Hornsea Project Four

Clarification Note on Marine Processes Mitigation and Monitoring

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Revision Summary

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1 Introduction and Background

1.1.1.1 Orsted Hornsea Project Four Limited (hereafter the Applicant) has submitted a Development Consent Order (DCO) application to the Planning Inspectorate (PINS), supported by a range of plans and documents including an Environmental Statement (ES) which set out the results of the Environmental Impact Assessment (EIA) on the Hornsea Project Four Offshore Wind Farm (hereafter Hornsea Four) and its associated infrastructure.

1.1.1.2 Within the marine geology, oceanography and physical processes (hereafter 'marine processes') assessment of the ES (**A2.1 Marine Geology Oceanography and Physical Processes (APP-013)**), Smithic Bank (a shallow sandbank feature in the lee of Flamborough Head) and the Flamborough Front (a temperature front between two water bodies that develops approximately 10 km offshore from Flamborough Head) were identified as marine processes features of interest with the Hornsea Four study area (**A5.1.1 Marine Processes Technical Report (APP-067)**).

1.1.1.3 In response to early stakeholder consultation, the DCO application included proposed mitigation and monitoring activities with regards to marine processes within its Outline Marine Monitoring Plan (**APP-242**) and Project Description (**REP4-003**), along with specific project commitments set out in the Commitments Register (**REP4-007**) which are drawn upon within this submission.

1.1.1.4 Within the Marine Management Organisation (MMO) and Natural England's Relevant Representations (**RR-020** and **RR-029**, respectively), concerns were raised in relation to the impact of Hornsea Four on Smithic Bank and the Flamborough Front. Discussions have continued throughout the Hornsea Four Examination process, with the Applicant producing a supplementary note to respond to stakeholder concerns raised (**G4.9 Marine Processes Supplementary Report (REP3-038)**). An Evidence Plan Technical Panel meeting was held on 10 June 2022 with the Applicant, the MMO (including its advisor Cefas) and Natural England in relation to the supplementary note, with the MMO and Natural England submitting a response to the supplementary report at Deadline 5 (**Marine Management Organisation's Deadline 5 comments, Responses to Examining Authority's Further Written Questions (ExQ2), Comments on any submissions received at Deadline 4 and 4a, Further information requested by the Examining Authority under Rule 17 (REP5-107)** & **Marine Management Organisation & Cefas review of G4.9 Marine Processes Supplementary Report (REP5-114)**).

1.1.1.5 In parallel, an independent review of the Hornsea Four marine processes submissions has been undertaken by Professor Mike Elliot (Director of International Estuarine & Coastal Specialists (IECS) Ltd and Professor of Estuarine and Coastal Sciences at the University of Hull), with specific focus on the issues raised by MMO and Natural England (**REP5-066**).

1.1.1.6 This report addresses specifically Natural England's Deadline 5 submission: [Natural England,] Marine Management Organisation & Cefas review of G4.9 Marine Processes Supplementary Report (**REP5-114**) and provides a synthesis (the Applicant's interpretation) of that advice along with G5.10 Professor Mike Elliot's Marine Processes Report Review (**REP5-066**) to guide the development of this submission in the absence of central point upon which parties can align to resolve.

1.1.1.7 This report provides a synthesis of the advice provided (**Section 2**), addresses the mitigation proposals as identified in **REP5-114** (**Section 3**), reviews the monitoring proposals committed to by the Applicant and reviews the monitoring requirements of other recently consented

offshore wind farms (OWFs) (Section 4) before proposing a way forward to resolve these issues by the end of Examination (Section 5).

2 Synthesis of advice received

2.1.1.1 This section presents the issues in relation to the marine processes receptors and assessment, as set out in REP5-114. For expedience, the comments and requests from MMO, Cefas and Natural England in other submissions are not addressed in this report, as it is assumed by the Applicant that the multi-agency response **(REP5-114)** should take precedence.

2.2 REP5-114: [Natural England,] Marine Management Organisation & Cefas review of G4.9 Marine Processes Supplementary Report

2.2.1.1 In the interests of expediating the examination process to a resolution on these issues, the Applicant has not provided a review or discussion of the points in REP5-114 and instead tabulates the proposed mitigations and monitoring requests proposed by the stakeholders under the headings of Smithic Bank and Flamborough Front and signposts where they have been addressed in this submission.

Smithic Bank

2.2.1.2 Potential mitigation and monitoring requirements for Smithic Bank as defined in section 1.6 of REP5-114 are set out in Table 1.

Table 1: Potential mitigation and monitoring requirements for Smithic Bank.

ID	Requirement	Where considered
a	Disposal sites for cable installation across Smithic Bank should be clearly defined and it should be demonstrated that dredged material will be retained within the Smithic Bank system.	Section 3: Mitigation and Table 4
b	Cable protection should be avoided within the nearshore area and across the full extent of the sandbank.	Section 3: Mitigation
c	The Dogger Bank A & B Cable Crossing should be sited as far to the east of the accurately defined geomorphological boundary as possible. (The most up to date information on Dogger Bank A&B's layout should be used to inform this).	Section 3: Mitigation and Table 4
d	Bundling of cables should be implemented where possible in the nearshore to reduce the impact and the number of cable crossings.	Section 3: Mitigation and Table 4
e	Due to the dynamic nature of Smithic Bank and the anticipated Dogger Bank A&B cable installations, monitoring of the area between the Holderness Coastline and the Dogger Bank Cable Crossing by swath bathymetry should be undertaken prior to construction to allow additional mitigation to be incorporated, as required.	Section 4: Monitoring
f	To identify and manage any residual risk, a robust monitoring plan should be agreed upon which incorporates "trigger points" to allow interventions or remediation, as required.	Section 4: Monitoring

Flamborough Front

2.2.1.3 Potential mitigation and monitoring requirements for Flamborough Front as defined in section 2.4 of REP5-114 are set out in Table 2.

Table 2: Potential mitigation and monitoring requirements for Flamborough Front.

ID	Requirement	Where considered
Paragraph 1	We recognise that the nature and extent of these changes are difficult to quantify and therefore assess. Consequently, we advise that Hornsea 4 seek to reduce the risks as far as possible.	The nature and extent of the changes have been quantified and assessed (A2.1 Marine Geology Oceanography and Physical Processes (**APP-013**) **A5.1.1 Marine Processes Technical Report (APP-067)** **G4.9 Marine Processes Supplementary Report (REP3-038)).** The Applicant has proposed several commitments to eliminate or reduce effects/risks as far as reasonably practical (see Table 3 and Section 4)
Paragraph 2	Key to this would be to reduce the MDS for foundations structures within the Hornsea Four array as much as possible, or removal of GBS as an option (i.e. using monopiles in place of the larger GBSs). There may also be merit in further consideration of the placement of structures within the developable area to reduce the potential for the effects of individual turbines acting in combination with each other.	Section 3: Mitigation and Table 4
Paragraph 3	Again, it will be important to establish a monitoring programme to record any changes to stratification and primary productivity, which would require surveys pre-construction, post-construction, and for the lifetime of the project. This should include "trigger points" to allow interventions/remediation if required.	Section 4: Monitoring
Paragraph 4	Lastly, we would advise that the impacts discussed above will need further consideration in the context of the HRA and MCZ assessments	Not considered further as all mitigations are proposed to reduce impacts assessed at Application. No new impacts arise that invalidate HRA or MCZ assessments provided at Application.

2.3 REP5-066: G5.10 Professor Mike Elliot's Marine Processes Report Review

2.3.1.1 The independent review provided by Prof Elliott, though substantive, has been condensed to those matters that relate specifically to the issues raised in **REP5-144**; Smithic Bank (**Table 1**) and Flamborough Front (**Table 2**). The synthesis in **REP5-066** is provided on a receptor basis with the inclusion of the ramp, as this has been linked to the Smithic Bank and

Holderness coastline and remains the subject of some clarifications and ongoing discussion with stakeholders.

2.3.2 Ramp

2.3.2.1 Prof Elliott states in 2.2.1.3 *"..it is expected that there will be additional coastal erosion on the down-current side of the ramp and so the ramp must be placed to account for this"*. The Applicant confirms that an access ramp would be placed in the upper intertidal zone and encroaches upon MHWS only, where active coastal processes would be reduced in frequency, intensity and duration. Sediment may build-up on the up-current side of the ramp (towards Bridlington) and in times of exposure to wave and tidal processes (only when tidal levels are at MHWS) erosion on the down-current side may take place.

2.3.2.2 The Applicant would like to take this opportunity to highlight that ERYC, as the Competent Authority for coastal management along the Holderness coastline, have reviewed the materials provided into Examination and have confirmed the following at Deadline 5 (**REP5-094**): *"This is a small-scale temporary ramp to be used in the event of emergency access. Should it be extended to the intertidal zone there would be no additional requirements"*.

