Planning Act 2008
Infrastructure Planning (Changes to, and Revocation of, Development Consent Orders) Regulations 2011
Document reference: TR030006/D1/8

Able Marine Energy Park

Material Change 2

Monitoring Plan

approved by MMO

(referenced in responses 3.03 and 4.0.7)

Marine Management Organisation

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Mr Richard Cram
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Billingham Reach Industrial Estate
Haverton Hill Road
Billingham, TS23 1PX

Our reference: DCO/2013/00020

[By email only]

10 July 2019

Dear Mr Cram,

Able Marine Energy Park (AMEP): Active Monitoring Scheme

I refer to the Active Monitoring Scheme (AMS) submitted to the Marine Management Organisation (MMO) on 19 May 2016 and subsequent revisions provided on 16 May 2018, 11 February 2019 and 24 April 2019. The submissions were submitted to address the AMEP Development Consent Order (DCO) Schedule 11 paragraphs 36 and 38 (DCO/2013/00020).

> *Cooling water intakes and outfalls*
>
> *36.—(1) No development is to commence until a scheme for the monitoring of sedimentation along the lines of and in front of the Centrica and E.ON cooling intakes and outfalls has been submitted to and approved by the MMO, in consultation with the Environment Agency, Centrica plc (now C.gen) and E.ON.*
> *(2) The scheme must include—*
> *(a) details of monitoring proposals, including location and frequency; and*
> *(b) details of trigger levels and resultant actions or mitigation required if trigger levels are exceeded.*
> *(3) Development must proceed in accordance with the approved scheme and any timetable contained in the scheme.*
>
> *Sedimentation*
>
> *38 .(1) No development is to commence until a scheme for the monitoring of the foreshore and sediment levels around the quay has been submitted to and agreed by the MMO, in consultation with the Environment Agency, C.RO and E.ON.*
> *(2) Annual monitoring reports must be submitted to the MMO within 6 weeks of each anniversary of implementation up to 2033.*
> *(3) The approved monitoring scheme must be implemented and complied with at all times.*

After full review of the submission and advice received from C.gen (formerly Centria) and Uniper (formerly E.ON) the MMO is content that it meets the requirements of Schedule 11, paragraphs 36 and 38. This is subject to the following agreements made by Able UK Ltd:

- Uniper will be informed if the total suspended solids (TSS) concentration exceeds the threshold level of 3000mg/l at the monitoring buoy;
- Uniper will be informed if the limits of acceptable change in bed level are triggered;
- Uniper will be informed 28 days prior to dredging activities commencing;
- Uniper and C.gen will be informed of the dredging schedule in order for them to plan their operations/avoid operating unnecessarily when dredging is in progress;
- The Sediment Monitoring Commitments Report will be disseminated to Uniper and C.gen within two weeks of completion of each survey via an agreed notification route; and
- If the power stations are closed, and the outfalls/intakes are no longer required then Able UK Ltd must consult with the owners of the infrastructure on the re-consideration of monitoring needs.

Given the above, the MMO is content that the submission is sufficient to discharge Schedule 11, paragraphs 36 and 38 of marine licence DCO/2013/00020. Please accept this letter as formal confirmation of the discharge.

Your feedback

We are committed to providing excellent customer service and continually improving our standards and we would be delighted to know what you thought of the service you have received from us. Please help us by taking a few minutes to complete the following short survey ([redacted].

If you require any further information please do not hesitate to contact me using the details provided below.

Yours Sincerely,

[redacted]

Sarah Errington
Marine Licensing Case Officer

[redacted]
[redacted]@marinemanagement.org.uk

ABLE MARINE ENERGY PARK

Sediment monitoring commitments

Document Ref: DS.AHP-AMEP.AH.D18-027

MAY 2018

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APPROVAL & REVISION REGISTER

	NAME	SIGNATURE	DATE
Originator:	Dave Sargent		15/05/18
Checked by:			
Approved by:	Richard Cram		

REVISION	COMMENTS	DATE
1		

CONTENTS

1 INTRODUCTION

1.1 Centrica and E-ON (now Uniper) were consulted in July 2016, by the MMO on the content of the report by HR Wallingford entitled "Monitoring Requirements: Schedule 11, Paragraphs 36 and 38" attached in Appendix 1.

1.2 The comments received, see MMO letter reference DCO/2013/00020, dated 27th July 2016 in Appendix 2, indicate that perhaps the overall project commitments in regards to sediment monitoring may not be fully appreciated.

1.3 To address the potential lack of clarity, this document sets out the full scope of sediment monitoring so that all parties can refer to the entire range of commitments.

1.4 This document also contains the summary results from the 12 month baseline survey and draws upon this to propose the framework for trigger levels and thresholds applicable to the monitoring and assessment of capital and maintenance dredging activities.

1.5 This information, when reviewed together should enable all parties to confirm that the requirements of Schedule 11 Paragraphs 36 and 38 have been fully addressed to in order that the MMO can discharge these conditions.

1.6 Once this has been confirmed, there should be no barrier to the MEMMP being fully agreed and finally discharged as an overall development precedent condition.

2 MARINE ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN - MEMMP

2.1 The MEMMP was compiled with extensive involvement of consultants and regulators and it contains detailed commitments, based on parameters from the Environmental Assessment, in regards sediment monitoring expressly focussed on the cooling water intakes.

2.2 The main body of the MEMMP along with selected figures which relate to the sediment monitoring and the cooling water aspects are attached in Appendix 3.

2.3 Chapter 2, in particular, of the MEMMP sets out the baseline sediment conditions and highlights potential impacts and concerns in relation to the intake and outfall structures.

3 HR WALLINGFORD REPORT

3.1 The MEMMP was reviewed by HR Wallingford to identify any further work which may be required to satisfy the specific requirements of DCO Schedule 11 Conditions 36 and 38.

3.2 It is any shortfalls in the MEMMP which are presented in the HR Wallingford document and NOT the full monitoring requirements and recommendations.

3.3 The recommendations from this report were transposed into the MEMMP Objective and Targets tables at Revision F.

4 BASELINE SEDIMENT CONCENTRATIONS

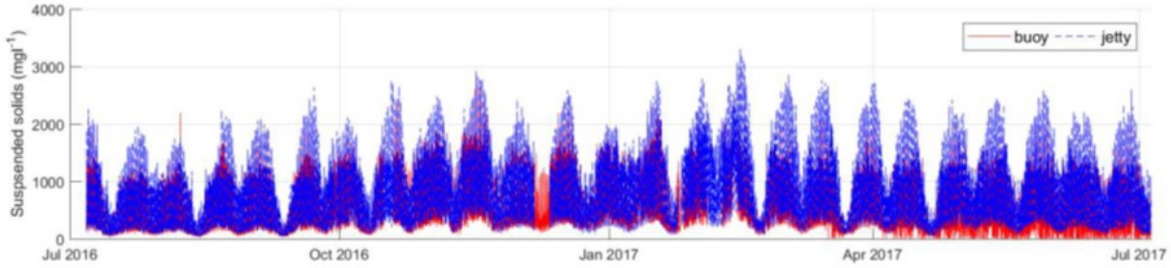
4.1 The findings and subsequent recommendations following the 12 month baseline estuarine environment monitoring programme, by Partrac, must also be factored into the overall sediment monitoring strategy during the dredging activities.

4.2 Attached, in Appendix 4, study by Partrac, ref P1428.03.05.D16v2 – AMEP- Limits of Acceptable Change, contains the results of the 12 month baseline study and demonstrates that the naturally occurring suspended sediment concentrations vary significantly.

4.3 Suspended sediment monitoring and levels are associated with the cooling water intakes for the E-ON and Centrica power station rather than in connection with any "Ecological" or "environmental" thresholds or triggers.

4.4 Thresholds and monitoring commitments are provided in order to assess any potential effect on the cooling water quality for the energy generating companies, and afford the basis for any potential compensation payments for (say) additional costs to cover increased filtration requirements.

4.5 The figure shown below indicates the annual time series throughout the year, both monitoring locations (bouy and jetty) reflect the same variation pattern associated with changes in tidal influences.



4.6 Extracted from the report, the table below, sets out the statistical detail relevant to the suspended sediment

Key annual statistics related to measured parameters (TSS, DO, temperature and salinity) derived from the buoy and jetty monitoring systems.									
Buoy Sensor Statistics					percentile				
Parameter	Min	Mean	Max	StDev	5th	10th	90th	95th	99th
Total Suspended Solids (mg l-1)	0	502	2888	403	87	121	1139	1338	1676
Jetty Sensor Statistics									
Total Suspended Solids (mg l-1)	38	812	3303	539	144	200	1556	1846	2368

4.7 The significant range between maximum and minimum concentrations is clear, and the statistical analysis serves to set out the details of the variation in suspended sediment concentration.

4.8 This statistical range will serve as the baseline against which future monitoring results will be assessed. Continual monitoring during construction and dredging will provide information on the precise suspended sediment concentrations and will either validate or refute the modelled predictions of an increase in suspended sediment during dredging of up to 1600mg per litre.

4.9 It will provide legitimacy to any potential dispute with the power generation companies on the grounds of increased sediment concentrations within abstracted cooling water.

4.10 These will be related to the percentiles of baseline concentrations along with the maximum concentration trigger concentrations proposed by Partrac of 3000mg per litre at the bouy and 3500mg per litre at the jetty.

4.11 Exceedance of these concentrations may be the basis for a claim, however, the most comprehensive comparison will look at the results for the same seasonal period prior to dredging and determine the statistical rage in the estuarine natural conditions and with dredging activities.

APPENDIX 1 - HR WALLINGFORD – MONITORING REQUIREMENTS

DLM7692-RT001-R01

HR Wallingford
Working with water

Able UK Ltd

Monitoring Requirements: Schedule 11, Paragraphs 36 and 38

DLM7692-RT001-R01-00 May 2016

Document information

Document permissions	Confidential - client
Project number	DLM7692
Project name	Able UK Ltd
Report title	Monitoring Requirements: Schedule 11, Paragraphs 36 and 38
Report number	RT001
Release number	R01-00
Report date	May 2016
Client	Able UK Ltd
Client representative	R. Cram
Project manager	Mark Lee
Project director	Mike Dearnaley

Document history

Date	Release	Prepared	Approved	Authorised	Notes
18 May 2016	01-00	MWL	MPD	MPD	

Document authorisation

Prepared	Approved	Authorised
[redacted]		

Executive Summary

The proposed development of the Able Marine Energy Park on the southern shore of the Humber Estuary upstream of Immingham has the potential to affect two outfalls and intakes owned by E.ON and Centrica, and to affect flood defences. For this reason the Development Consent Order (DCO) for the Able Marine Energy Park has put in place certain strictures regarding the monitoring required relating to the project.

This report considers these requirements in the light of the monitoring programme set out in the Marine Environmental Management and Monitoring Plan (MEMMP) developed for the project.

The MEMMP meets all of the requirements of Paragraph 38 of Schedule 11 of the DCO, but less effectively addresses the requirements of Paragraph 36. Additional commitments and clarifications are set out which address the requirements of Schedule 11, Paragraph 36.

Contents

Figures

Tables

1. Background

Able UK Ltd proposes to construct a Marine Energy Park (MEP) near Immingham on the southern bank of the Humber Estuary. The MEP will be a facility for the construction of offshore wind turbines and other activities associated with sources of renewable energy.

