wave propagates.
Pre-construction	The phases of VE before construction takes place.
Sensitivity	The potential vulnerabilities of receptors to an impact from VE, their recoverability and the value/importance of the receptor.
Significant Effects	It is a requirement of the EIA Regulations to determine the likely significant effects of the development on the environment which should relate to the level of an effect and the type of effect. Where possible significant effects should be mitigated.

Term	Definition
Sound Exposure Level	Measure that considers both the received level of the sound and duration of exposure.
Sound Pressure Level	Measure of the average unweighted level of sound, usually a continuous noise source.
The Applicant	The company Five Estuaries Offshore Wind Farm Ltd.
VE	Five Estuaries Offshore Wind Farm (VE) including the proposed offshore and onshore infrastructure.

1 INTRODUCTION

1.1 PROJECT BACKGROUND

The Five Estuaries Offshore Wind Farm (hereafter VE) is a proposed extension to the operational Galloper Offshore Wind Farm, which is located off the coast of Suffolk (England, United Kingdom (UK)) in the Southern North Sea. At its closest point, VE is located 37 kilometres (km) off the Suffolk coast.

1.2 PURPOSE OF THIS DOCUMENT

1.2.1 The primary objective of this Outline Marine Mammal Mitigation Protocol (MMMP) for Unexploded Ordnance (UXO) Clearance is to detail the potential contingency measures which could be used by VE to manage the risk of permanent threshold shift (PTS) auditory injury to marine mammal species arising from UXO clearance operations to a negligible level. This document incorporates guidance from the Joint Nature Conservation Committee (JNCC, 2010), integrates recommendations on the utilisation of Acoustic Deterrent Devices (ADD) as outlined by McGarry (2020),~~ and~~ adheres to the UXO clearance joint interim position statement[1], ~~and~~ established industry best practices, policy and guidance (UK Government, 2025; JNCC, 2025).

1.2.2 The need for UXO clearance is expected before construction of VE. This requirement arises from the proximity of VE area to coastal areas of strategic importance during World War Two. While efforts will be made to avoid any underwater UXO, it is essential to address the possibility of underwater UXO detonation when retrieval is unsafe, or avoidance is impractical. UXO clearance will be controlled through a separate Marine License (ML).

1.2.3 The measures outlined in this document should be considered as examples of potential mitigation measures which could be employed by VE at the point of construction to provide confidence to stakeholders that the proposed MMMP will be sufficient to ensure the risk of injury is as low as reasonably practicable. It is not intended to identify specific mitigation measures that will be implemented during UXO clearance as this will be determined prior to construction by VE in consultation with the regulators and their advisors. Prior to the commencement of offshore construction for VE, a formal UXO clearance MMMP will be drafted and submitted to the regulator as part of a separate ML application which will be based on the best available evidence at that point in time.

1.2.4 VE has developed mitigation measures during the Environmental Impact Assessment (EIA) process to minimise potential impacts to marine mammals, which involves the creation and implementation of an UXO clearance MMMP (see Volume 6, Part 2, Chapter 7: Marine Mammal Ecology for full details).

[1] Marine environment: unexploded ordnance clearance joint interim position statement, https://www.gov.uk/government/publications/marine-environment-unexploded-ordnance-clearance-joint-interim-position-statement

1.3 IMPLEMENTATION OF THE OUTLINE MMMP FOR UXO CLEARANCE

1.3.1 A Final UXO Clearance MMMP will be prepared once the final project design has been confirmed, and when more information is available on the sizes and locations of any found UXO devices on-site and secured through a ML. That plan will follow the principles established in this Outline MMMP for UXO Clearance. Details regarding the proposed mitigation can be found in Section 4 below.

2 UXO CLEARANCE SCENARIOS

2.1 KEY RELEVANT PROJECT CHARACTERISTICS

2.1.1 The final design of VE, e.g., number of wind turbine generators (WTGs, layout configuration, foundation type and requirement for scour protection, will not be fully determined until post-consent. Therefore, realistic maximum design scenarios (MDS) in terms of potential impacts are considered for assessment as precautionary approach.

2.1.2 At this stage, the Applicant does not have the precise count or duration of potential UXO detonations during clearance operations. A geophysical survey would be completed prior to construction and the results of which would identify potential UXO and UXO hazards. A visual assessment will follow, involving a remotely operated vehicle (ROV) to confirm whether these targets are UXO.