2.3.3 Smithic Bank

2.3.3.1 Prof Elliott states at paragraph 2.5.1.1 *"..Literature suggests that in the case of Flamborough Head, the north-south currents are much more important than any east-west ones.."*. Furthermore at paragraph 2.5.1.5 Prof Elliott states *"..NE are concerned that moderate elevation changes to the sandbank through construction/decommissioning (and maintenance) activities, ..., might modify the Holderness shoreline response to storm waves, and the Holderness shoreline morphology over the lifetime of the project/installed infrastructure. ..All of this is possible but is it probable?"*.

2.3.3.2 The Applicant agrees that north-south sediment transport are a key consideration at the location of the Dogger Bank A&B OWF export cable crossing and that there is limited sediment transport interaction east-west.

2.3.4 Flamborough Front

2.3.4.1 Prof Elliott states at paragraph 2.6.1.2 *"..Seasonal stratification occurs north of the Front but assessing the dynamic of this stratification and modelling it in relation to any introduced structures is particularly difficult.. there is the need to exercise caution regarding the use of the term 'significant' and refer to a signal to noise ratio and assumption that the change can be detected.."*.

2.3.4.2 Prof Elliott states at paragraph 2.6.1.3 *"Carpenter et al. (2016) and Hill et al. (1993) show the complexity in the dynamics of tidal mixing fronts in the North Sea and hence the difficulty of not only describing and predicting their position and seasonal changes but also the difficulty of modelling any interference to the fronts"*. This is particularly problematic in quantifying and monitoring any project-scale (~30km width of AfL) effects which may affect the form and functioning of the front (~320 km long at peak occurrence).

2.3.4.3 At paragraph 2.6.1.4 Prof Elliott states *"..the importance of the Flamborough-Helgoland front to primary productivity in the North Sea has long been agreed, ..it will be difficult to refute the NE question that "Turbulent wakes are not expected to interact with the Flamborough Front.""*. Furthermore, at paragraph 2.6.1.5 Prof Elliott states *"..the behaviour of the front is poorly understood as is its means of formation and the mechanisms for nutrient delivery and primary production. As the content of nutrients in the area will not change, even if there are minor changes in concentration, and the light regime stays the same then it is not easy to see*

how the primary production will change. This is the subject of proposals to the ECOWind programme and will provide evidence if funded."

3 Mitigation

3.1.1.1 This section of the report sets out the commitments Hornsea Four made during the development phase of the project in relation to marine and coastal process receptors in response to stakeholder feedback and considers further potential mitigation requirements suggested in **REP5-114**.

3.2 Hornsea Four marine processes commitments

3.2.1.1 In line with Hornsea Four's proportionate approach to EIA, **Table 3** sets out the Commitments, made and secured, to eliminate or reduce potential environmental effects upon marine process receptors to environmentally acceptable levels. It should be noted that the early adoption of commitments to avoid designated sites for nature conservation (i.e. commitments Co2, Co44 and Co45 in **Volume A4, Annex 5.2: Commitment Register**) had a direct influence on the nature of the project design brought forward.

Table 3: Project Commitments Related to Marine Processes.

Commitment Reference	Hornsea Four Commitment	Receptor/Impact mitigation	How is the Commitment secured?	Relevant Application Documents
Co2	A range of sensitive historical, cultural and ecological conservation areas (including statutory and non-statutory designations) have been directly avoided by the permanent Hornsea Four footprint, at the point of Development Consent Order Submission (DCO). These include, but are not restricted to: Listed Buildings (564 sites); Scheduled Monuments (30 sites); Registered Parks and Gardens (Thwaite Hall and Risby Hall); Onshore Conservation Areas (18 sites); Onshore National Site Network (one site); Offshore National Site Network (three sites); Offshore Marine Conservation Zones (two sites); Sites of Special Scientific Interest (two sites); Local Nature Reserves (none have been identified); Local Wildlife sites (33 sites); Yorkshire Wildlife Trust Reserves (none have been identified); Royal Society for the Protection of Birds (RSPB) Reserves (none have been identified); Heritage Coast; National Trust land; Ancient Woodland (10 sites and known Tree Preservation Orders (TPOs)); non-designated built heritage assets (334 sites); and historic landfill (none have been identified). Where possible, unprotected	Statutory and non-statutory designations were avoided in the route planning process.	DCO Works Plan - Onshore; and DCO Works Plan - Offshore	DCO Works Plan - Onshore (Doc No. D1.4.2) DCO Works Plan - Offshore (Doc No. D1.4.1)

Commitment Reference	Hornsea Four Commitment	Receptor/Impact mitigation	How is the Commitment secured?	Relevant Application Documents
	areas of woodland, mature and protected trees (i.e. veteran trees) have and will also be avoided.			
Co44	The Holderness Inshore Marine Conservation Zone (MCZ) will not be crossed by the offshore export cable corridor including the associated temporary works area.	MCZ seabed disturbance and sediment deposition	DCO Works Plans - Offshore	DCO Works Plan - Offshore (Doc No. D1.4.1)
Co45	The Holderness Offshore Marine Conservation Zone (MCZ) will not be crossed by the offshore export cable corridor including the associated temporary works area.	MCZ seabed disturbance and sediment deposition	DCO Works Plans - Offshore	DCO Works Plan - Offshore (Doc No. D1.4.1)
Co82	A Scour Protection Management Plan will be developed. It will include details of the need, type, quantity and installation methods for scour protection.	To minimise scour development	DCO Schedule 11, Part 2 - Condition 13(1)(e) and; DCO Schedule 12, Part 2 - Condition 13(1)(e) *(Scour Protection Management Plan)*	n/a
Co83	Where possible, cable burial will be the preferred option for cable protection.	To minimise cable protection, to minimise sediment transport effects.	DCO Schedule 11, Part 2 - Condition 13(1)(h) and; DCO Schedule 12, Part 2 - Condition 13(1)(h) *(Cable specification and installation plan)*	Outline Offshore Cable Specification and Installation Plan (Doc No. F2.15)

Commitment Reference	Hornsea Four Commitment	Receptor/Impact mitigation	How is the Commitment secured?	Relevant Application Documents
Co96	The project commits to agree layout principles with the Marine Management Organisation (MMO), in consultation with the Maritime Coastguard Agency (MCA) and Trinity House.	To maintain navigational safety.	DCO Schedule 11, Part 2 - Condition 13(1)(a) and; DCO Schedule 12, Part 2 - Condition 13(1)(a) (Pre-construction plans and documentation)	Layout Principles (Doc No. A4.4.7)
Co176	A Cable Specification and Installation Plan will be produced prior to construction of the offshore export cable which will include; details of cable burial depths; a detailed cable laying plan which ensures safe navigation is not compromised; details of cable protection for each cable crossing; and proposals for monitoring of offshore cable.	To maintain safe navigation, minimise cable protection and monitoring of offshore cables.	DCO Schedule 11, Part 2 - Condition 13(1)(h) and; DCO Schedule 12, Part 2 - Condition 13(1)(h) (Cable specification and installation plan)	Outline Offshore Cable Specification and Installation Plan (Doc No. F2.15)
Co181	An Offshore Decommissioning Plan will be developed prior to decommissioning.	To remove all infrastructure from the seabed and return to pre-construction state.	DCO Schedule 11, Part 1(6) and; DCO Schedule 12, Part 1(6) *(General Provisions)*	n/a
Co187	The installation of the offshore export cables at landfall will be undertaken by Horizontal Directional Drilling or other trenchless methods.	To preclude any work on the rapidly eroding, sensitive Holderness coastline and to minimise the requirement for any intertidal works.	DCO Requirement 17 (Code of construction practice); and DCO Schedule 12, Part 2 - Condition 13(1)(h) (Cable specification and installation plan)	Outline CoCP (Doc No. F2.2) Outline Offshore Cable Specification and Installation Plan (Doc No. F2.15)

Commitment Reference	Hornsea Four Commitment	Receptor/Impact mitigation	How is the Commitment secured?	Relevant Application Documents
Co188	No cable protection will be employed within 350 m seaward of MLWS.	To minimise longshore sediment transport processes and mitigate any potential effects on sediment transport along the Holderness coastline and maintain sediment exchange from Smithic Bank.	DCO Schedule 11, Part 2 - Condition 13(1)(h) and; DCO Schedule 12, Part 2 - Condition 13(1)(h) *(Cable specification and installation plan)*	Outline Offshore Cable Specification and Installation Plan (Doc No. F2.15)
Co189	The Dogger Bank cable crossing will be positioned east of Smithic Bank (as identified at https://data.gov.uk/dataset/d19f631c-27c0-4c74-804f-d76a4632b702/annex-i-sandbanks-in-the-uk-v2-public) and seaward of 20 m depth contour.	To minimise hydrodynamic and sediment transport process changes and eliminate morphological effects upon Smithic Bank.	DCO Schedule 11, Part 2 - Condition 13(1)(h) and; DCO Schedule 12, Part 2 - Condition 13(1)(h) *(Cable specification and installation plan)*	Outline Offshore Cable Specification and Installation Plan (Doc No. F2.15)
Co201[1]	Gravity Base Structure (GBS) foundations (WTG type) will be utilised at a maximum of 110 of the 180 WTG foundation locations. The location of GBS foundations, if used for WTG, will be confirmed through a construction method statement which will include details of foundation installation methodology.	To minimise hydrodynamic changes associated with flow and wave related blockage effects.	DCO Schedule 11, Part 2 - Condition 13(1(c) (Construction Method Statement)	n/a

3.2.1.2 It should be noted that in making the commitments (Co2, Co44 and Co45 in **Volume A4, Annex 5.2: Commitment Register**) to avoid the Holderness Marine Conservation Zones (MCZ) - a lesson learned and applied with vigor from the consenting of Hornsea Three OWF (where the ECC route and landfall at Weybourne was required to avoid the Cromer Shoal Chalk Beds MCZ), the Applicant was left with very limited sea room (see Panel D of Figure 3 in **Annex 3.1 Selection and Refinement of the Cable Landfall (APP-036)**) within which to route the ECC to landfall.