The MEP construction will require a reclamation approximately 1300 m long along the shore and up to 400 m wide in the offshore direction. Immediately to the north west of the reclamation there are two existing pairs of intakes and outfalls for two gas-fired power stations, which are located some 2 km inland of the proposed reclamation. These structures abstract and discharge cooling water for the power stations. One plant is operated by Centrica and the other by E.ON.

Sediment transport modelling undertaken as part of the consenting process has indicated that intertidal and subtidal sediment levels (bathymetry) to both the north west and south east of the reclamation have the potential to be changed as a consequence of the development, which may affect the intakes and outfalls to the north and flood defences to the north or south (see Appendix A of this report for further information).

Schedule 11 (Requirements) of the Development Consent Order (DCO) for the Able Marine Energy Park (2014 No. 2935) includes the paragraphs set out below; with Paragraph 36 having been written in response to concerns regarding bed level change at the Centrica and E.ON intakes and outfalls, and Paragraph 38 having been written in response to concerns regarding potential effects on flood defences (arising from bed level changes):

> Paragraph 36.
>
> (1) No development is to commence until a scheme for the monitoring of sedimentation along the lines of and in front of the Centrica and E.ON cooling intakes and outfalls has been submitted to and approved by the MMO, in consultation with the Environment Agency, Centrica plc and E.ON.
>
> (2) The scheme must include—(a) details of monitoring proposals, including location and frequency; and (b) details of trigger levels and resultant actions or mitigation required if trigger levels are exceeded.
>
> (3) Development must proceed in accordance with the approved scheme and any timetable contained in the scheme.

> Paragraph 38.
>
> (1) No development is to commence until a scheme for the monitoring of the foreshore and sediment levels around the quay has been submitted to and agreed by the MMO, in consultation with the Environment Agency, C.RO and E.ON.
>
> (2) Annual monitoring reports must be submitted to the MMO within 6 weeks of each anniversary of implementation up to 2033.
>
> (3) The approved monitoring scheme must be implemented and complied with at all times.

Both of these requirements were previously set out in Written Representations made by the Environment Agency dated 29th June 2012 (Unique Reference Number 10015552). Within this EA document, conditions for inclusion in the DCO were suggested.

In order to ensure that the mitigation and compensation provisions that are incorporated into the works are as effective as reasonably practicable, Able UK Ltd has established a Marine Environmental Management and Monitoring Plan (MEMMP) for the development of the MEP. Provisions have been made in the MEMMP for monitoring of bathymetric change to both the north and south of the proposed development using a combination of bathymetric and airborne topographic survey techniques.

This document considers the monitoring proposed and addresses the question of whether it is sufficient to meet the requirements of DCO Paragraphs 36 and 38 in full. Where the monitoring proposed in the MEMMP is considered not to completely address the requirements outlined, recommendations are made as to how the monitoring might be improved upon to better address the relevant requirements of the DCO.

It is noted that both E.ON and Centrica announced in 2015 plans to close the facilities which the outfalls and intakes to the north of the proposed development service. If such plans come to fruition **and** the outfalls and intakes are no longer required then the necessity for some aspects of the monitoring to the north of the reclamation may be removed, hence, there would be good justification for re-considering the monitoring needs through consultation with the owners of the infrastructure and Regulators (potential for monitoring reduction).

Positions of the outfalls and intakes to the north of the reclamation are presented in Table 1.1 and are shown in Figure 1.1.

The outfall and intake closest to the proposed quay are operated to E.ON, whilst those to the north are operated by Centrica.

Table 1.1: Location of the EON and Centrica intakes and outfalls

Outfall / Intake	Northing	Easting	Intake/Outfall Height (mODN)	Bed Elevation (mODN)
EON Outfall	419528	517396	-3.25	-5.08
EON Intake	419565	517455	-4.60	-7.30
Centrica Outfall	419738	517244	-4.85	-5.84
Centrica Intake	419772	517293	-4.95	-8.18

Source: HR Wallingford Ltd

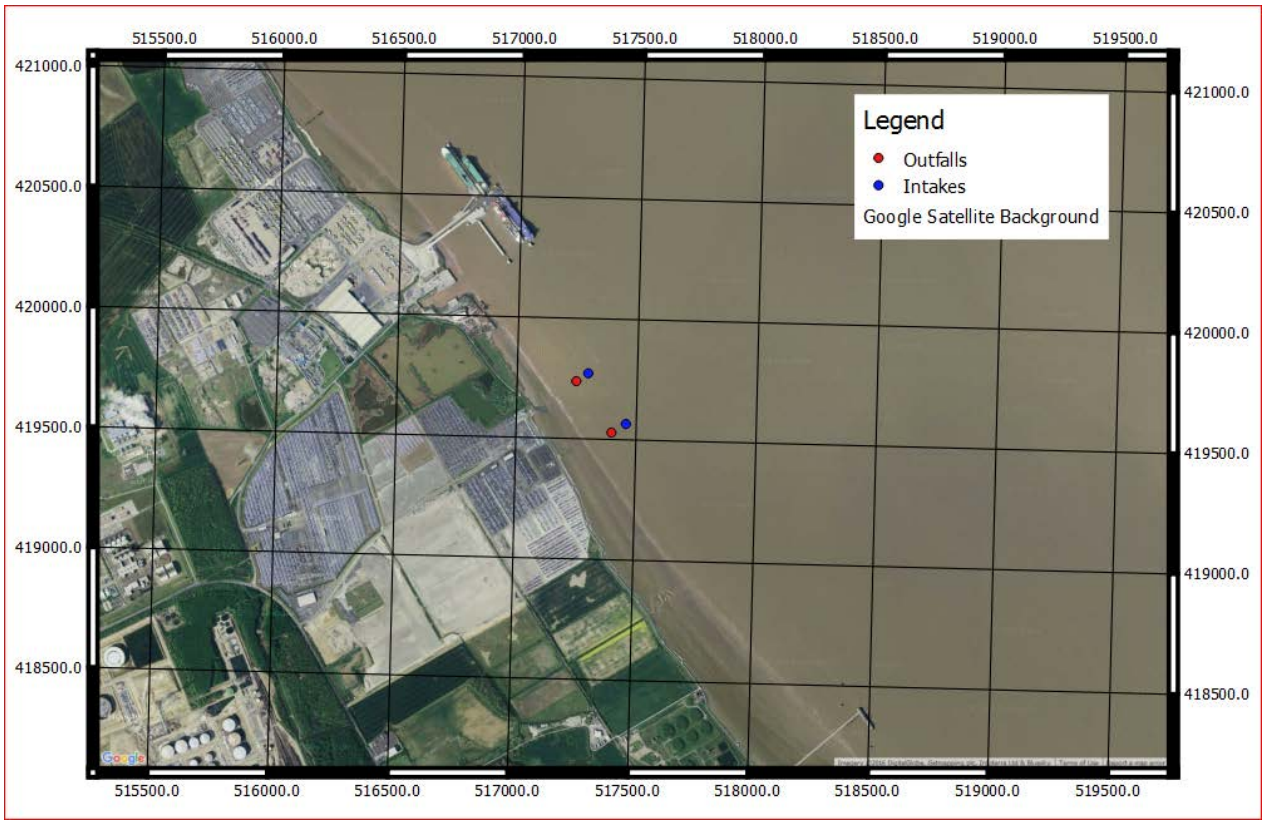


Figure 1.1: Location map showing outfalls in red and the intakes in blue. Coordinates OSGB 1936

Source: Satellite imagery - Google Earth © 2015

2. Assessment of Existing Monitoring Commitments

The key monitoring relevant to DCO Paragraphs 36 and 38 already committed to by Able UK Ltd is of two types:

- bathymetric (echosounder) surveys; and
- airbourne LiDAR (Light Distance And Ranging) surveys.

In Tables 2.1 and 2.2 the requirements of Paragraph 36 (which relates to effects on intakes and outfalls) and Paragraph 38 (which relates to effects on flood defences) of the DCO are compared against the most relevant monitoring commitments already made by Able UK Ltd (as set out in the MEMMP) and an opinion is provided with respect to whether the commitments meets the requirements of the paragraphs.

Table 2.1: Assessment of Paragraph 36 requirements (relates to effects on intakes and outfalls) versus monitoring commitments made

Item	Paragraph 36 Requirement	Relevant MEMMP Commitment	Assessment of Commitment WRT the Paragraph
i	Scheme for monitoring of sedimentation along the lines of and in front of the Centrica and E.ON cooling water intakes and outfalls.	Bathymetric and LiDAR surveys (see Section 4 and the Appendices of the MEMMP).	Insufficient, the lengths of the intakes and outfalls are not fully covered by the bathymetric and LiDAR surveys in combination. Also it is bad practice to use two (very) different techniques to undertake a single survey / piece of monitoring unless unavoidable. Note the inclusion of line spacing in Appendix 1B of the MEMMP (LiDAR) appears erroneous and the reference to line spacing in Appendix 1A of the MEMMP is redundant / confusing as the bathymetric surveys are required to deliver full coverage as described later in Appendix 1 of the MEMMP.
ii	Details of the monitoring proposals, including location and frequency.	Set out in Section 4 and Appendices of the MEMMP.	Sufficient, it is considered that the details required are provided (although these stop short of scopes of work).
iii	Details of trigger levels.	None.	Insufficient.
iv	Details of actions / mitigation if trigger level exceeded.	Dredging to meet the operational requirements of the intakes and outfalls.	Insufficient. With respect to Dredging, the action is identified but not described in detail see Section 4 of the MEMMP (Objective M2).

Source: HR Wallingford Ltd

Table 2.2: Assessment of Paragraph 38 requirements (relates to effects on flood defences) versus monitoring commitments made

Item	Paragraph 38 Requirement	Relevant MEMMP Commitment	Assessment of Commitment WRT the Paragraph
i	Scheme for monitoring of the foreshore and sediment levels around the quay.	LiDAR surveys (see Section 4 and the Appendices of the MEMMP).	Sufficient.
ii	Annual monitoring reports submitted to the MMO within 6 weeks of each anniversary of implementing, up to 2033.	Report analysing and collating LiDAR data every 12 months from the commencement of monitoring. Surveys to run annually until 2033 (see Section 4, Objective M16 of the MEMMP).	Sufficient.

Source: HR Wallingford Ltd

3. Additional Measures

The following additional measures address the gaps associated with the fulfilment of Paragraph 36 (see Section 2 of this report).

Table 3.1: Additional measures to address Paragraph 36 requirements (relates to effects on intakes and outfalls)

Item	Paragraph 36 Requirement	Additional Measures
i	Scheme for monitoring of sedimentation along the lines of and in front of the Centrica and E.ON cooling intakes and outfalls.	As part of each of the bathymetric surveys to be undertaken a survey line will be sailed along the full route of each of the intakes and outfalls and parallel survey lines will be sailed along either side of each of the intakes / outfalls at a range of 10m upstream and downstream (all where safe navigation allows). The target vertical accuracy of each survey will be +/- 0.05m. Given the relatively small size of the intake/outfall structures a hit count of somewhat greater than 10 hits per square metre will need to be achieved to clearly resolve the levels of sedimentation around the structures themselves. In terms of the data deliverables, the bathymetric data for this survey component will be presented as a 0.5m x 0.5m grid rather than at the coarser level used for the survey areas presently covered in the MEMMP.
iii	Details of trigger levels.	Within the results of any single bathymetric survey, bed elevation at an intake rises to within 1.5m of the bottom of the inlet or bed elevation at an outfall rises to within 0.25m the level of the bottom of the outlet.
iv	Details of actions / mitigation if trigger level exceeded.	Subject to all necessary licencing / permissions being in place, dredging will return the bed profile around the intake / outfall which has triggered the action to its baseline level (its level as measured prior to the works commencing). The dredging will be carried out within 2 weeks of the survey triggering the action. The method used will be that for outfall maintenance dredging set out in the project's Dredging Strategy (Report Ex 7.8, October 2012, or any subsequent approved revision). The dredging will be carried out in such a way that suspended sediment concentrations at the intakes do not rise above those permissible for their successful operation.