2.1.3 It is anticipated the primary method that will be employed for VE will be low-order detonation, known as deflagration. When deflagration is adopted, the explosive material would be burned without causing an explosion, and this process would be initiated by a small, shaped charge. Field measurements that compare low-order and high-order detonations reveal a significant reduction in peak sound levels and the overall acoustic energy of the detonation when deflagration is employed. It is worth noting that deflagration has been in use by the UK military since the early 2000s (Merchant and Robinson, 2019).It is not currently known the size or type of the UXO that could be present in the area, therefore a range of charge sizes have been considered in Volume 6, Part 2, Chapter 7: Marine Mammal Ecology, with a maximum charge weight of up to 698 kg + 0.5 kg donor charge assumed.

2.1.4 The maximum charge weight assumed is considered to provide a good baseline for predicting and measuring the worst-case effects of any UXO that could be encountered within VE area.

2.2 MAXIMUM DESIGN SCENARIO (MDS)

2.2.1 Table 2.1~~Table 2.1~~ details the realistic MDS parameters for marine mammal UXO assessment.

Table 2.1: Maximum design scenario for marine mammal UXO assessment

Parameter	Notes and Rationale
Types and Sizes of UXO: Various possible types and sizes of UXO. The maximum charge weight for the potential UXO devices that could be present within VE site boundary has been estimated as 698 kg + 0.5 kg donor. This has been modelled alongside a range of smaller high-order charges at 25, 55, 120, 240 and 525 kg.	Indicative only. A detailed UXO survey would be completed prior to construction. The exact type, size and number of possible detonations and duration of UXO clearance operations is therefore not known at this stage.
Number of UXO requiring clearance: 2,000 expected potential UXO targets with 950 predicted to require inspection or which 60 may require clearance in the pre-construction phase.	
Maximum number of clearance events within 24 hours: Two Indicative duration: 30 days	VE is not seeking to licence the disposal of UXO in the DCO application, but it is included in the impact assessment of Volume 6, Part 2, Chapter 7: Marine Mammal Ecology.
Clearance techniques: Low-order clearance would be the first and preferred method for UXO that requires clearance[2]. A deflagration charge of 0.5 kg is estimated. As a worst-case scenario, assessments are based on high-order clearance without bubble curtain, although high-order clearance detonation with a bubble curtain is the current recommendation (see Section 4.4). A maximum charge size of 698 kg + 0.5 kg donor is assumed. The clearance works are expected to occur prior to foundation installation.	High-order clearance would only be undertaken if low-order clearance ~~is not possible or~~ failed to clear the device completely (JNCC, 2025a). This is therefore unlikely to be required, however, it is considered as the MSD as a precautionary approach.

[2] This aligns with the UK Government (2025) policy

3 SUMMARY OF POTENTIAL IMPACTS

3.1.1 VE has assessed the potential UXO clearance impacts to marine mammals as part of the Environmental Impact Assessment (EIA), and this is detailed in Volume 6, Part 2, Chapter 7: Marine Mammal Ecology.

3.1.2 The potential impacts from underwater noise from UXO clearance at VE has been assessed for PTS on grey seal, harbour porpoise and harbour seal, referring to the PTS-onset thresholds presented by Southall *et al.* (2019). Additional detail on the UXO assessment on marine mammals can be found in Volume 6, Part 2, Chapter 7: Marine Mammal Ecology.

3.1.3 Whilst any identified UXO would preferentially be avoided, it is necessary to consider the requirement for underwater UXO detonation where it is deemed unsafe to retrieve a UXO from the seafloor.

3.1.4 Predicated PTS-onset impact ranges were calculated for a range of expected UXO sizes and presented in Table 3.1~~Table 3.1~~. The maximum charge weight for the potential UXO devices that could be present within VE site boundary has been estimated as 698 kg. This has been modelled alongside a range of smaller high-order charges at 25, 55, 120, 240 and 525 kg. In addition, a low-order deflagration has been assessed, which assumes that the donor or shaped-charge (charge weight 0.5 kg) detonates fully but without the follow-up detonation of the UXO. No mitigation measures have been considered for the modelling of the range and number of animals predicted to be disturbed by the detonation of high order and low order charges.

3.1.5 The maximum predicted PTS-onset impact range is 13 km for harbour porpoise, from the high-order clearance of a 698 kg UXO plus donor charge (Table 3.1~~Table 3.1~~).

Table 3.1: PTS-onset impact ranges (in km) for UXO detonation using as per the impulsive noise criteria from Southall *et al.* (2019). For all charge sizes above 25 kg a donor charge of 0.5 kg is assumed.