[1] Commitment 201 will be updated at Deadline 5a to 80 WTG gravity base foundations. Reduced from 110.

3.2.1.3 The Commitments proposed by the Applicant at the route planning and site selection phase to avoid the MCZ were welcomed by Natural England and other stakeholders.

3.2.1.4 Furthermore, when impacts from cable installation upon the MCZs (closest MCZ located approximately 753 m to the south of the ECC) were considered, the Applicant proposed a commitment to apply a 500 m temporary works area buffer to minimise/exclude construction impacts upon the MCZs. This resulted in further constraining the feasible space for the ECC route to landfall, leaving no alternative other than the crossing of the Smithic Bank, which is not a designated site for nature conservation.

3.2.1.5 Furthermore, in relation to the commitment to using HDD techniques for the installation of the offshore export cables at landfall (Co187), it is important to note that this commitment was made by the project early in the design phase to avoid/reduce/mitigate impacts to key receptors in the nearshore area as far as possible. The Applicant highlights that this commitment is in contrast to the methodologies within the envelope for the Dogger Bank A and B export cables, which allows for open-cut trenching at landfall.

3.2.1.6 Commitment Co 188, which restricts cable protection within 350m seaward of MLWS was also adopted by the project in response to early stakeholder comments to limit avoid/reduce/mitigate impacts to key receptors in the nearshore area as far as possible – this commitment mirrors the restriction that is secured in the Dogger Bank A & B DCO.

3.3 Further potential mitigation requirements suggested in REP4-114

3.3.1.1 Hornsea Four have given due consideration to the further potential mitigation requirements suggested in REP4-114 along with other marine processes mitigations and monitoring requests raised by the MMO, Cefas and Natural England (see Table 4). In line with the proportionate approach to EIA, further mitigations to eliminate or reduce potential environmental effects beyond what is typically required to reduce negligible impacts to acceptable (acceptable to the MMO, Cefas and Natural England) are presented in Table 4. These mitigations build upon the commitments made and secured in Table 3.

Table 4: Further potential mitigation requirements suggested in REP4-114.

Mitigation Considered	Receptor/Impact mitigation	Comment
Disposal sites for cable installation across Smithic Bank should be clearly defined and it should be demonstrated that dredged material will be retained within the Smithic Bank system.	Smithic Bank	The Applicant confirms that all sediment will be retained within the Smithic Bank system. The level and quality of data obtained for the region suggests very little sediment mobility on Smithic Bank. Therefore, sandwave clearance is not expected. In the unlikely event that seabed levelling is required, there is no plan to transport any sediment outside the region. Installation is envisaged using standard installation tools such as Ploughing (Simultaneous Burial or Pre-Trench), Jetting or Cutting, dependent on the seabed conditions. Any disruption to seabed will be localised and there is no plan to transport sediments out of the region. Sediment disturbed during cable installation will be deposited within the cable corridor und utilised for backfilling (Pre-Trench solution).

Mitigation Considered	Receptor/Impact mitigation	Comment
Cable protection should be avoided within the nearshore area and across the full extent of the sandbank.	Smithic Bank	The Applicant has already committed (see Co188 in **A4.5.2: Commitment Register**) to exclude cable protection within 350 m seaward of MLWS to protect nearshore sediment transport processes and avoid effects upon the Holderness coastline. This commitment aligns with the Dogger Bank A & B project. The Applicant has made a further commitment to reduce the cable protection requirement from the standard 10% to 5% specifically across Smithic Bank. Further reduction in cable protection requires the conclusion of the Cable Burial Risk Assessment (CBRA) before the Applicant can conclude no cable protection in Smithic Bank is possible. The CBRA is not complete until appointment of the Principal Contractor however, which is some time in the future (anticipated to be 2027 at the earliest). While the Applicant acknowledges the advice in REP5-114, such as the requirement to exclude cable protection on Smithic Bank, to the Applicant's knowledge, such rigors have not been placed upon other developers who have also crossed (Dogger Bank A and B) or will cross the Smithic Bank to attain landfall on an otherwise highly physically constrained coastline.
The Dogger Bank A & B Cable Crossing should be sited as far to the east of the accurately defined geomorphological boundary as possible.	Smithic Bank	The Applicant has concluded some analysis to confirm he geomorphological boundary of the Smithic Bank (REF). The Applicant confirms that the JNCC shapefile for Smithic Bank is a good representation of the geomorphological boundary as it broadly aligns with the sandwaves/bedforms and change in bed roughness on the eastern flank of the bank. Therefore, the JNCC boundary is used as the datum for all monitoring works proposed.as it an agreed upon and openly available boundary not subject to debate or uncertainty. The Applicant has already committed (see Co189 in **A4.5.2: Commitment Register**) to ensuring the Dogger Bank A & B cable crossing is positioned as far east as is currently possible, past the 20 m contour east of the Smithic Bank. A final decision on the implementation of further mitigation is dependent upon receipt of the final location of the Dogger Bank A & B, cables, confirmation of the Hornsea Four decision on HVAC (6 cables) or HVDC (2 cable) electrical system and the appointment of a principal contractor. The Principal Contractor is responsible for the production of the CBRA before the Applicant is able to confirm cable protection requirements or exact location.

Mitigation Considered	Receptor/Impact mitigation	Comment
		The CBRA is not complete until appointment of the Principal Contractor, which is some time in the future (anticipated to be 2027 at the earliest). The Applicant can commit to review the proposed mitigation at the point when all the necessary information is available. A cable specification and installation plan will be submitted to the MMO for approval post-consent, in accordance with the requirements of condition 13(1)(h) of Part 2 of Schedules 11 and 12 of the DCO.
Shifting of the cable crossing with Dogger Bank A & B further offshore.	Smithic Bank	See point 3. above.
Bundling of cables should be implemented where possible in the nearshore to reduce the impact and the number of cable crossings (requested by MMO).	Smithic Bank	The Applicant's Technical Team (electrical infrastructure and cables teams) have given due consideration to the request to bundle cables and have provided the following response: a) a detrimental effect on the rating of the cables (i.e. their capacity to export energy) as the temperature of the cables would be higher due to the thermal interaction between neighbouring cables. Bundling of cables will effectively curtail windfarm generation. b) cable spacing serves also for the purpose of enabling cable repairs without the need to de-energise other circuits. If cables are bundled there is the risk that cable damage extends to other neighbouring cables in the bundle, or that during the repair other cables in the bundle are damaged by the intrusive repair operation. Laydown of the repair cable and further burial will likely be obstructed by the presence of the other cables. It is therefore not a practice that Orsted promote and will have multiple negative effects in the future operation of the windfarm. The Applicant considers any measure which could curtail generation of Hornsea Four (and the provision of much needed renewable energy to the UK national grid) to be entirely disproportionate to the potential level of impact (negligible).
Key to this would be to reduce the MDS for foundations structures within the Hornsea Four array as much as possible, or removal of GBS as an option	Flamborough Front	The Applicant has reviewed the Maximum Design Scenario for Gravity Base Foundations and confirms Gravity Base Structure (GBS) foundations (WTG type) will be utilised at a maximum of 80 of the 180 WTG foundation locations. This represents a reduction from the maximum number of GBS WTG foundations at DCO Application which was 110. The location of GBS

Mitigation Considered	Receptor/Impact mitigation	Comment
(i.e. using monopiles in place of the larger GBSs).		foundations, if used for WTG, will be confirmed through a construction method statement which will include details of foundation installation methodology. The Applicant confirms that recently consented OWFs have included Gravity Base Foundations as part of their consent envelope (see 3.3.1.2 & 3.3.1.3).
There may also be merit in further consideration of the placement of structures within the developable area to reduce the potential for the effects of individual turbines acting in combination with each other.	Flamborough Front and Smithic Bank	The Applicant has committed through Co96 (see **A4.5.2: Commitment Register**) to reaching agreement with the Marine Management Organisation (MMO), in consultation with the Maritime & Coastguard Agency (MCA) and Trinity House (TH) on these layout principles. The assessment of turbulent wakes as presented in **Marine Processes Technical Report** (**APP-067**) confirms "the minimum spacing between the centres of all infrastructure will not be less than 810 m. The measurable distance of any wake is likely to be less than this distance. No further mitigation is proposed or required.