4. Conclusions

In order to address the requirements of Schedule 11, Paragraph 36 of the project's DCO a number of supplements to the contents of the MEMMP have been identified, these relate to:

- modification to the design of the planned bathymetric surveys to better capture bed level changes which are likely to occur in the vicinity of the intakes and outfalls;
- bed levels (relative to the heights of the intakes and outfalls) which will trigger intervention by Able UK Ltd; and
- further details relating to the form that intervention will take.

5. References

HR Wallingford, 2011. Able Marine Energy Park 3D Mud Modelling, Assessment of the Effects of a Proposed Development on the South Bank of the Humber Estuary on Fine Sediments. Report EX6603, November 2011.

Appendix

A. Predictions of topographic and bathymetric change

Numerical model studies were undertaken to assess the likely changes to bed levels to the north and south of the reclamation should it be constructed. Example results are presented in Figures A.1 to A.3. It should be recognised that uncertainties in the morpho-dynamic modelling will exist.

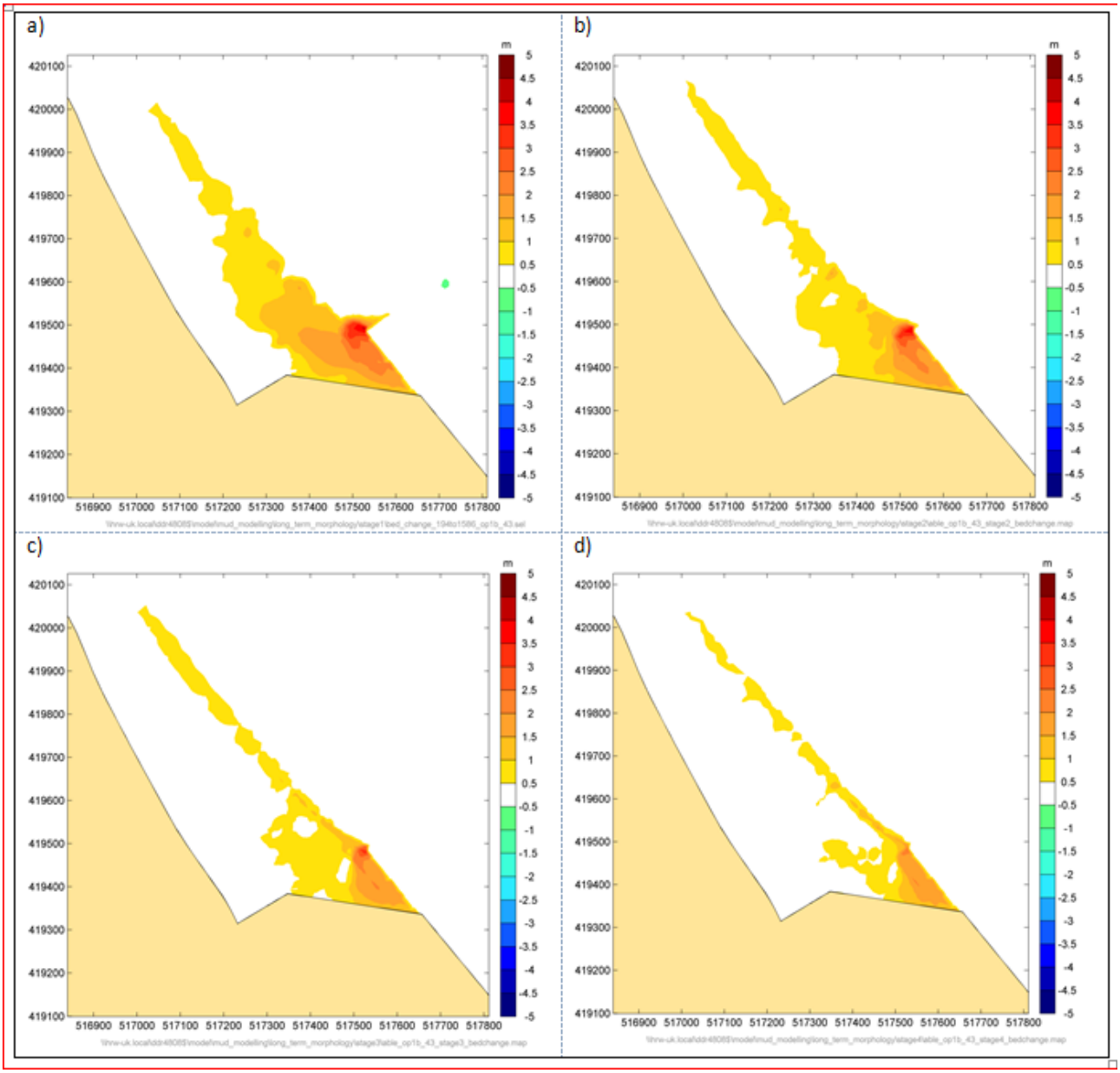


Figure A.1: Evolution of depositional patterns at six weekly intervals following construction of the Able UK MEP a) elevation change (in metres) weeks 0-6, b) elevation change (in metres) weeks 6-12, c) elevation change (in metres) weeks 12-18 d) elevation change (in metres) weeks 18-24

Source: HR Wallingford (2011)

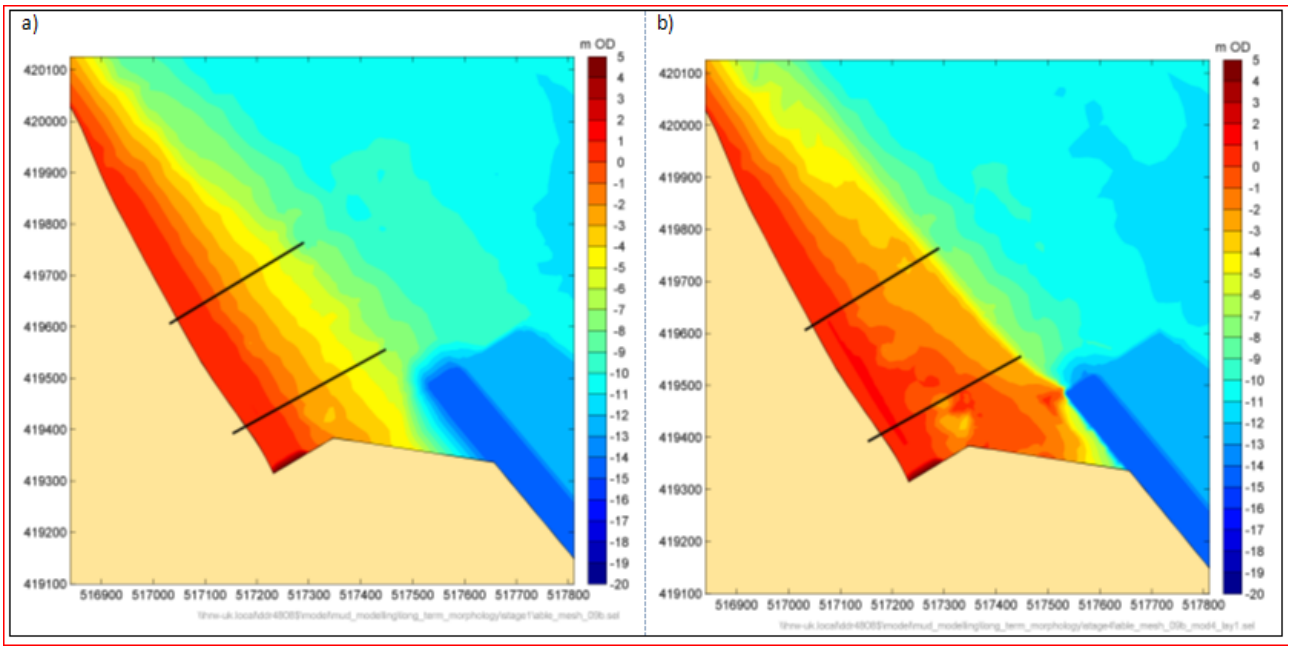


Figure A.2: Comparison of initial and final bathymetry following a 24 week model run

Source: HR Wallingford (2011)

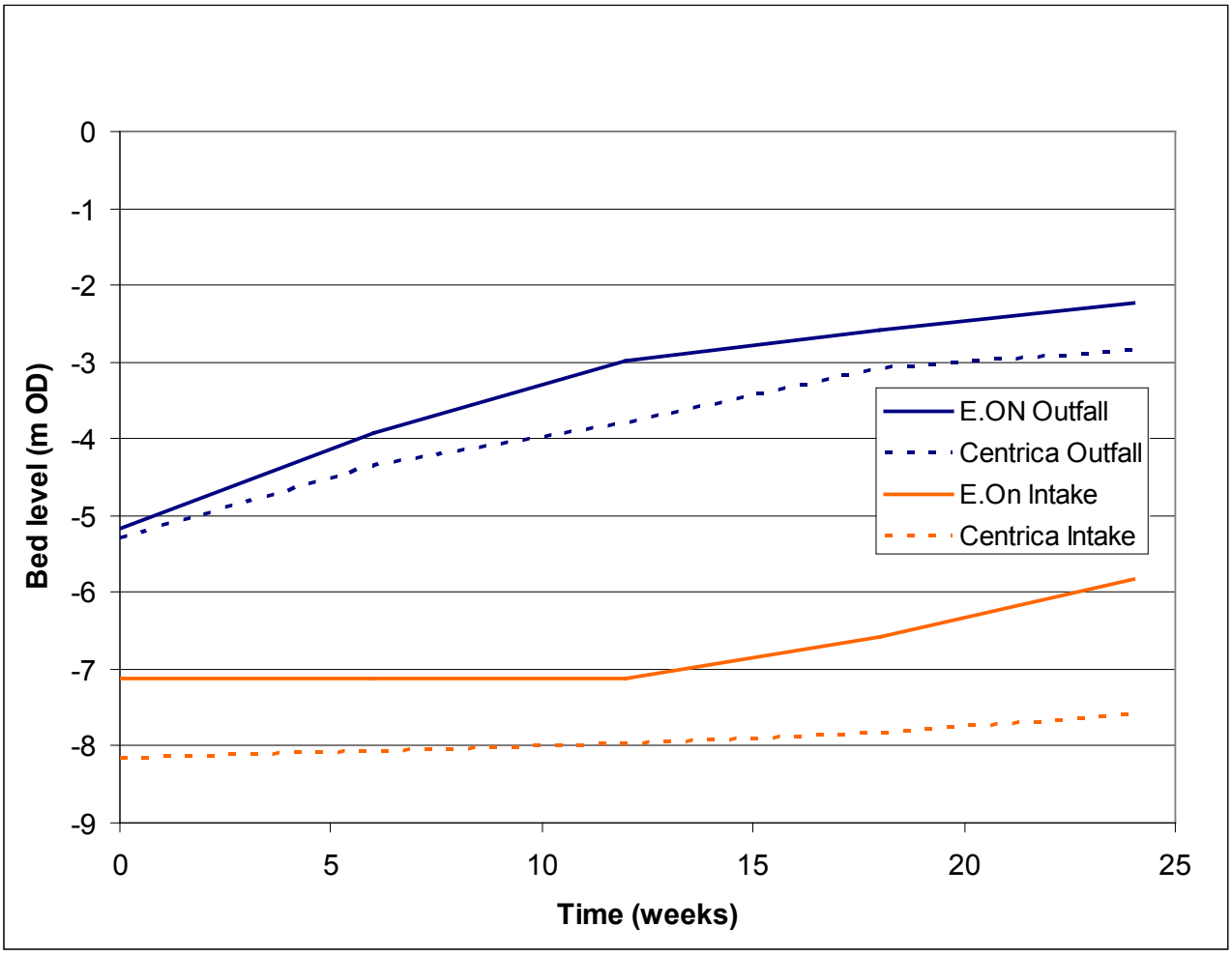


Figure A.3: Predicted longer term changes to morphology at intakes and outfalls

Source: HR Wallingford (2011)

HR Wallingford
Working with water

HR Wallingford is an independent engineering and environmental hydraulics organisation. We deliver practical solutions to the complex water-related challenges faced by our international clients. A dynamic research programme underpins all that we do and keeps us at the leading edge. Our unique mix of know-how, assets and facilities includes state of the art physical modelling laboratories, a full range of numerical modelling tools and, above all, enthusiastic people with world-renowned skills and expertise.