Species	Threshold		Charge Size						
			0.5 kg	25 kg + donor	55 kg + donor	120 kg + donor	240 kg + donor	525 kg + donor	698 kg + donor
Unweighted SPL_{peak} (dB re 1µPa)									
Harbour porpoise	202 dB (VHF)	Max range (km)	1.2	4.6	6.0	7.8	9.8	12.0	13.0
Harbour & Grey seals	218 dB (PCW)	Max range (km)	0.24	0.91	1.1	1.5	1.9	2.5	2.7
Weighted SEL_{ss} (dB re 1µPa^2s)									
Harbour porpoise	155 dB (VHF)	Max range (km)	0.11	0.57	0.74	0.95	1.1	1.4	1.5
Harbour & Grey seals	185 dB (PCW)	Max range (km)	0.06	0.39	0.57	0.83	1.1	1.6	1.9

3.2 SUMMARY OF IMPACTS ASSESSED FOR MARINE MAMMALS IN RELATION TO PTS FOR UXO DETONATION

3.2.1 Volume 6, Part 2, Chapter 7: Marine Mammal Ecology presents the full assessment of impacts of PTS-onset from UXO clearance on marine mammals. In summary, the assessment concluded that, with the use of mitigation methods (outlined within this document), it is expected that the risk of PTS will be negligible even when considering the maximum modelled charge size of 698 kg + donor charge. Therefore, it is considered not to have a significant effect on any marine mammal species considered in the assessment.

4 MITIGATION METHODOLOGY

4.1 INTRODUCTION

4.1.1 In order to minimise the risk of any auditory injury to marine mammals from underwater noise during UXO clearance operations, there are a suite of mitigation measures that the Applicant could implement for VE UXO clearance. These mitigation measures may include (but are not limited to) the following:

- Low-order clearance techniques such as deflagration will be the default method for clearance (UK Government, 2025);
- High order clearance as a contingency measure should it be required (UK Government, 2025);
- The use of bubble curtains if any high-order detonation is required (taking into consideration the environmental limitations);
- All UXO clearance operations to take place during daylight hours and, when possible, in favourable weather conditions with good visibility (*i.e.,* a sea state of 3 or less) in line with JNCC (2025a);
- Establishment of a monitoring area with a minimum of 1 km radius. The observation of the monitoring area will be conducted by dedicated and trained marine mammal observers (MMOb(s)) during daylight hours and under suitable visibility;
- Deployment of passive acoustic monitoring (PAM) systems, if required, and if equipment can be safely deployed and retrieved;
- The activation of an acoustic deterrent device (ADD);
- Establishing a protocol in line with JNCC guidelines in the event marine mammals are observed within the mitigation zone (JNCC, 2010);
- The controlled explosions of the UXO, undertaken by specialist contractors, using the minimum amount of explosive required to achieve safe disposal of the UXO;
- In the event of multiple UXO's located in close proximity to each other, with potential risk for a chain of uninitiated detonations, where practicable detonations would start with the smallest detonations and end with the larger detonations;
- Other UXO clearance techniques, such as avoidance of UXO or relocation of UXO; and
- If more than one high-order detonation is required or if UXO's are in close proximity, other measures will also be considered in consultation with the Marine Management Organisation (MMO) and SNCBs.

4.1.2 The UXO clearance mitigation measures for VE will be determined in consultation with relevant SNCBs once charge weights, survey data, noise data, and information on maturation of emerging technologies are confirmed. This additional data and information will inform noise modelling to be fed into the Final UXO Clearance MMMP and discussions on suitable mitigation measures.

4.1.3 The following sections provide a high-level methodology for each of these elements. A Final UXO Clearance MMMP will be produced prior to the relevant stage of construction for approval by the MMO.

4.2 MITIGATION ZONE

4.2.1 The mitigation zone is defined as the maximum potential PTS-onset impact range. The Applicant will update the noise modelling prior to UXO clearance activities commencing, once more information is available to inform the final UXO details. For low order clearance ~~T~~he JNCC (2025a~~10~~) recommends a mitigation zone of the full extent within which PTS could occur or a ~~at least~~ 1 km radius, whichever is larger~~for UXO detonation~~. The actual mitigation zone for VE UXO detonation will be confirmed in the Final UXO Clearance MMMP and will be determined based on the final noise modelling data, expected charge sizes and detonation methods. ~~If the final noise modelling estimates result in a PTS-onset impact range larger than the 1 km suggested radius, the mitigation zone would be increased to cover the PTS-onset impact range.~~ For both low and high order clearances at least two dedicated MMObs should work together to monitor the zone, due t~~o~~ the minimum size of the mitigation area and ideally at least one MMOb should be on an elevated platform (JNCC, 2025).