3.3.1.2 The Applicant highlights that recently consented OWFs include Gravity Base Structure (GBS) foundations within their consented envelopes and DCO (notably Hornsea Project Three, East Anglia One North, East Anglia Two, Norfolk Vanguard and Norfolk Boreas OWFs). This has been standard procedure for all development for some considerable time (see Hornsea Project One, Hornsea Project Two and Burbo Bank Extension OWFs). The Applicant would affirm that any uncertainty, as alluded to by the MMO, Cefas and Natural England, in GBS dimension and/or number of structures, their layout or the fact that they have not been built out in the UK, is not a prerequisite to their inclusion within a DCO for an OWF.

3.3.1.3 Hornsea Four has therefore made considerable reductions in the number of GBS foundations, relative to the total number of foundations, in relation to other consented wind farms where the express concerns on GBS as a foundation type was not paramount.

4 Monitoring

4.1.1.1 This section of the report sets out Hornsea Four's interpretation of the monitoring requirements as requested in **REP5-114** and presents the monitoring commitments already secured through the Hornsea Four Outline Marine Monitoring Plan (**APP-242**) and Project Description (**REP4-003**), specific to the receptors, mitigation and monitoring defined in **REP5-114**. Additionally, this section provides a brief summary of the monitoring secured on other recently consented OWF projects.

4.1.1.2 The monitoring requests are presented in **Table 5**.

Table 5: Potential monitoring requirements suggested for Smithic Bank and Flamborough Front in REP4-114.

Monitoring proposed	Receptor/Impact mitigation	Comment
Due to the dynamic nature of Smithic Bank and the anticipated Dogger Bank A&B cable installations, monitoring of the area between the Holderness Coastline and the Dogger Bank Cable Crossing by swath bathymetry should be undertaken prior to construction to allow additional mitigation to be incorporated as required.	Smithic Bank	The Applicant has committed to pre-construction surveys along the entire ECC. These will be followed by bi-annual asset integrity surveys at the Dogger Bank A & B cable crossing for the first three years. As highlighted by Prof Mike Elliott's review (Section 2.3.3)), the key sediment transport (impact pathways) is north to south. Therefore, survey lines will be orientated east to west to capture any change. The monitoring will be used to report to the MMO, Cefas and Natural England. No additional mitigation or monitoring beyond this is required to validate negligible impacts.
To identify and manage any residual risk, a robust monitoring plan should be agreed upon which incorporates "trigger points" to allow interventions or remediation as required.	Smithic Bank	The Applicant has provided a monitoring plan in **Section 4** and **Table 6** (Smithic Bank).
Again, it will be important to establish a monitoring programme to record any changes to stratification and primary productivity, which would require surveys pre-construction, post-construction, and for the lifetime of the project. This should include "trigger points" to allow interventions/remediation if required.	Flamborough Front	The Applicant has provided a monitoring plan in **Section 4** and **Table 7** and **Table 8** (Flamborough Front).

4.2 Purpose of Environmental Monitoring

4.2.1.1 In the present context, the purpose of the proposed environmental monitoring is to address perceived information gaps and by doing so help to resolve different viewpoints between the Applicant and Natural England, MMO and Cefas. Specifically, the perceived information gaps relate to validating the level of potential operational impacts of Hornsea Four on (i) Smithic Bank; and (ii) Flamborough Front.

4.2.2 Principles of monitoring

4.2.2.1 In developing this clarification note the following monitoring principles have been considered:

- All monitoring is hypothesis / objective led with a clearly defined purpose;
- Data collection need to be safe, practical, cost effective and remain consistent over the monitoring period;
- Monitoring data is reviewed with regard to attributable and detectable effects that exceed natural variations (signal >> noise); and
- Mid-term reviews provide the option to terminate further monitoring (i.e. if noise >> signal).

4.3 Smithic Bank

4.3.1.1 A key premise for monitoring across Smithic Bank and the Dogger Bank crossing is that the boundary of the bank is understood. For the purposes of monitoring, this boundary is the one developed by JNCC for the designation of the feature (for which Smithic Bank wasn't selected for designation and therefore is a sandbank, as any other sand banks in the southern North Sea, of which there are significant numbers) and the shapefile/boundary used to inform all works and assessment to date.

4.3.1.2 The boundary is used to verify the pre-construction distance to the east to the Dogger Bank A & B Cable Crossing and based on the location of recently installed cables. An alternative boundary was proposed by MMO, Cefas and Natural England as the geomorphological boundary of the Smithic Bank. **Figure 1** presents the JNCC Smithic Boundary with the 2021 Orsted (Clinton Marine) 2021 geophysical survey with hillshade analysis. The data sets shown broad general agreement between the JNCC shapefile and geomorphological boundary (see Hillshade inset).