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APPENDIX 2 – CONSULTATION CORRESPONDENCE

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www.gov.uk/mmo

Mr Richard Cram
Able UK Ltd.

(*By e-mail only*)

Our reference:
DCO/2013/00020

27 July 2016

Dear Mr Cram,

Able Marine Energy Park – Monitoring Requirements: Schedule 11, Paragraph 36 and 38 – Changes Required.

I refer to the updated Monitoring Requirements: Schedule 11, Paragraph 36 and 38 document entitled DLM7692-RT001-R01-00 submitted to the Marine Management Organisation (MMO) on 19th May 2016 in order to discharge DCO Schedule 11, Requirement 36 and 38.

I can confirm that the MMO have reviewed the document in consultation with the Environment Agency, E.ON (now Uniper UK Limited), Centrica plc. and C.RO Ports.

Please find consultation responses below:

1. **Monitoring**

Observation

1.1. Uniper UK Limited has remaining questions regarding the scope of the monitoring. The MMO is seeking confirmation of these matters and whether they require attention as part of the MMO's review of the deemed marine licence requirements discharge or whether Uniper wish to address as part of their protective provisions.

2. **Sediment / Silt Deposition**

Observation

2.1. The proposed quay will interfere with the hydrodynamic and sedimentary regime of the Humber Estuary and will result in increased levels of silt being deposited close to the cooling inlet and outfall. Increases in sediment deposition could potentially result in a reduced ability to extract and discharge water, as well as the increased likelihood of sediment-laden water

entering the cooling inlet. The identification that additional surveys are required to accurately monitor sedimentation levels is welcomed.

Change Required

2.2. However trigger points need to be agreed after careful consideration to ensure that there is a sufficient time period to remove the build up around the inlet/outfall.

3. Dredging

Changes required

3.1. Dredging the river bed close to the cooling inlet, as a result of the proposed AMEP development, will increase the level of sediment in the water column and will result in increased levels of sediment-laden water entering the power station's cooling water systems. This does not seem to be addressed in the report and remains a significant concern. This must be addressed in the document.

3.2. No consideration has been given to the impact of the increased suspended solids levels that will occur during the dredging of the proposed Quay. This must be addressed in the document.

4. Inclusion in the MEMMP

Changes required

4.1. No specific change is required to document DLM7692-RT001-R01-00. However, the report must be integrated into the MEMMP document, so that the reports are reflective of each other, in order to discharge the above requirements. It is only through a combined approach, with inclusion of the recommendations in Tables 2.1 and Table 3.1 into the MEMMP, that these Requirements will be adequately covered.

The recommendations of report DLM7692-RT001-R01-00 need to be incorporated into the MEMMP so that all the monitoring measures and recommendations are in one document and there is a more assured implementation mechanism under the supervision of the Environmental Steering Group (as set out in the Able – Natural England legal agreement which states that "Able shall…..have regard to any reviews, recommendations or updates received from the steering group……and thereafter employ reasonable endeavours to implements any recommendations…").

The above 'changes required' must be addressed before the MMO can discharge DCO Schedule 11, Requirement 36 and 38.

Should you have any queries regarding this correspondence, please do not hesitate to contact the undersigned.

Yours sincerely,

[redacted]

Abbey Pennington
Marine Licensing Case Officer

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[redacted]@marinemanagement.org.uk

Miss Abbey Pennington
Marine Management Organisation
PO Box 1275
Newcastle upon Tyne
NE99 5BN

Our ref: AN/2015/121978/04-L01
Your ref: DCO/2013/00020

Date: 07 July 2016

Dear Abbey

Discharge of Schedule 11, Requirements 36 & 38: cooling water intakes & outfalls and sedimentation
Able Marine Energy Park, East Halton

Thank you for consulting us on the above application on 19 May 2016 and subsequently agreeing to an extension of time in which to receive our comments due to the document's cross-references to the Marine Environmental Management and Monitoring Plan (MEMMP).

We have reviewed document DLM7692-RT001-R01-00 dated May 2016, and note that it seeks to make "additional commitments and clarifications" to include areas not currently covered in the MEMMP, namely addressing Schedule 11 Requirement 36. There has been no attempt to integrate this report into the MEMMP and it is our opinion that in order to discharge the above requirements, both documents need to be reflective of each other. It is only through a combined approach, with inclusion of the recommendations in Tables 2.1 and Table 3.1 into the MEMMP, that these Requirements will be adequately covered.

The recommendations of report DLM7692-RT001-R01-00 need to be incorporated into the MEMMP so that all the monitoring measures and recommendations are in one document and there is a more assured implementation mechanism under the supervision of the Environmental Steering Group (the role of the steering group is set out in the legal agreement Able has with Natural England and this states that "Able shall…..have regard to any reviews, recommendations or updates received from the steering group……and thereafter employ reasonable endeavours to implements any recommendations…"). Please note, we are not yet in agreement that the MEMMP is currently adequate to discharge Requirement 19(2) for the reasons set out in our previous letter of 11 March 2016 and further comments also being provided today in separate correspondence to you.

Accordingly, I would advise you that the Environment Agency does not support the discharge of Requirements 36 and 38 for the reasons outlined above.

Should you require any additional information, or wish to discuss these matters further, please do not hesitate to contact me on the number below.

Yours sincerely

Annette Hewitson
Principal Planning Adviser

[redacted]
[redacted]
[redacted]@environment-agency.gov.uk

End

APPENDIX 3 – MEMMP EXTRACTS

AMEP

Marine Environmental Management and Monitoring Plan (MEMMP)

JUNE 2017

.

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checked by:	Dave Sargent	*Dave Sargent*	12th August 2016
approved by:	Richard Cram	*Richard Cram*	13th June 2017

revision	comments	date
A	initial issue for consultation	2nd June 2015
B	comments incorporated, issued for approval	January 2016
C	Revised following further comments received from MMO, Cefas and EA. – "Able" formatted, badged and QA information added	31st May 2016
D	Final comment from EA addressed. Objectives references to sediment and noise monitoring amended Document DLM7692-RT001-R01-00 requirements/amendments incorporated	12th August 2016
E	Further comments from EA addressed. Continuity errors in tables corrected. Discrepancies corrected in M1 and M12	5th October 2016
F	Sediment monitoring amended, noise monitoring refined. Monitoring requirements clarified in regards to Killingholme Marshes Drainage system and pumping station	13th February 2017
G	MMO 26th April comments on noise monitoring incorporated, MMO comments 12th May comments included	13th June 2017

Purpose:

This document is produced to effect the discharge of the condition detailed in schedule 11, requirement 19 "environmental management and monitoring plans" paragraph (2) of the development consent order.

This document shall set out information relevant to the discharge of the aforementioned DCO requirement and may be subject to change. Any change may result in this document being updated, reviewed and approved in accordance with the DCO.

DCO condition:

The specific condition submitted for discharge with this document states:

Environmental management and monitoring plans

19.—(2) The authorised development must not commence until a marine environmental management and monitoring plan, reflecting the survey results and ecological mitigation and enhancement measures included in the environmental statement, has been submitted to and approved by the MMO after consultation with the Environment Agency, Natural England and the relevant planning authority.

TABLE OF CONTENTS

1. INTRODUCTION

1.1 Background and Aims of the Marine EMMP (MEMMP)

1. The development of the Able Marine Energy Park (AMEP) will provide a new and substantial manufacturing base for the offshore marine energy sector. AMEP is located in an area known as Killingholme Marshes on the southern bank of the Humber Estuary, lying between the Humber Sea Terminal (HST) and ABP Immingham Port.
2. The AMEP site comprises the following core development works:
    - The quay, with a frontage of 1,279 m in length located close to the western edge of the existing dredge channel that provides access into HST;
    - Capital dredging, over part of the footprint of the proposed new quay;
    - Heavy component manufacturing site; Supply Chain Park, as a base for supply chain industries serving the offshore energy sector; and an overflow storage area.
3. The development of AMEP will partly affect the Humber Estuary Special Area of Conservation (SAC) and the Special Protection Area (SPA) / Ramsar site. Measures to both compensate and mitigate for the effects of AMEP on these habitats and species have been identified, and will be implemented as part of any future development (see Compensation Environmental Management and Monitoring Plan (CEMMP) and the Terrestrial Environmental Management and Monitoring Plan (TEMMP)).
4. This Marine Environmental Management and Monitoring Plan (MEMMP) has been drawn-up taking account of guidance on management planning produced by the Conservation Management System (CMS) Consortium (www.cmsconsortium.org). It describes the mitigation measures that are required and lists specific objectives which are fundamental to their delivery. Further, it includes targets and management actions which support the objectives and the monitoring which will be undertaken to confirm progress towards the objectives, and ultimately confirming that they have been achieved. Limits of acceptable change are defined where appropriate and any necessary remedial actions which will be undertaken should the monitoring show that these limits have not been met.

1.2 Process of Finalising Outstanding Targets

5. The mitigation proposals for AMEP are complex, and the objectives and targets / management options included in this version of the MEMMP have been subject to extensive discussions with stakeholders.

6. The MEMMP will continue to be a live working document which will be in place for as long as it is deemed necessary to achieve the agreed objectives set out in it. Updates to it will be overseen by the Steering Group, whose role is explained below and includes undertaking a complete review of the MEMMP every five years.

1.3 The Steering Group

7. Able Humber Ports Limited (AHPL) will have overall responsibility for the implementation of the MEMMP. However, the involvement of other stakeholders is essential for the effective working of the MEMMP, and hence AHPL will establish a Steering Group whose members and terms of reference are set out in a '*Deed in Relation to the Able Marine Energy Park'*, between Able Humber Ports Limited and Natural England (NE).
8. An agenda will be drawn up in advance of each Steering Group meeting by AHPL and minutes will be produced after the meeting by them for agreement.
9. Unless otherwise stated, the default duration for the ecological monitoring survey work (e.g. saltmarsh, intertidal and subtidal benthos and fish communities) described within this document is 10 years following completion of construction. Continuance of any of these components beyond that period will be determined through discussion on findings etc by the Steering Group. It is expected that some components of the compensation and the mitigation will require ongoing management to ensure that the objectives continue to be met.