4.3 PRE-UXO CLEARANCE

MARINE MAMMAL OBSERVER (MMOB)

4.3.1 The JNCC (2025a~~10~~) recommends a minimum 60-minute pre-detonation search by a qualified MMOb(s) within the mitigation zone for both low order and high order UXO detonation and a 30-minute search prior to ADD activation[3]. If this mitigation measure is adopted, the MMOb(s) would record monitoring periods, environmental conditions, and marine mammal sightings as per JNCC guidelines. Identified behavioural responses to ADD activation (if used) would also be documented.

4.3.2 If a marine mammal is detected within the mitigation zone during the pre-detonation search, the operation would be delayed and the MMOb(s) should monitor and track the marine mammal until it moves out of the mitigation zone. The detonation should not occur within 20 minutes of a marine mammal being detected in the mitigation zone. If the marine mammal is not detected again within 20 minutes, then it is assumed It has left the mitigation zone and detonation can commence.

4.3.3 The JNCC guidelines have stipulated fully-trained MMOb(s) are used for minimising marine mammal risks associated with explosive use (JNCC, 2025~~10~~). Specific details on MMOb(s) and methods will be updated in the Final UXO Clearance MMMP, considering any available guidance at that time.

PASSIVE ACOUSTIC MONITORING (PAM)

4.3.4 A PAM system, operated by a trained operator, would be used to supplement visual monitoring during daylight and in conditions of reduced visibility (*e.g.,* night, fog, high sea state as per JNCC, 2023; JNCC, 2025 guidance). If an animal is acoustically detected within the mitigation zone, UXO operations would be delayed until the PAM operator (or MMObs (if used)) confirms its departure from the mitigation zone.

[3] ADDs will be used for their required time in conjunction with the visual watch. This may require the total visual watch time to be longer than 1 hour when the ADD activation time is longer than 30 minutes

ADD CHOICE AND SPECIFICATION

4.3.5 The typical ADD used in UK waters for current construction phase projects is the Lofitech AS seal scarer. Extensive studies, such as those by Sparlin *et al.* (2015) and McGarry *et al.* (2017), have consistently demonstrated the high effectiveness of this ADD in deterring harbour seals, grey seals and harbour porpoise, particularly in conditions resembling offshore wind farm (OWF) construction sites.

4.3.6 Lofitech ADDs have been proven to significantly deter harbour porpoise up to 7.5 km, without causing complete displacement of this species (Brandt *et al.,* 2013). Moreover, these ADDs have elicited responses in seals within a radius of less than 1 km. However, it is noteworthy that the observed responses did not always lead to substantial movements away from the source, especially for seals that were travelling at the time of exposure (Gordon *et al.,* 2019).

4.3.7 The Lofitech AS seal scarer boasts a commendable track record in mitigating marine mammal interactions across various European OWF projects. Its successful application has been documented in projects such as C-Power Thornton Bank OWF in Belgium (Haelters *et al.,* 2012), Horns Rev II, Nysted and Dan Tysk OWFs in Denmark (Carstensen *et al.,* 2006; Brandt *et al.,* 2016), and has been widely used for UK projects including Hornsea Project One, Hornsea Project Two, Dogger Bank A and B and for the Sofia OWF unexploded ordnance (UXO) campaign among others.

4.3.8 It is important to note that there may be additional ADD models identified in the pre-construction phase for VE that are available and suitable for use. As such, if an ADD is identified as a mitigation measure within the Final UXO Clearance MMMP, the final ADD choice and specification would follow current best practice as advised by the relevant SNCB(s) and would be approved by the MMO.

ADD DEPLOYMENT PROCEDURE

4.3.9 If an ADD is used during UXO detonation, one ADD would be deployed from the platform/vessel deck, with the control unit and power supply on board in safe positions. Verification of ADD operations would be required before pre-detonation activation. The deployment procedure would be determined with the UXO contractor and would adhere to safe, standard practices, using experienced/trained staff to ensure proper ADD equipment.

ADD DURATION OF DEPLOYMENT

4.3.10 The duration of ADD deployment would be calculated based on assumed swimming speeds to ensure that marine mammals are safely outside the mitigation zone when piling begins. An assumed swim speed of 1.5 m/s would be applicable to both porpoise and seals. These selected swim speeds are considered precautionary, as evidence suggests that animals often flee at much higher initial speeds. For instance, a study by Kastelein *et al.* (2018) demonstrated that captive harbour porpoises responded to pile driving sounds by swimming at significantly higher speeds than their baseline, reaching speeds of up to 1.97 m/s sustained for a 30-minute test period. Another study by van Beest *et al.* (2018) showed that a harbour porpoise responded to airgun noise exposure with a fleeing speed of 2 m/s.