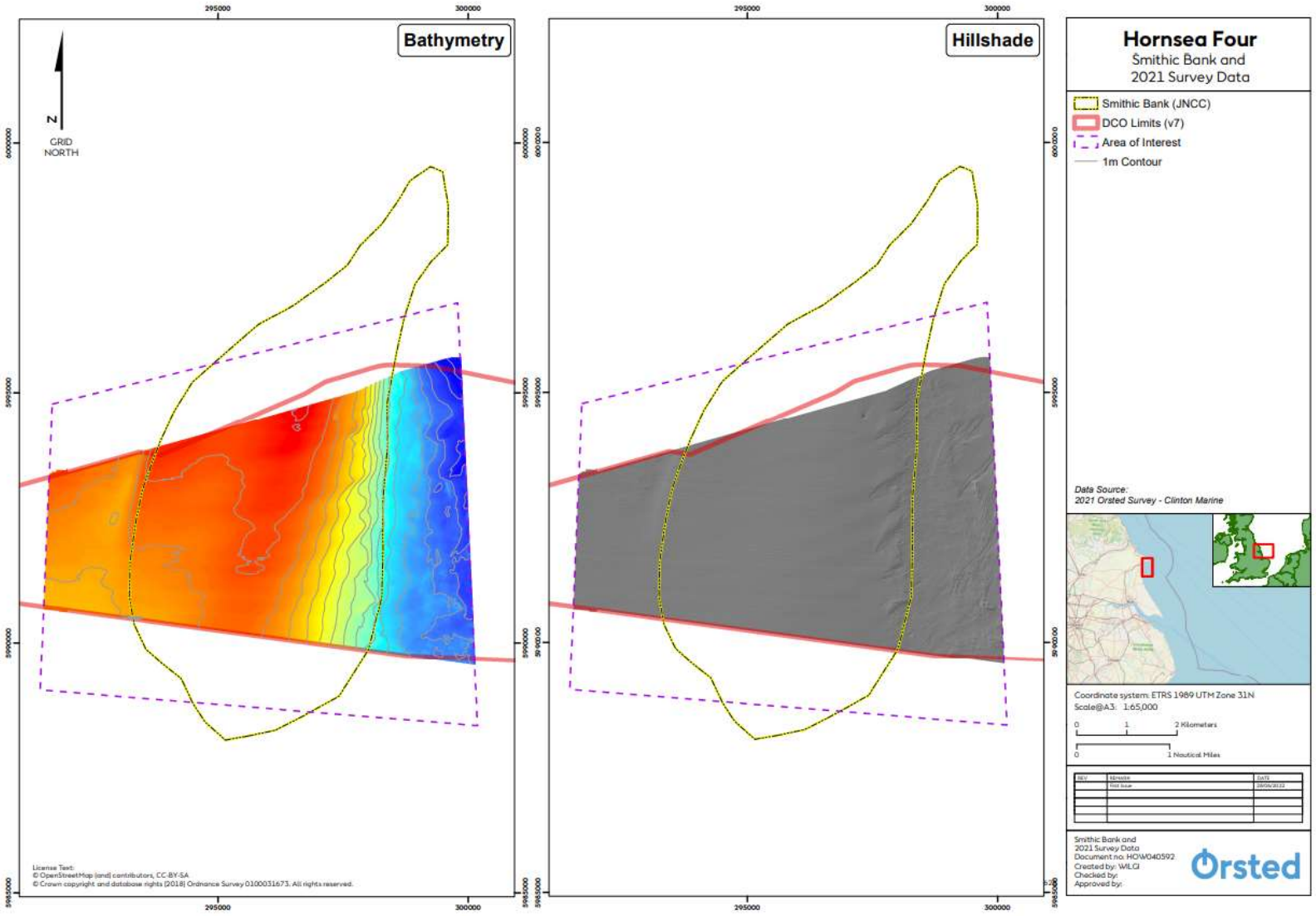

Figure 1 Smithic Bank and 2021 Survey Data

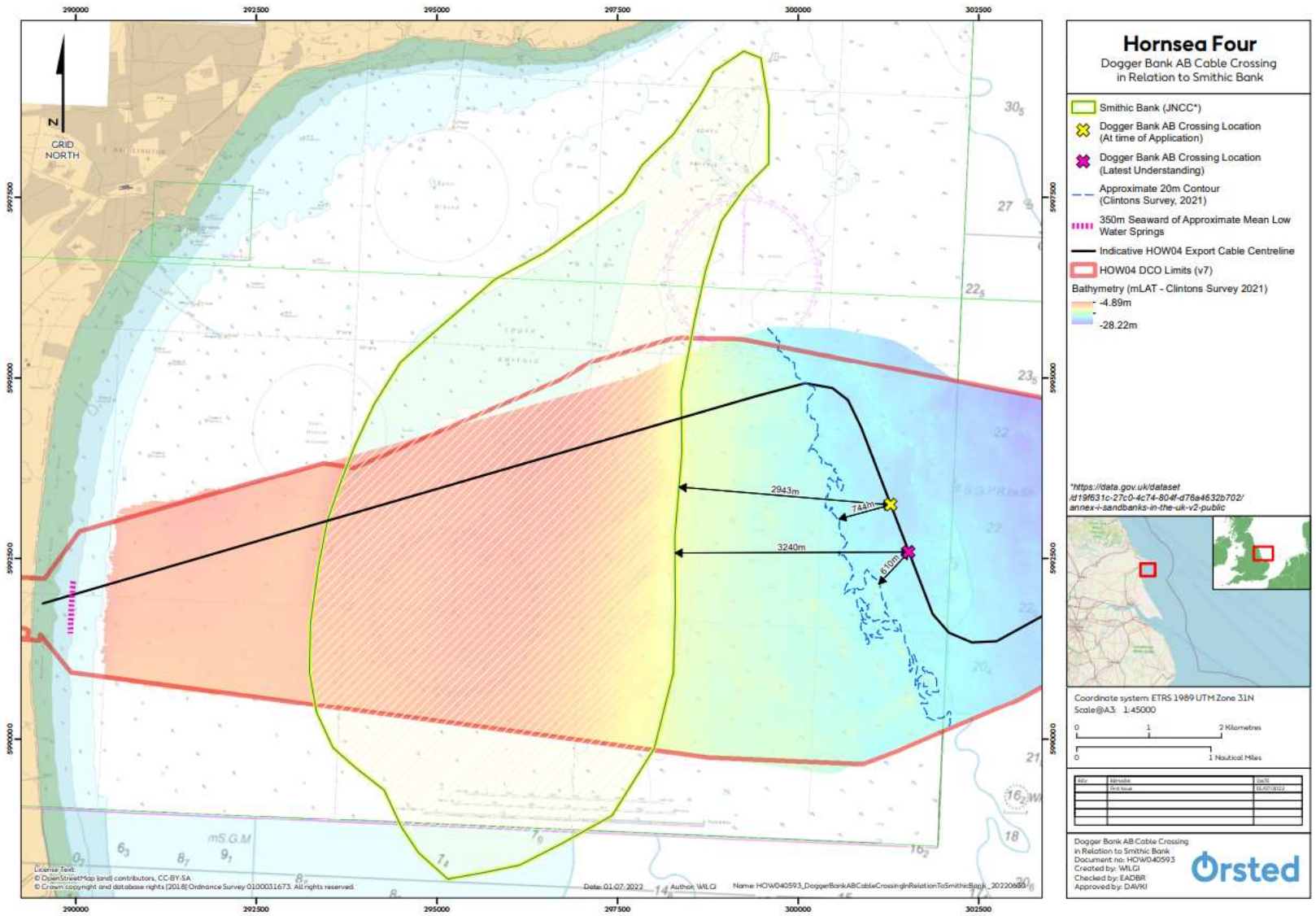

Figure 2 Dogger Bank AB Cable Crossing in Relation to Smithic Bank

4.3.1.3 The boundary between the Dogger Bank A & B Cable Crossing, based on the location of recently installed cables, and the eastern boundary of Smithic Bank is presented in **Figure 2.** The distance is 2.9 km (At time of Application) or 3.2 km (Latest Understanding).

4.3.1.4 **Table 6** outlines the proposed approach to monitoring of Smithic Bank. The monitoring is proposed to be captured in an updated Outline Marine Monitoring Plan (**APP-242**) to be submitted at Deadline 6.

Table 6: Monitoring proposals for Smithic Bank.

Criteria	Recommendation
Location	From the Holderness Coast (MLWS), across Smithic Bank and onto the Dogger Bank A & B Cable Crossing. Survey at the width of all export cables, plus 10% buffer either side to help determine any up- or down-drift issues.
Type of survey	High-resolution multi-beam bathymetry.
Survey frequency	Pre-construction followed by 6-monthly surveys for the first 3 years (asset crossing), requirement for further surveys reviewed thereafter.
Reviews	Pre-construction survey reviewed to validate the baseline Smithic Bank and dogger bank cable crossing). Post-construction surveys are reviewed against pre-construction survey to determine any change. Reviews reported annually to MMO. Any notable changes will need to consider natural variability (such as seabed response to metocean events) and potential influences due to installed structures.
Interventions	None proposed. Concludes 3 years after crossing installation.
Costs	Moderate additional costs to analyse and report monitoring evidence to MMO.
Other considerations	There are multiple projects installing cables across Smithic Bank, including cables relating to Hornsea Four. Comparable monitoring requirements are expected for each set of cables with comparable outcomes. Technical and cost benefits to co-ordinate survey and reporting requirements with other projects to achieve consistency in monitoring approaches and interpretation of outcomes.

4.4 Flamborough Front

4.4.1.1 This section considers the issue of increased turbulent mixing due to Hornsea Four foundation wakes on water column stratification and the Flamborough Front.

4.4.1.2 Near-field - the Applicant's hypothesis is that the consequence of increased mixing due to turbulent wakes will remain small-scale and localised to foundations and not interact at the array scale to the detriment of water column stratification or the Flamborough Front.

4.4.1.3 Far-field - Natural England, MMO, and Cefas are concerned with the level of uncertainty with the Applicant's assumptions, especially when large GBS foundations may be used across the array (WTG type and box-type for sub-stations) and therefore consider that larger array-scale interactions still might occur with potential consequences further afield.

4.4.1.4 Although these two assertions are related a different monitoring approach is offered to each one according to the scales involved.

4.4.2 Near-field monitoring

4.4.2.1 The hypothesis put forward by the Applicant is that wake effects would remain small-scale and localised to individual foundations with no wider array-scale effect and that the

additional mixing provided in the turbulent wake would not be sufficient to overcome seasonal thermal stratification and there would be no discernible effect on the Flamborough Front.

4.4.2.2 Near-field evidence related to wake effects created by individual GBS foundations is considered to be an industry-wide knowledge gap. On this basis, monitoring of such wakes and the potential consequence of increased turbulent mixing on destabilising stratification should be considered as a research opportunity funded by existing programmes, such as The Offshore Wind Evidence and Change programme or the ECOWind initiative.

4.4.2.3 Table 7 outlines the proposed approach to near-field monitoring of stratification. The monitoring is proposed to be captured in an updated Outline Marine Monitoring Plan (APP-242) to be submitted at Deadline 6.

Table 7: Monitoring proposals for near-field stratification.

Criteria	Recommendation
Location	In the lee wake of three GBS foundations (if used) across Hornsea Four array, notionally; • One WTG-GBS • One Box-type GBS Large (150 m width) • One Box-type GBS Small (75 m width)
Type of survey	Towed thermistor chain (comparable to the field surveys conducted by Schultze et al, (2020) and ADCP. Transects across observed wake at 100 m intervals downstream of each foundation to a maximum of 1,000 m.
Survey frequency	Single survey during spring tides to coincide with times of peak flood or ebb flow (maximum wake effect) during a period of summer stratification (the exact mechanism to determine peak needs to be defined with MMO, Natural England and Cefas).
Reviews	Data to be reported as an industry publication to on the scale and intensity of wake related effects from larger foundation types (GBS only) (determined by towed ADCP) and the consequence of increased turbulent mixing (maximum of 500m from foundation centre) within the wake on vertical thermal stratification (determined by thermistor chain).
Interventions	Not applicable. Though should turbulent wakes exceed those predicted in the EIA, this will trigger far-field (array-scale) monitoring (see Table 5).
Costs	To be concluded by the Applicant.
Other considerations	Comparable surveys of turbulent wakes in the lee of monopiles where previously achieved for the Burbo Bank Extension, so the specific knowledge gap is addressing larger width/diameter foundation types. If Hornsea Four adopts any other consented foundations rather than GBS then this monitoring requirement does not apply, noting the previous remarks offered by Natural England, MMO and Cefas related to monopiles (see 4.4.1.2).