1.4 Stages of development and monitoring

10. The DCO condition requires this document to have been agreed prior to any commencement of development, but does not clarify at which point in time or stage of development would trigger the onset of the surveys, monitoring and mitigations as agreed.
11. The MEMMP was intended to monitor the construction of the entire AMEP Quay development along with its massive capital dredging programme, in effect, large scale activities within the marine environment.
12. From the DCO (Part 1)"the marine environmental management and monitoring plan" means the plan for environmental management and monitoring below the high water mark referred to at paragraph 19(2) of Schedule 11;
13. The AMEP Stages of development are also a DCO condition and as such must be agreed in advance of development commencing, this is to ensure the required mitigation, survey and monitoring occurs proportionally to, and sequentially with, the development.
14. Previously the MEMMP was considered to be applicable to:

AMEP Quay construction

Cherry Cobb Sands Breach

AMEP Quay operation

(And to a lesser extent)

AMEP Terrestrial area construction which included the Killingholme Marshes drainage scheme outfall and channel

15. Recently the AMEP "stages of development" have been amended to identify the Killingholme Marshes Drainage Scheme (KMDS) as a unique "stage" of development (now Stage 1) within the DCO. Previously the scheme was part of the AMEP terrestrial works.(at that time Stage 4)

1.5 Stages where the MEMMP monitoring will be applicable

16. Commencement of AMEP Quay Construction (now Stage 5) will evoke the full implementation of the monitoring and mitigation as set out in the MEMMP. It will continue to be implemented as applicable in relation to the Cherry Cobb Sands Breach (now stage 8) and AMEP Quay Operation. (now stage 9)
17. Full monitoring for 10 years period as required under the DCO commences on completion of the AMEP quay.

1.6 Killingholme Marshes Drainage Scheme

18. The surveys and monitoring and mitigation within the MEMMP will not be applied to the KMDS (Stage 1). The environmental management, mitigation and monitoring are adequately addressed by the "stage specific" DCO conditions, and in particular the requirement to have approved Code of Construction Practice.

19. Tabulates summary of monitoring activities in relation to stages of development

MEMMP Monitoring		Stage of development									
		Pre-construction	1 KMDS	2 HMWG	3 CCS RTE	4 CCS WG	5 Quay	6 AMEP	7 AMEP operation	8 Cherry Cobb breach	9 Quay operation
reference	Purpose/reason for monitoring										
Background	Establish baseline estuarine DO/SS/Temp etc	✓	---		---		---	---	---	---	---
Objective M1	During dredging ensure sediment levels remain within limits agreed under the DML in relation to Centrica and E.ON intake/outfall operation	✓	---		---		✓	---	---	---	✓
Objective M2	To corroborate predictions on intertidal accretion/erosion from EX11.24 (Medium and long term quantum of habitat loss)	✓	---		---		✓	---	---	---	✓
Objective M3	To record changes in extent and composition of saltmarsh	---	---		---		---	---	---	---	✓
Objective M4:	To identify deleterious change to intertidal benthic invertebrate fauna	✓	---		---		---	---	---	---	✓
Objective M5	To record and identify changes in intertidal topography & extent	---	---		---		✓	---	---	---	✓
Objective M6:	To identify deleterious change to subtidal benthic invertebrate fauna due to dredging and dredge disposal e.g. including WFD Compliance	✓	---		---		---	---	---	---	✓
Objective M7:	To derive references for dredging and disposal impacts	---	---		---		✓	---	---	---	✓

MEMMP Monitoring		Stage of development								
		Pre-construction	1 KMDS	2 HMWG	3 CCS RTE	4 CCS WG	5 Quay	6 AMEP	7 AMEP operation	8 Cherry Cobb breach	9 Quay operation
reference	Purpose/reason for monitoring										
	and to validate boundaries of disposal grounds										
Objective M8:	To identify deleterious change to intertidal fish populations	✓	-- -		-- -		-- -	-- -	-- -	---	✓
Objective M9:	To identify deleterious change to subtidal fish populations	✓	-- -		-- -		-- -	-- -	-- -	---	✓
Objective M10:	Ensure compliance with percussive piling restrictions to restrict or remove potential impacts on sensitive fish receptors. To be monitored via controls set out in the agreed AMS	✓	-- -		-- -		✓	-- -	-- -	---	-- -
Objective M11:	Ensure compliance with percussive piling restrictions to restrict or remove potential impacts on sensitive fish receptors. To be monitored via controls set out in the agreed AMS	✓	-- -		-- -		✓	-- -	-- -	---	-- -
Objective M12	Ensure compliance with percussive piling restrictions to restrict or remove potential impacts on sensitive fish receptors. To be monitored via controls set out in the agreed AMS	-- -	-- -		-- -		✓	-- -	-- -	---	-- -
Objective M13	Ensure compliance with percussive piling restrictions to restrict or remove potential	-- -	-- -		-- -		✓	-- -	-- -	---	-- -

MEMMP Monitoring		Stage of development								
		Pre-construction	1 KMDS	2 HMWG	3 CCS RTE	4 CCS WG	5 Quay	6 AMEP	7 AMEP operation	8 Cherry Cobb breach	9 Quay operation
reference	Purpose/reason for monitoring										
	impacts on sensitive marine mammal receptors. To be monitored via controls set out in the agreed AMS										
Objective M14:	Ensure compliance with percussive piling restrictions to restrict or remove potential impacts on sensitive bird receptors. . To be monitored via controls set out in the agreed AMS	---	---		---		✓	---	---	---	---
Objective M15:	To assess longer-term impacts of AMEP within the wider estuary on standard of protection of EA defences	---	---		---		✓	---	---	---	✓
Objective M16:	To assess longer-term impacts of AMEP within the wider estuary on standard of protection of EA defences	---	---		---		✓	---	---	---	✓

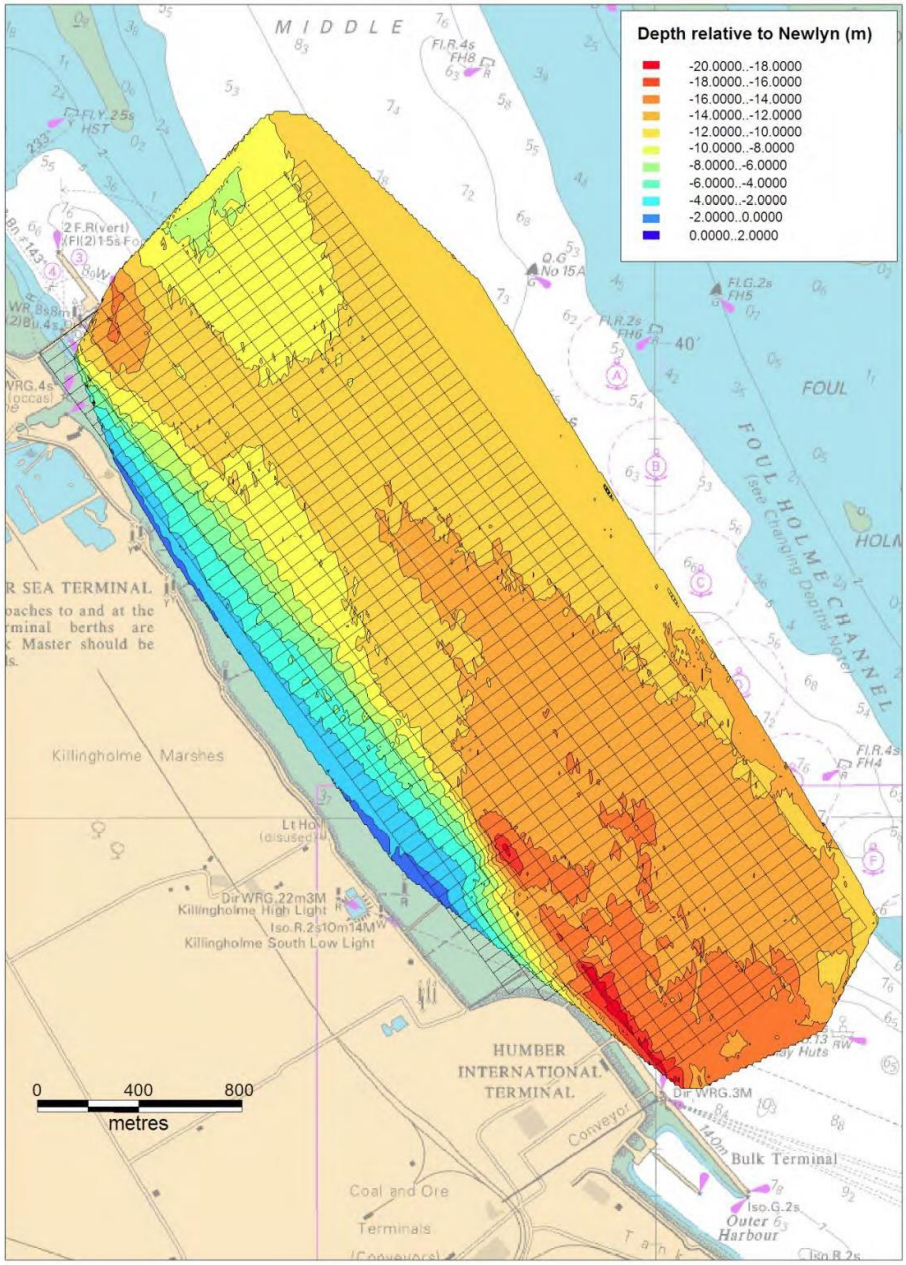
2. ENVIRONMENTAL BASELINE AND IDENTIFIED IMPACTS

20. The following main environmental topic sections provide an overview of relevant headline environmental baseline data gathered from the Environmental Statement (ES) and associated documents submitted to the Planning Inspectorate in relation to AMEP.
21. Where these data form specific monitoring and management target(s) then these are identified. Document references are provided for additional context and information where necessary.
22. Impacts raised by the relevant Defra agencies are summarised in relation to the environmental topic sections.