4.3.11 During ADD deployment, marine mammals are expected to continue moving away from the noise source. Additionally, the presence of other construction vessel activity on-site would be likely to induce animals to move away from the immediate area (e.g. Brandt *et al.,* 2018; Graham *et al.,* 2019; Benhemma-Le Gall *et al.,* 2021, Benhemma-Le Gall *et al.,* 2023).

ADD OPERATOR TRAINING AND RESPONSIBILITIES

4.3.12 A trained and dedicated ADD operator would be responsible for ADD maintenance, operation, and reporting. Their duties would include deploying the ADD, verifying its operation, maintaining charged batteries and spare equipment, recording and reporting ADD and detonation activities. Before the MMOb(s) and/or PAM operator's pre-detonation watch, the ADD operator would test and deploy the ADD to the agreed depth and distance.

4.4 NOISE ABATEMENT

4.4.1 UK Government (2025) policy states that high order clearance should only be used as a contingency measure when there are circumstances that mean low order clearance cannot be undertaken. Technologies are available which reduce the amount of noise emitted at the source (noise abatement). Such technologies are being adopted in other parts of the North Sea to reduce the risk of impact on marine life, particularly marine mammals (Merchant and Robinson, 2019). It is important to note that metocean conditions, ground conditions and water depth all influence or constrain the selection of suitable noise abatement measures. JNCC (2025a) guidelines identify the need for noise abatement measures for high order detonations.

4.4.2 The noise abatement system (NAS) employed for UXO clearance entails the deployment of bubble curtains for high-order detonations. Bubble curtains have been extensively proven to be effective in waters up to 45 m however, their effectiveness diminishes with increasing water depth due to bubble dispersion (Merchant and Robinson, 2019; Verfuss *et al.,* 2019). It is important to acknowledge that the noise abatement techniques discussed here may not be exhaustive, as new technologies continue to emerge over time.

4.4.3 Following the full UXO search, and assessment will be made as to the number and magnitude of UXO's present. ~~, a decision will be made on whether noise abatement measures will be required for the site.~~ More information on NAS is provided in the Outline SNS SAC SIP (Volume 9, Report 15).

4.5 POST UXO DETONATION PROTOCOL

4.5.1 According to JNCC (2025a~~10~~) guidelines, a post-detonation search of at least 15 minutes would be conducted after the last detonation. The purpose of the post-detonation search is to look for any evidence of injury to marine mammals, as well as including a log of any fish kills.

4.6 DELAYS IN COMMENCEMENT OF UXO DETONATION

4.6.1 If UXO detonation is delayed, there would be a risk of animals re-entering the mitigation zone when ADDs are switched off. However, turning on ADDs for extended periods may lead to habituation. Therefore, ADDs would be promptly turned off during delays and reactivated when detonation is ready to commence. The break in ADD use would be for greater than 20 minutes to ensure a startle and flee response when the ADD is reactivated. ADDs would then be used for the minimum duration required to ensure animals leave the mitigation zone, alongside ongoing visual and/or acoustic monitoring. The MMOb(s) and/or PAM Operator would continue their visual or acoustic searches during this time.

4.7 COMMUNICATIONS

4.7.1 The Final UXO Clearance MMMP would specify a communication protocol for implementing marine mammal mitigation measures, including any UXO detonation delays due to marine mammal presence. It would also outline the roles and responsibilities of key personnel to ensure these mitigation measures are effectively carried out. Personnel details and roles would be finalised based on contractual agreements and mitigation needs.

4.8 REPORTING

4.8.1 Reports on UXO clearance and mitigation measures would be prepared, including, but not limited to:

- Activity reference number (if applicable);
- Date and location of act;
- Operation details (*e.g.,* charge size, detonation start times, watch times by MMOb(s), PAM use);
- Summarised marine mammal sightings using “Marine Mammal Recording Forms”;
- Information on ADD and its effectiveness; and
- Noted problems and instances of non-compliance with JNCC guidelines.

4.8.2 The final report would cover detonation events, mitigation methods, issues, sightings, behavioural observations, and potential protocol improvements. It would be submitted to the regulator as agreed following completion of UXO clearance.

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