4.4.3 Far-field monitoring

4.4.3.1 The far-field issue relates to the hypothesis put forward by Natural England, MMO and Cefas that array scale effects from multiple wakes could develop cold water plumes with significant ecological impact on primary production and the wider marine ecosystem.

4.4.3.2 Table 8 outlines the proposed approach to far-field monitoring of stratification. Far-field monitoring would only be required should the near-field monitoring confirm turbulent wakes in exceedance of those predicted in the EIA. The monitoring is proposed to be captured in an updated Outline Marine Monitoring Plan (APP-242) to be submitted at Deadline 6.

Table 8: Monitoring proposals for far-field stratification.

Criteria	Recommendation
Location	The Hornsea Four array area to establish any array scale effect.
Type of survey	Part 1 Evaluation of relevant satellite images that represent sea surface temperature, e.g. Sentinel 3. Part 2 Evaluation of relevant satellite images that represent chlorophyll concentrations, e.g. Sentinel 3. N.b. Satellite image resolution is 1,000 m for sea surface temperature and 300 m for chlorophyll which limits this approach to discerning array scale effects rather than individual wake effects.
Survey frequency	Sentinel 3 already has a data bank that will cover the pre-construction period. Initial interest in post-construction period and timed with the near-field survey. Overpass tracks from Sentinel 3 repeat every 27 days but the large swath widths of 1,270 km enable images to be available every 1.4 days (Sentinel 3A and 3B). Images only provide useable data where there is no cloud cover. Bi-monthly composite images for an initial period of 12 months to represent seasonal variations.
Reviews	Part 1 The far-field hypothesis requires a net reduction in sea surface temperature to be detectable across the Hornsea Four array area relative to the temperature of undisturbed surrounding water. A provisional reduction of 2°C relative to the average temperature of surrounding water is proposed (the level of temperature reduction during seasonal stratification needs to be confirmed with consideration to natural variations from pre-construction periods and the magnitude of the thermocline as established from available 3D modelling) (phase 1) Part 2 If there is a detectable change in water temperature above the ambient background for an attributable effect at the array scale (Part 1) then the analysis will extend to examining chlorophyll concentrations as a proxy for influences on primary production (Part 2). A standalone report will be prepared covering a pre-construction baseline characterisation (1 year), construction (1 years) and a post-construction/operational (1 year) comparison.
Interventions	Not applicable.
Costs	The requisite satellite images are freely available so the main cost is associated with data management, image analysis, reporting and dissemination to NE, MMO and Cefas.
Other considerations	This work should tie in with the requirements for near-field surveys. If near-field surveys confirm the localised extent of wakes has no discernible temperature reduction which develop as cold water plumes then the far-field effect monitoring is not required. Present assumptions linked to the availability of Sentinel 3 satellite images. It is acknowledged that this subject may be a subject of proposals to the ECOWind programme and will provide evidence if progressed.

4.5 Outline monitoring in Hornsea Four DCO

4.5.1.1 The section of the report sets out the current monitoring requirements as defined in the Outline Marine Monitoring Plan (APP-242) and Project Description (REP4-003).

4.5.1.2 In addition to the environmental survey and monitoring required as conditions of the DMLs within the DCO, additional studies will be undertaken by the Applicant for engineering and design purposes (see Project Description (REP4-003).

4.5.1.3 Some of these will overlap with the conditioned monitoring and wherever possible the Applicant will look to combine surveys for monitoring purposes with those already being carried out for engineering purposes. These are:

- Geophysical asset surveys
- Geotechnical surveys
- Pre-lay grapnel runs
- UXO survey; and,
- Cable burial survey.

4.5.1.4 The combined pre-construction, construction and post-construction environmental and engineering survey and monitoring are presented in Table 9. Where monitoring is for multiple purposes the Applicant has shaded **bold** those directly related to the proposed monitoring of either the Dogger Bank Cable Crossing, Smithic Bank or Flamborough Front and the rationale for their applicability to the outline monitoring report outlined.

Table 9: Hornsea Project Four Proposed Monitoring

ID	Proposed Monitoring	Phase of Project	Duration of proposed monitoring	Applicability to Marine process monitoring
F2.7 Outline Marine Monitoring Plan (APP-242)				
M1	Geophysical and geotechnical surveys to inform aspects including: • Wind Turbine Generator (WTG) and Offshore Substation (OSS) foundation design and siting; • **Cable crossing design**; • Horizontal Directional Drill (HDD) design and siting; • **Cable design, burial and protection plans and siting**; • Scour protection requirements; • Boulder clearance requirements; • Sandwave clearance requirements; and • Initial Unexploded Ordnance (UXO) clearance requirements.	Pre-construction	Pre-construction as required.	Monitoring to establish baseline conditions to inform best engineering and environmental design of cable crossing and protection.
M2	Studies required to ensure the safe placement of jack-up vessel legs on the seabed during construction and any maintenance. Techniques	Construction Post-construction	Construction and Post-construction as required by maintenance events.	Potential to include any surveys of seabed and jack-up vessel footprints, where used to construct

ID	Proposed Monitoring	Phase of Project	Duration of proposed monitoring	Applicability to Marine process monitoring
	may include: Geophysical surveys using high resolution SSS, MBES, and ROV techniques. Survey extents will cover the areas within which construction activity is proposed.		Details of all maintenance activities that may require a JUV, and their maximum design parameters are listed in Table 4.45 in **A1.4 Project Description (REP4-003).**	the Dogger Bank cable crossing to inform monitoring. Potential to include this asset integrity survey into monitoring plan to confirm cable burial and requirement for cable protection.
M3	Geophysical surveys (techniques as described under pre-construction phase) to confirm: • Cable burial success; • Adequate protection of buried assets, foundations and crossings; and • Presence of any dropped objects. Survey extents will cover the areas within which construction activity has taken place.	Post-construction	Twice yearly for first three years; followed by yearly thereafter. **NOTE**: If asset integrity is maintained after 3 years then surveys cease.	Potential to include this asset integrity survey into monitoring plan to confirm cable burial and requirement for cable protection.
M4	Periodic geophysical surveys to ensure that assets remain suitably buried and or protected and where necessary, inform the need for any remedial measures (re-burial / further protection etc). Techniques will be as described under pre-construction phase.	Post-construction	Twice yearly for first three years; followed by yearly thereafter.	Potential to include this asset integrity survey into monitoring plan to confirm post-construction changes ot baseline environment from Dogger Bank crossing to HDD exit pits in the nearshore.
M5	Full sea floor coverage swath bathymetry survey within the areas within which construction works are proposed to determine the location, extent and composition of any potential habitats of principal importance (Section 41 of the NERC Act) including biogenic or geogenic reef features (as defined by Irving (2009) and Gubbay (2007) and in Table D1 of **Appendix D of Volume A5, Annex 2.1: Benthic Subtidal and Intertidal Ecology Technical Report**). Targeted Drop-Down Video (DDV) survey to confirm the presence,	Pre-construction	Benthic DDV surveys may be undertaken up to 12 months prior to the commencement of offshore construction works (exact timings to be agreed post-consent with the MMO and its advisors).	Where there is an overlap with the Smithic Bank, this can be incorporated within the monitoring plan. The Applicant commits to reviewing the monitoring Plan at this stage when the necessary information is available.

ID	Proposed Monitoring	Phase of Project	Duration of proposed monitoring	Applicability to Marine process monitoring
	nature and extent of any potential habitats of principle importance (Section 41 of the NERC Act) features identified in the preconstruction geophysical data.			
M6	Where pre-construction surveys confirm the presence of potential habitats of principle importance (Section 41 of the NERC Act) in the areas surveyed during the pre-construction surveys, targeted swath bathymetry and DDV survey of previously identified habitats of principle importance will be undertaken. The aims of which are to identify any changes to the location, extent and composition of any potential habitats of principle importance (Section 41 of the NERC Act) identified during preconstruction surveys.	Post-construction	Post-construction confirmation survey.	May not be applicable to monitoring as the requirement will only be established after the pre-construction surveys confirm presence or absence. The Applicant commits to reviewing the monitoring Plan at this stage when the necessary information is available.
M7	Targeted Particle Size Analysis (PSA) survey within the export cable corridor along planned cable routes and adjacent areas – focused on cable sections where it is thought that flow tools may be required (e.g. sandwaves or more challenging ground conditions) to provide a baseline of the sediment suitability within the cable corridor for herring and sandeel spawning (as defined by Reach et al. (2013) and Latto et al. (2013) for herring and sandeel, respectively). Where flow tools have been used along pre-surveyed areas, a targeted PSA survey using the same survey locations as for the pre-construction survey to enable any changes in sediment suitability for spawning for herring and sandeel to be determined.	Pre-construction and Post-construction	Pre-construction and Post-construction confirmation survey.	Where there is an overlap with the Smithic Bank, this can be incorporated within the monitoring plan. The Applicant commits to reviewing the monitoring Plan at this stage when the necessary information is available.