2.1 Bathymetry/Topography and Sediment Parameters

2.1.1 BASELINE

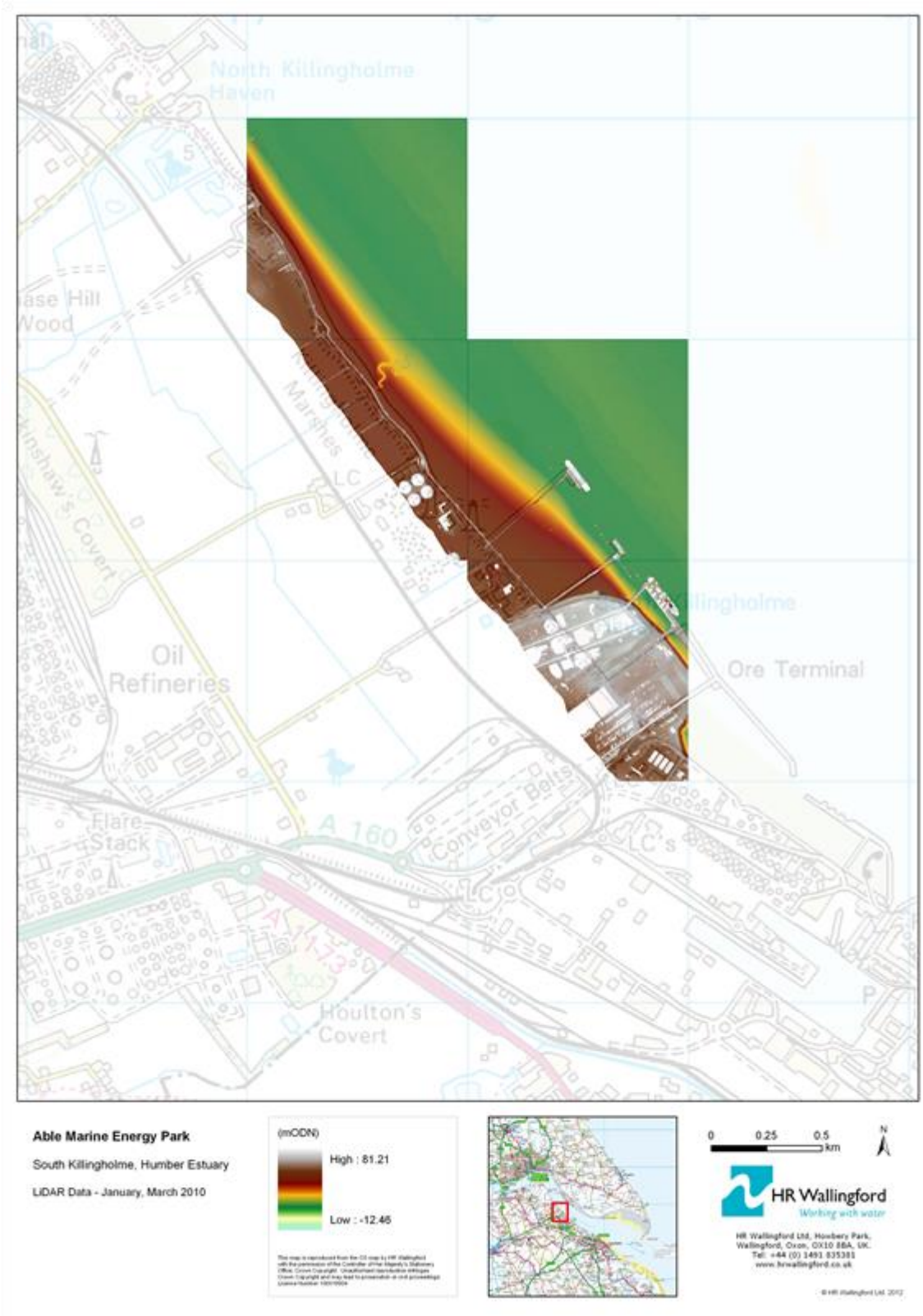
23. A survey of subtidal bathymetry was undertaken in March 2010; this is graphically summarised in Figure 1. Further information (including figures of changes to intertidal profiles since 2000) is available in EX 28.3 Prt 2 (Baseline of North Killingholme Foreshore) and in Annex 9.1 of the ES (Bathymetry Hydrography Survey).



Note: The lower extent of the intertidal zone is denoted by the seaward extent of the 2m to -4mAOD contour range (-4mAOD = -0.1mCD)

Figure 1: Subtidal Bathymetry (2010)

24. The topography of the intertidal reach around AMEP has been routinely covered by LiDAR surveys. The baseline LiDAR output from 2010 and the change in topography between 2001 and 2010 are shown in Figures 2 and 3 respectively.


North Killingholme Haven
Oil Refineries
Ore Terminal
Conveyor Belts
Flare Stack
A 160
A 1173
Houlton's Covert
Able Marine Energy Park
South Killingholme, Humber Estuary
LiDAR Data - January, March 2010
(mODN)
High : 81.21
Low : -12.46
0 0.25 0.5 km
N
HR Wallingford
Working with water

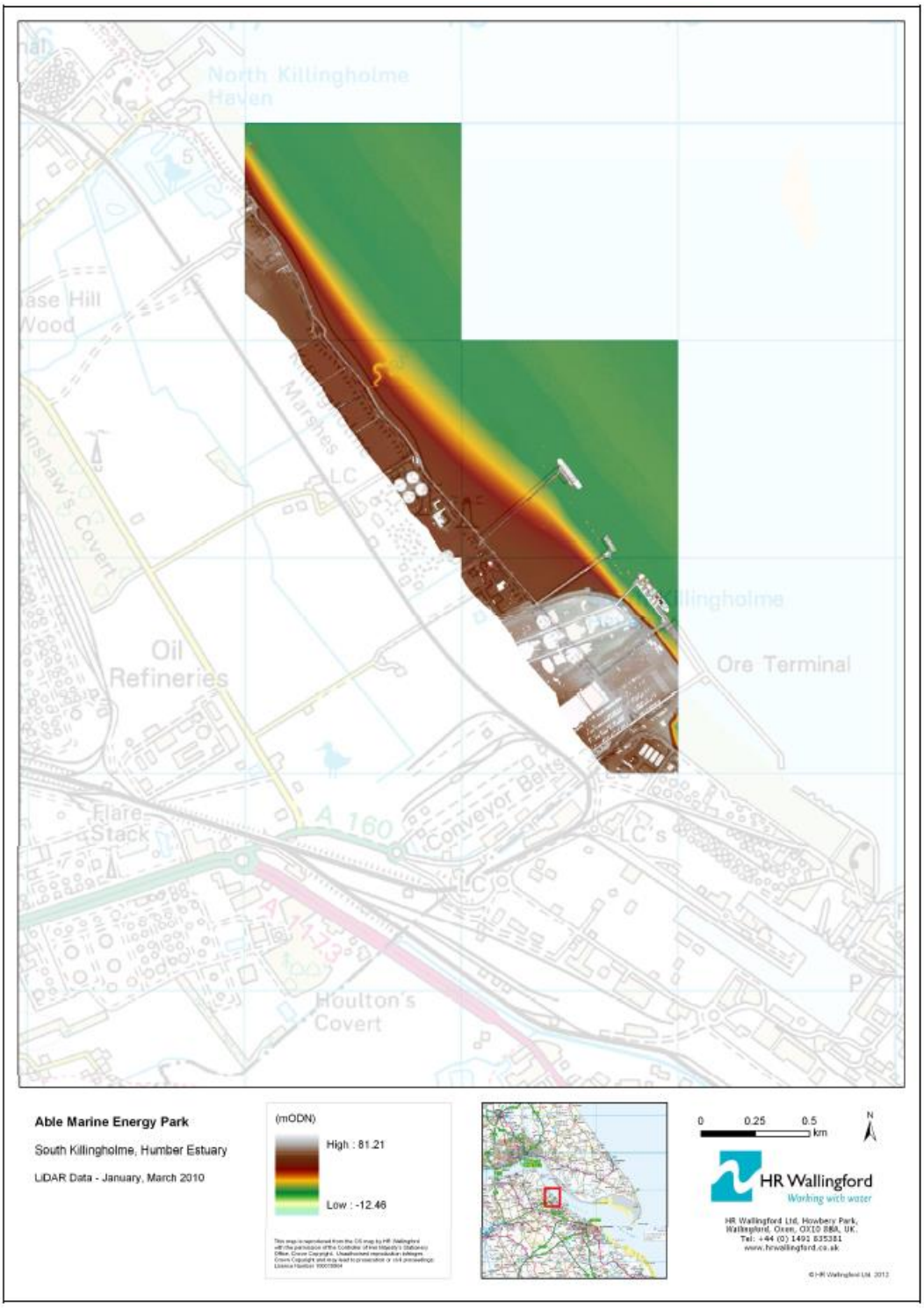
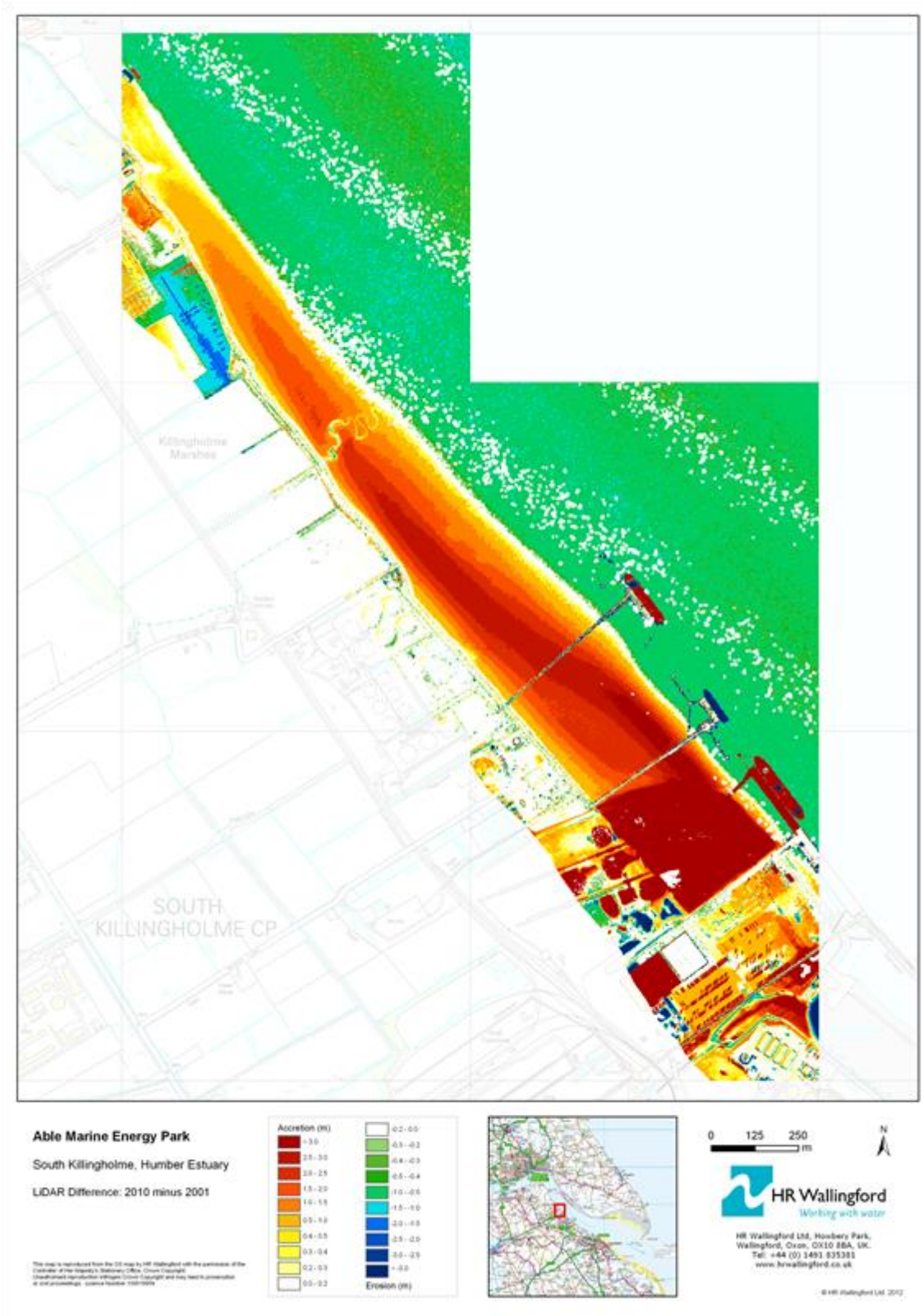


Figure 2: Intertidal Topography (2010) (EX 8.9)


Killingholme Marshes
SOUTH KILLINGHOLME CP
Able Marine Energy Park
South Killingholme, Humber Estuary
LiDAR Difference: 2010 minus 2001
Accretion (m)
Erosion (m)
0 125 250
m
N
HR Wallingford
Working with water

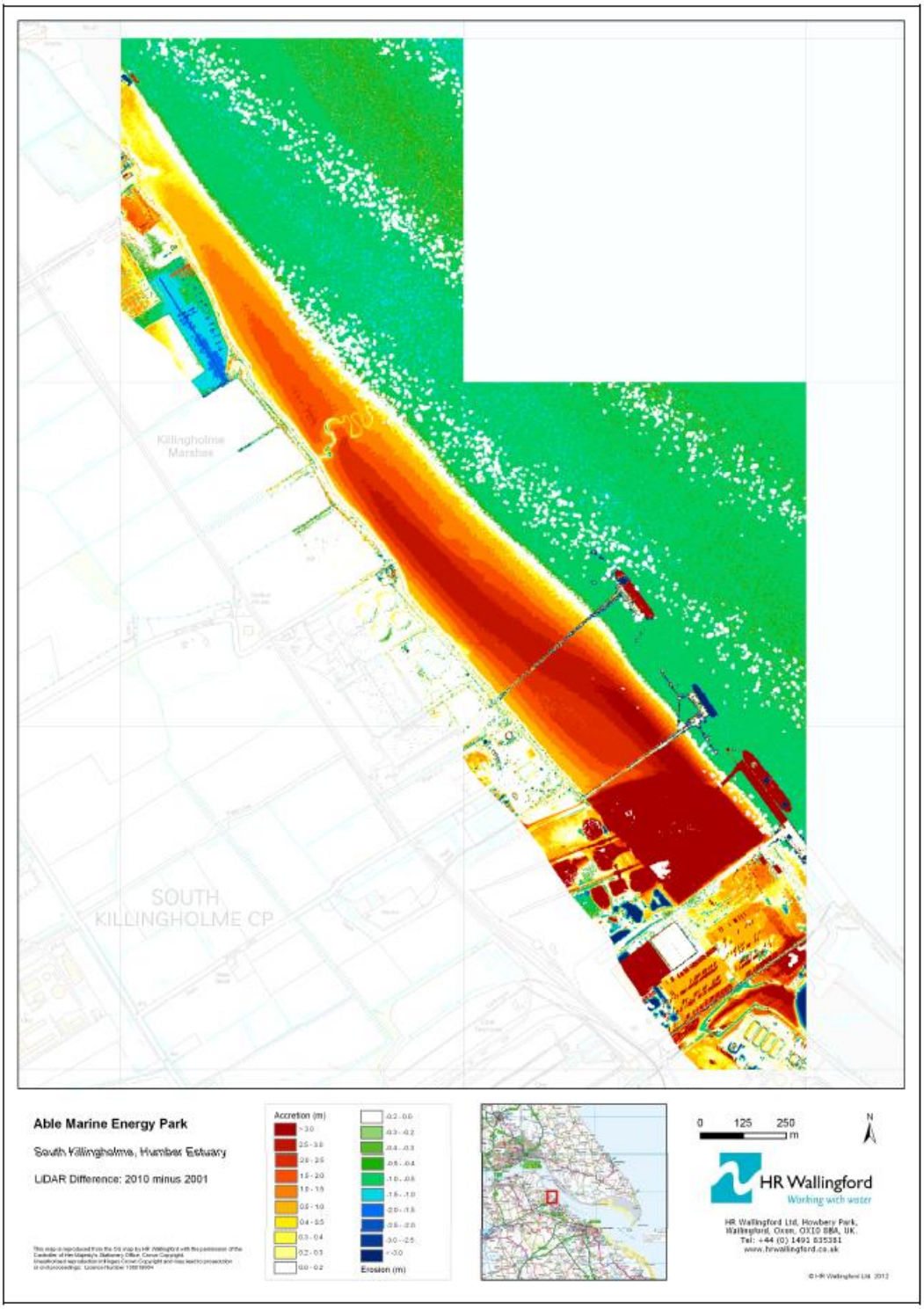


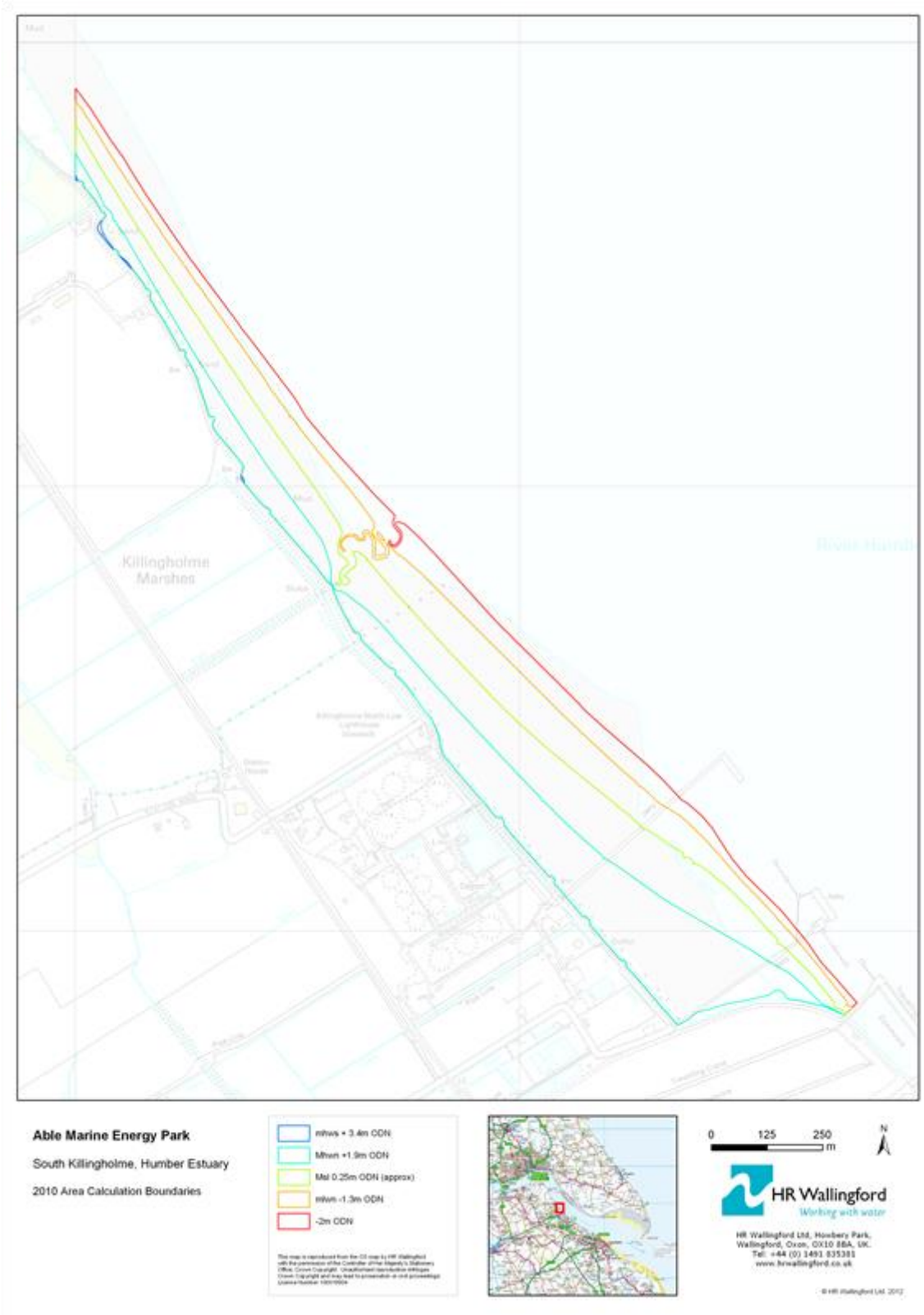
Figure 3: Change in intertidal topography (2001-2010) (EX8.9)

25. Figures 2 and 3 indicate a general accretion of the mudflat between 2001 and 2010 of between 0.5m and 3.0m over a 2km length of intertidal between Humber

International Terminals (HIT) and C.RO Port (Killingholme) Ltd (CPK). The largest amount of accretion has occurred adjacent to the HIT on the lower intertidal area, extending north-westwards along the foreshore. Figure 4 shows the LiDAR information for 2010 translated into a series of contours.

26. The review of topographic change provided in EX8.9 (Assessment of changes to morphology (particularly intertidal) between the Humber International Terminal (HIT) and Humber Sea Terminal (HST)) identifies an ongoing trend of accretion in the zone, leading to both increases in elevation, but also extension downshore. This is expected to be ongoing.

27. Further details are provided in EX8.9 which concludes that as changes to the intertidal zone from HIT have continued for 9-10 years, they are predicted to be ongoing. Expert predictions are that it is likely that a stable landform upstream from the AMEP would not be reached for many years, but would take the form of a new low water line coming off the end of the quay/dredged side-slopes and extending approximately parallel and seawards of the current low water line up to CPK.


Killingholme Marshes
Able Marine Energy Park
South Killingholme, Humber Estuary
2010 Area Calculation Boundaries
mhws + 3.4m ODN
Mhwn +1.9m ODN
Msl 0.25m ODN (approx)
mlwn -1.3m ODN
-2m ODN
0
125
250
m
N
HR Wallingford
Working with water