4.5.1.5 Figure 3 sets out the monitoring that has been proposed as part of the Hornsea Four application documents. The exact timings in each year of the monitoring are not defined and as such the below figure should be used as an indicative summary.

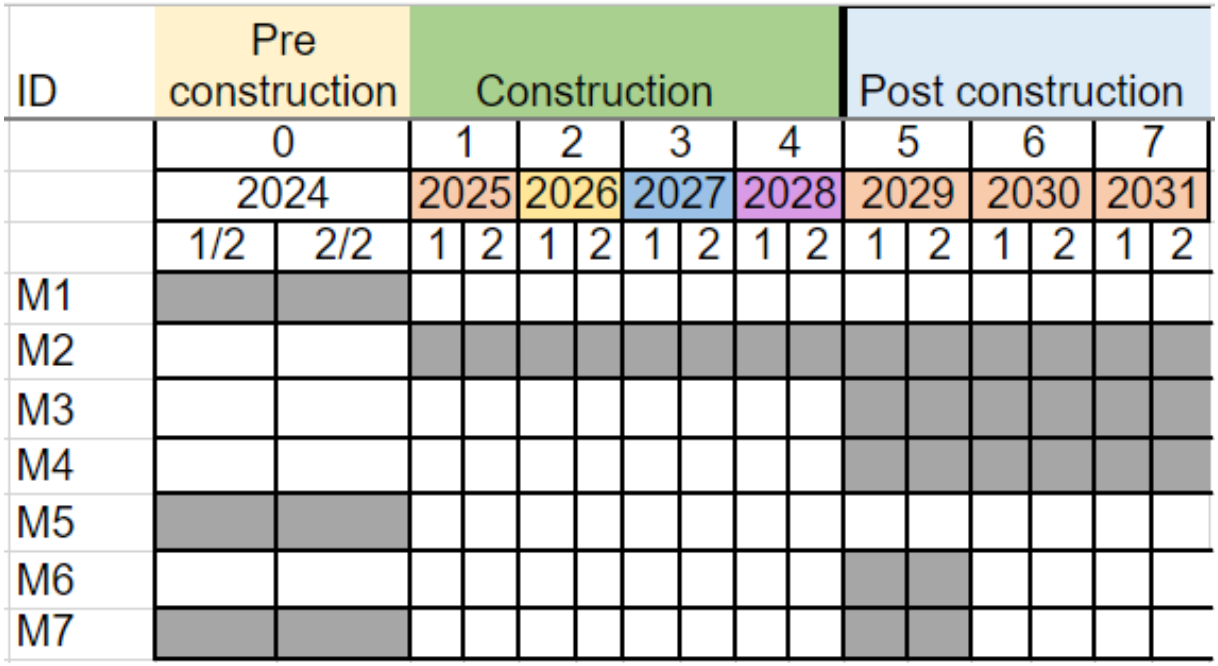

Figure 3: Timeline of current outline monitoring as proposed in the Hornsea Project Four Application

4.6 Outline Monitoring in Other Consented OWFs

4.6.1.1 The section of the report sets out the current monitoring requirements set out in the In Principle Monitoring Plans for Hornsea Project Three, East Anglia One North, Two and Three, Norfolk Boreas and Norfolk Vanguard.

Table 10: Monitoring requirements at other OWFs.

Hornsea Project Three	
Monitoring Approach	**Monitoring timeline**
Pre-construction	
A comprehensive geophysical survey (comprising a combination of multibeam echosounder and, high resolution side scan sonar, as described in Table 4.1) to encompass the areas within which construction activity is planned, both within the Hornsea Three array area and along the Hornsea Three offshore cable corridor, up to MLWS. The survey will be undertaken prior to commencement of construction (and therefore, seabed preparation works) to enable a baseline to be established against which post-construction monitoring outlined below can be compared.	The survey will be undertaken prior to commencement of construction.
East Anglia One North	
Monitoring Approach	**Monitoring timeline**
Pre-construction	

A single survey within the agreed East Anglia ONE wind farm site and offshore cable corridor survey areas using full sea bed coverage swath-bathymetric, MBES and SSS surveys (to meet the requirements of Marine Guidance Note (MGN) 543 and its Annexes) of the area(s) within the Order Limits in which it is proposed to carry out construction works, including a 500m buffer area around the site of each works. (The "site of each works" being the area within the order limits which is actually taken forwards to construction noting that it is possible that certain areas within the order limits may not be developed.).	Scope of surveys and programmes and methodologies for the purposes of monitoring shall be submitted to the MMO for written approval at least 6 months prior to the commencement of any survey works. Surveys carried out for up to 3 years post-construction, which could be non-consecutive years, with provision of the agreed reports in the agreed format in accordance with the agreed timetable, unless otherwise agreed in writing with the MMO in consultation with the relevant statutory nature conservation bodies.
Post-construction	
Surveys within the agreed East Anglia ONE North wind farm site and offshore cable corridor survey areas using full sea bed coverage swath-bathymetric surveys undertaken to meet the requirements of MGN 543 and its Annexes. For this purpose the undertaker will, prior to the first such survey, submit a desk based assessment (which takes account of all factors which influence scour) to identify the sample of adjacent wind turbines with greatest potential for scour. The survey will be used to validate the desk based assessment: further surveys may be required if there are significant differences between the modelled scour and recorded scour. The quantity of turbines subject to monitoring will be confirmed following the completion of detailed design studies and in consultation with the MMO.	Scope of surveys and programmes and methodologies for the purposes of monitoring shall be submitted to the MMO for written approval at least 6 months prior to the commencement of any survey works. Surveys carried out for up to 3 years post-construction, which could be non-consecutive years, with provision of the agreed reports in the agreed format in accordance with the agreed timetable, unless otherwise agreed in writing with the MMO in consultation with the relevant statutory nature conservation bodies.
East Anglia Two	
Monitoring Approach	**Monitoring timeline**
Pre-construction	
A single survey within the agreed East Anglia TWO wind farm site and offshore cable corridor survey areas using full sea bed coverage swath-bathymetric, MBES and SSS surveys (to meet the requirements of Marine Guidance Note (MGN) 543 and its Annexes) of the area(s) within the Order Limits in which it is proposed to carry out construction works, including a 500m buffer area around the site of each works. (The "site of each works" being the area within the order limits which is actually taken forwards to construction noting that it is possible that certain areas within the order limits may not be developed.).	Scope of surveys and programmes and methodologies for the purposes of monitoring shall be submitted to the MMO for written approval at least 6 months prior to the commencement of any survey works. Surveys carried out for up to 3 years post-construction, which could be non-consecutive years, with provision of the agreed reports in the agreed format in accordance with the agreed timetable, unless otherwise agreed in writing with the MMO in consultation with the relevant statutory nature conservation bodies.
Post-construction	
Surveys within the agreed East Anglia TWO wind farm site and offshore cable corridor survey areas using full sea bed coverage swath-bathymetric surveys undertaken to meet the requirements of MGN 543 and its Annexes. For this purpose the undertaker will, prior to the first such survey, submit a desk based assessment (which takes account of all factors which influence scour) to identify the sample of adjacent wind turbines with	Scope of surveys and programmes and methodologies for the purposes of monitoring shall be submitted to the MMO for written approval at least 6 months prior to the commencement of any survey works. Surveys carried out for up to 3 years post-construction, which could be non-consecutive years, with

greatest potential for scour. The survey will be used to validate the desk.	provision of the agreed reports in the agreed format in accordance with the agreed timetable, unless otherwise agreed in writing with the MMO in consultation with the relevant statutory nature conservation bodies.
East Anglia Three	
Monitoring Approach	**Monitoring timeline**
In addition to the environmental survey and monitoring required as conditions of the DMLs within the DCO, additional studies will be undertaken for engineering and design purposes. Some of these will overlap with the conditioned monitoring and wherever possible the Applicant will look to combine surveys for monitoring purposes with those already being carried out for engineering purposes. These are: Geophysical; Geotechnical; pre-lay grapnel; UXO survey and clearance; ROV survey; and Cable burial survey.	High-level engineering and design related monitoring. No detail provided on timelines.
Pre-construction	
A single survey within the agreed array and cable corridor survey areas using full sea floor coverage swath-bathymetric and side-scan surveys of the area(s) within the Order limits in which it is proposed to carry out construction works, including a 500m buffer area around the site of each works. (The "site of each works" being the area within the order limits which is actually taken forwards to construction noting that it is possible that certain areas within the order limits may not be developed.)	Scope of surveys and programmes and methodologies for the purposes of monitoring shall be submitted to the MMO for written approval at least 4 months prior to the commencement of any survey works.
Post-construction	
A single survey within the agreed array and cable corridor survey areas using full sea floor coverage swath-bathymetric surveys undertaken to IHO Order 1A standard and side scan sonar surveys around appropriate samples of adjacent infrastructure to assess any changes in seabed topography. For this purpose the undertaker will, prior to the first such survey, submit a desk based assessment (which takes account of all factors which influence scour) to identify the sample of adjacent turbines with greatest potential for scour. The survey will be used to validate the desk based assessment: further surveys may be required if there are significant differences between the modelled scour and recorded scour. The quantity of turbines subject to monitoring will be confirmed following the completion of detailed design studies and in consultation with the MMO and relevant SNCBs.	Scope of surveys and programmes and methodologies for the purposes of monitoring shall be submitted to the MMO for written approval at least 4 months prior to the commencement of any survey works.
Norfolk Boreas	
Monitoring Approach	**Monitoring Approach**
In addition to the environmental survey and monitoring required as conditions of the DMLs within the Development Consent	High-level engineering and design related monitoring. No detail provided on timelines.

Order (DCO), additional studies will be undertaken for the project for engineering and design purposes. Some of these will overlap with the conditioned monitoring and wherever possible the Applicant will look to combine surveys for monitoring purposes with those already being carried out for engineering purposes. Examples of these surveys are: • Geophysical; • Geotechnical; • Unexploded ordnance (UXO) survey and clearance; and • Cable burial survey.	
Pre-construction	
A single survey within the agreed array and cable corridor survey areas using full sea floor coverage swath-bathymetric undertaken to IHO S44ed5 Order 1a standard and side-scan surveys of the area(s) within the order limits in which it is proposed to carry out construction works, including a 500m buffer area around the site of each works. (The "site of each works" being the area within the order limits which is actually taken forwards to construction noting that it is possible that certain areas within the order limits may not be developed.)	Scope of surveys and programmes and methodologies for the purposes of monitoring shall be submitted to the MMO for written approval in accordance with the timescales required by the DMLs.
Post-construction	
A single survey within the agreed array and cable corridor survey areas using full sea floor coverage swath-bathymetric surveys undertaken to IHO S44ed5 Order 1a standard and side scan sonar surveys around appropriate samples of adjacent infrastructure to assess any changes in seabed topography. For this purpose the undertaker will, prior to the first such survey, submit a desk based assessment (which takes account of all factors which influence scour) to identify the sample of adjacent turbines with greatest potential for scour. The survey will be used to validate the desk based assessment: Further surveys may be required at a frequency to be agreed with the MMO (e.g. 3 years non-consecutive e.g. 1, 3 and 6 years or 1, 5 and 10 years). If evidence of recovery is recorded and agreed with the MMO, monitoring will cease.The quantity of turbines subject to monitoring will be confirmed following the completion of detailed design studies and in consultation with the MMO and relevant SNCBs.	Scope of surveys and programmes and methodologies for the purposes of monitoring shall be submitted to the MMO for written approval in accordance with the timescales required by the DMLs.
Norfolk Vanguard	
Monitoring Approach	**Monitoring Approach**
In addition to the environmental survey and monitoring required as conditions of the DMLs within the Development Consent Order (DCO), additional studies will be undertaken for the project for engineering and design purposes. Some of these will overlap with the conditioned monitoring and wherever possible the Applicant will look to combine surveys for monitoring purposes with those already being carried out for engineering purposes. Examples of these surveys are: • Geophysical;	High-level engineering and design related monitoring. No detail provided on timelines.

• Geotechnical; • Unexploded ordnance (UXO) survey and clearance; and • Cable burial survey.	
Pre-construction	
A single survey within the agreed array and cable corridor survey areas using full sea floor coverage swath-bathymetric undertaken to IHO S44ed5 Order 1a standard and side-scan surveys of the area(s) within the order limits in which it is proposed to carry out construction works, including a 500m buffer area around the site of each works. (The "site of each works" being the area within the order limits which is actually taken forwards to construction noting that it is possible that certain areas within the order limits may not be developed.)	Scope of surveys and programmes and methodologies for the purposes of monitoring shall be submitted to the MMO for written approval in accordance with the timescales required by the DMLs.
Post-construction	
A single survey within the agreed array and cable corridor survey areas using full sea floor coverage swath-bathymetric surveys undertaken to IHO S44ed5 Order 1a standard and side scan sonar surveys around appropriate samples of adjacent infrastructure to assess any changes in seabed topography. For this purpose the undertaker will, prior to the first such survey, submit a desk based assessment (which takes account of all factors which influence scour) to identify the sample of adjacent turbines with greatest potential for scour. The survey will be used to validate the desk based assessment. Further surveys may be required at a frequency to be agreed with the MMO (e.g. 3 years non-consecutive e.g. 1, 3 and 6 years or 1, 5 and 10 years). If evidence of recovery is recorded and agreed with the MMO, monitoring will cease. The quantity of turbines subject to monitoring will be confirmed following the completion of detailed design studies and in consultation with the MMO and relevant SNCBs.	Scope of surveys and programmes and methodologies for the purposes of monitoring shall be submitted to the MMO for written approval in accordance with the timescales required by the DMLs.

4.6.2 Summary of review and application to Hornsea Four

4.6.2.1 As highlighted in **Table 10**, standard monitoring for OWFs, with the inclusion of GBS in their DCO, is for a pre-construction and post-construction array and cable corridor survey (including a 500m buffer area around the site of each works) using full sea floor coverage swath-bathymetric surveys undertaken to IHO S44ed5 Order 1a. The post-construction survey is typically around appropriate samples of adjacent infrastructure to assess any changes in seabed topography.

4.6.2.2 Typically, the undertaker will, prior to the first such survey, submit a desk-based assessment (which takes account of all factors which influence scour) to identify the sample of adjacent wind turbines with greatest potential for scour. The survey will be used to validate the desk-based assessment: further surveys may be required if there are significant differences between the modelled scour and recorded scour.

4.6.2.3 Only Hornsea Project Three deviated from this standard approach due to the export cables traversing the North Norfolk Sandbanks and Saturn Reef (NNSSR) SAC and The Wash and

North Norfolk Coast (WNNC) SAC. Surveys were proposed to be undertaken at a representative number of locations where sandwave clearance activity had taken place. The scope of the post-construction surveys being identical to pre-construction surveys to ensure a direct comparison between the pre-construction and postconstruction outputs can be made. The first survey undertaken within one year following completion of cable installation works.

4.6.2.4 Hornsea Four proposes additional monitoring and reporting, above and beyond the standard OWF deliverables as set out in **Table 10**. These include:

- Studies required to ensure the safe placement of jack-up vessel legs on the seabed during construction;
- Targeted swath bathymetry and DDV survey of previously identified habitats of principle importance will be undertaken; and
- Targeted Particle Size Analysis (PSA) survey within the export cable corridor along planned cable routes and adjacent areas.

4.6.2.5 The proposed Marine Processes Monitoring includes pre-construction, construction, and post-construction survey, monitoring and reporting. Monitoring for Smithic Bank is set out in **Table 6** and **Table 9**. Monitoring for Flamborough Front is set out in **Table 7, Table 8** and **Table 9.**

5 Way Forward

5.1.1.1 The Applicant has proposed a number of commitments and an update Outline Marine Monitoring Plan (**APP-242**) for Smithic Bank and Flamborough Front based on the monitoring requirements proposed in **REP5-114**.

5.1.1.2 Commitment 201 (which read "Gravity Base Structure (GBS) foundations (WTG type) will be utilised at a maximum of 110 of the 180 WTG foundation locations. The location of GBS foundations, if used for WTG, will be confirmed through a construction method statement which will include details of foundation installation methodology") has been reviewed and the Applicant confirms that the maximum number of GBS foundations for WTGs has been further reduced to a maximum of 80.

5.1.1.3 The monitoring is proposed to be captured in an updated Outline Marine Monitoring Plan (**APP-242**) to be submitted at Deadline 6. The Deadline 6 submission will capture any comments and recommendations from MMO, Cefas and Natural England during the Issue Specific Hearing (ISH10) on offshore matters, should they attend.

5.1.1.4 The updated commitment on GBS foundations has been secured in the Hornsea Four DCO and DML (submitted at Deadline 5a) and the certified documents (e.g. monitoring plans) will be updated for Deadline 6.