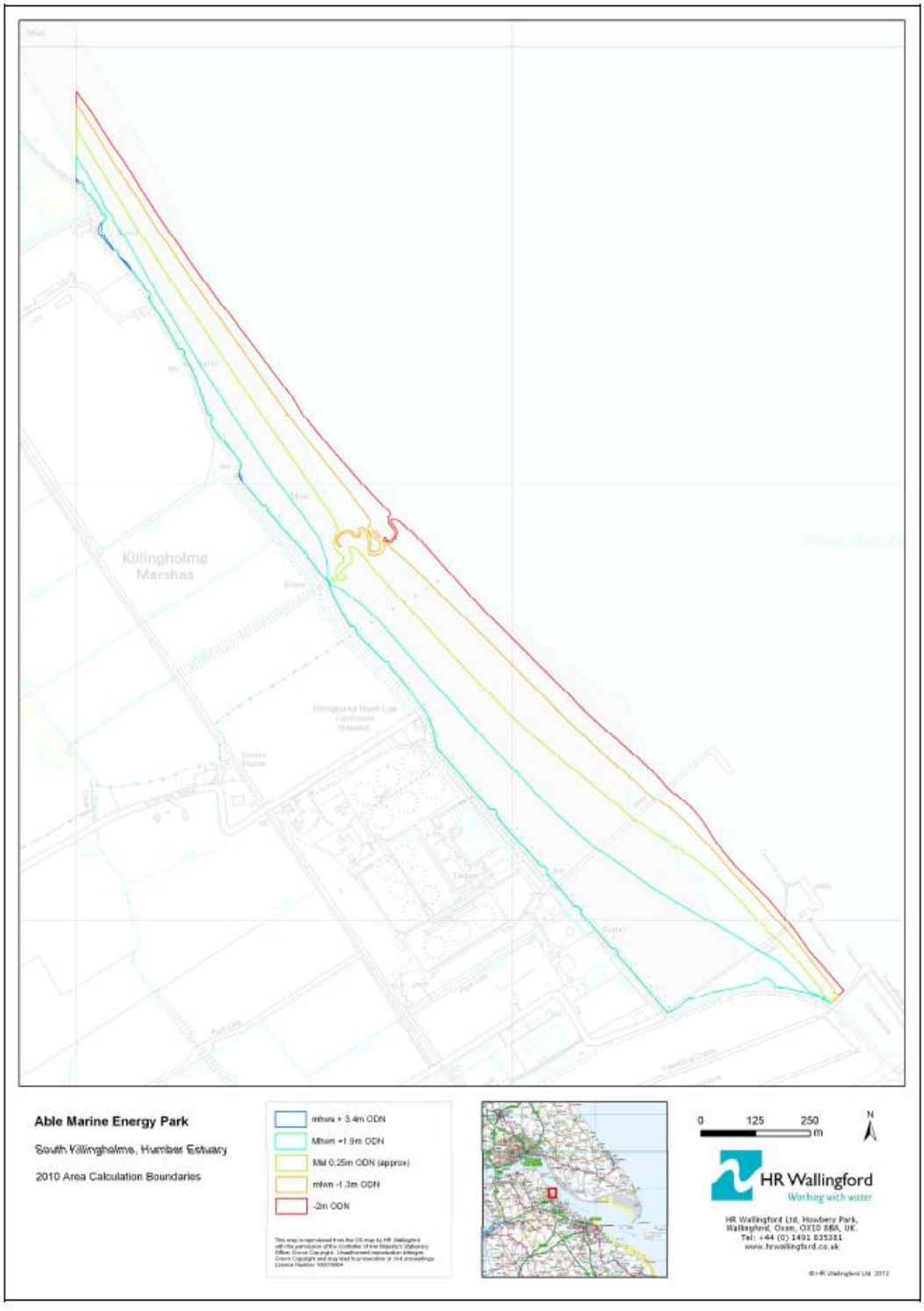


Figure 4: Intertidal contours based on 2010 LiDAR data (EX 8.9)

28. Analysis of sediment particle size was undertaken on samples taken at the same locations as the benthic intertidal and subtidal samples during the 2010 study (see Annex 7.2 to the ES – Water and Sediment Quality). The baseline findings are

given here for the intertidal zone locations (Table 1) and subtidal zone locations (Table 2).

Table 1: Intertidal Sediment Particle Size Data (2010)

Transect	Shore position	Mean φ	Mean µm	% Gravel	% Sand	% Mud	Sediment name	Textural group
1	Upper	5.880	16.98	0.0%	14.5%	85.5%	Very Fine Sandy Very Coarse Silt	Sandy Mud
1	Middle	6.255	13.10	0.0%	10.5%	89.5%	Very Fine Sandy Fine Silt	Sandy Mud
1	Lower	5.772	18.31	0.0%	19.0%	81.0%	Very Fine Sandy Very Coarse Silt	Sandy Mud
2	Upper	6.379	12.02	0.0%	7.5%	92.5%	Medium Silt	Mud
2	Middle	6.326	12.47	0.0%	6.9%	93.1%	Medium Silt	Mud
2	Lower	4.617	40.74	0.0%	48.5%	51.5%	Very Fine Sandy Very Coarse Silt	Sandy Mud
3	Upper	6.774	9.139	0.0%	4.5%	95.5%	Fine Silt	Mud
3	Middle	5.461	22.70	0.0%	20.6%	79.4%	Very Fine Sandy Very Coarse Silt	Sandy Mud
3	Lower	5.893	16.83	0.0%	14.5%	85.5%	Very Fine Sandy Coarse Silt	Sandy Mud
4	Upper	6.616	10.20	0.0%	5.5%	94.5%	Medium Silt	Mud
4	Middle	5.864	17.17	0.0%	15.5%	84.5%	Very Fine Sandy Very Coarse Silt	Sandy Mud
4	Lower	5.908	16.65	0.0%	12.4%	87.6%	Very Fine Sandy Coarse Silt	Sandy Mud
5	Upper	6.416	11.71	0.0%	7.5%	92.5%	Medium Silt	Mud
5	Middle	5.847	17.38	0.0%	16.0%	84.0%	Very Fine Sandy Very Coarse Silt	Sandy Mud
5	Lower	5.839	17.47	0.0%	17.3%	82.7%	Very Fine Sandy Very Coarse Silt	Sandy Mud
6	Upper	6.654	9.930	0.0%	5.2%	94.8%	Medium Silt	Mud
6	Middle	5.608	20.51	0.0%	20.3%	79.7%	Very Fine Sandy Very Coarse Silt	Sandy Mud
6	Lower	5.618	20.36	0.0%	23.8%	76.2%	Very Fine Sandy Very Coarse Silt	Sandy Mud
7	Upper	6.122	14.36	0.0%	8.4%	91.6%	Coarse Silt	Mud
7	Middle	4.828	35.22	0.0%	42.4%	57.6%	Very Fine Sandy Very Coarse Silt	Sandy Mud
7	Lower	5.878	17.01	0.0%	16.8%	83.2%	Very Fine Sandy Medium Silt	Sandy Mud
8	Upper	6.459	11.37	0.0%	6.9%	93.1%	Medium Silt	Mud
8	Middle	5.605	20.54	0.0%	19.9%	80.1%	Very Fine Sandy Very Coarse Silt	Sandy Mud
8	Lower	6.050	15.09	0.0%	11.5%	88.5%	Very Fine Sandy Coarse Silt	Sandy Mud
9	Upper	6.249	13.15	0.0%	8.7%	91.3%	Medium Silt	Mud
9	Middle	5.764	18.41	0.0%	17.3%	82.7%	Very Fine Sandy Very Coarse Silt	Sandy Mud
9	Lower	6.148	14.10	0.0%	10.4%	89.6%	Very Fine Sandy Coarse Silt	Sandy Mud
10	Upper	6.120	14.37	0.0%	13.3%	86.7%	Very Fine Sandy Fine Silt	Sandy Mud
10	Middle	6.087	14.71	0.0%	13.3%	86.7%	Very Fine Sandy Medium Silt	Sandy Mud
10	Lower	5.133	28.49	0.0%	29.3%	70.7%	Very Fine Sandy Very Coarse Silt	Sandy Mud
11	Upper	5.541	21.48	0.0%	19.3%	80.7%	Very Fine Sandy Very Coarse Silt	Sandy Mud
11	Middle	5.158	28.00	0.0%	29.8%	70.2%	Very Fine Sandy Very Coarse Silt	Sandy Mud
11	Lower	6.041	15.19	0.0%	12.6%	87.4%	Very Fine Sandy Coarse Silt	Sandy Mud
12	Upper	6.687	9.708	0.0%	6.7%	93.3%	Fine Silt	Mud
12	Middle	5.397	23.73	0.0%	23.2%	76.8%	Very Fine Sandy Very Coarse Silt	Sandy Mud
12	Lower	5.879	16.99	0.0%	14.1%	85.9%	Very Fine Sandy Very Coarse Silt	Sandy Mud

29. The baseline bathymetry and hydrography study (Annex 9.1 to the ES – Bathymetry Hydrography Survey) indicates that typical suspended sediment concentrations near to AMEP measured in September 2010 range from 100mg/l at slack water on a neap tide to 400-500mg/l during the neap tide ebb flow. Concentrations during the spring tides reached 1,600mg/l during peak flood flow and were in excess of 800mg/l on the ebb flow. Again, these values will vary on an intra-annual basis due to natural processes.

Table 2: Subtidal Sediment Particle Size Data (2010)

Station No.	Mean φ	Mean µm	% Gravel	% Sand	% Mud	Sediment name	Textural group
1	2.492	177.8	0.0%	95.9%	4.1%	Moderately Sorted Fine Sand	Sand
2	5.849	17.35	0.0%	21.2%	78.8%	Very Fine Sandy Medium Silt	Sandy Mud
3	4.907	33.34	0.0%	43.5%	56.5%	Very Fine Sandy Medium Silt	Sandy Mud
4	3.797	71.95	0.0%	70.9%	29.1%	Very Coarse Silty Fine Sand	Muddy Sand
5	6.236	13.26	0.0%	14.4%	85.6%	Very Fine Sandy Fine Silt	Sandy Mud
6	2.944	130.0	0.0%	77.5%	22.5%	Fine Silty Medium Sand	Muddy Sand
7	4.274	51.68	0.0%	60.4%	39.6%	Very Coarse Silty Very Fine Sand	Muddy Sand
8	5.910	16.64	0.0%	18.8%	81.2%	Very Fine Sandy Fine Silt	Sandy Mud
9	5.770	18.33	0.0%	20.3%	79.7%	Very Fine Sandy Fine Silt	Sandy Mud
10	5.014	30.96	0.0%	41.0%	59.0%	Very Fine Sandy Fine Silt	Sandy Mud
11	6.056	15.03	0.0%	15.0%	85.0%	Very Fine Sandy Fine Silt	Sandy Mud
12	1.879	271.8	1.6%	83.8%	14.6%	Slightly Very Fine Gravelly Fine Silty Medium Sand	Slightly Gravelly Muddy Sand
13	3.305	101.2	0.0%	70.5%	29.5%	Fine Silty Medium Sand	Muddy Sand
14	6.071	14.88	0.0%	14.2%	85.8%	Very Fine Sandy Fine Silt	Sandy Mud
15	3.181	110.3	0.2%	71.1%	28.7%	Slightly Very Fine Gravelly Fine Silty Medium Sand	Slightly Gravelly Muddy Sand
16	3.366	97.02	2.2%	60.5%	37.3%	Slightly Very Fine Gravelly Fine Silty Medium Sand	Slightly Gravelly Muddy Sand
17	4.474	44.99	0.7%	44.5%	54.9%	Slightly Very Fine Gravelly Medium Sandy Medium Silt	Slightly Gravelly Sandy Mud
18	3.405	94.39	0.0%	69.9%	30.1%	Fine Silty Medium Sand	Muddy Sand
19	2.909	133.2	3.0%	69.6%	27.3%	Slightly Very Fine Gravelly Fine Silty Medium Sand	Slightly Gravelly Muddy Sand
20	3.296	101.8	0.9%	68.2%	30.9%	Slightly Very Fine Gravelly Fine Silty Medium Sand	Slightly Gravelly Muddy Sand
21	3.734	75.15	0.0%	59.8%	40.2%	Fine Silty Medium Sand	Muddy Sand
22	2.681	155.9	0.5%	78.7%	20.8%	Slightly Very Fine Gravelly Fine Silty Medium Sand	Slightly Gravelly Muddy Sand
23	3.122	114.9	2.9%	65.0%	32.0%	Slightly Very Fine Gravelly Very Coarse Silty Medium Sand	Slightly Gravelly Muddy Sand
24	2.315	201.0	0.0%	83.6%	16.4%	Fine Silty Medium Sand	Muddy Sand
25	4.969	31.92	0.0%	43.2%	56.8%	Very Fine Sandy Very Coarse Silt	Sandy Mud
26	2.490	177.9	6.7%	72.2%	21.1%	Very Fine Gravelly Fine Silty Medium Sand	Gravelly Muddy Sand
27	3.671	78.50	7.6%	52.3%	40.1%	Medium Gravelly Fine Silty Medium Sand	Gravelly Muddy Sand
28	4.338	49.45	0.0%	47.5%	52.5%	Medium Sandy Very Coarse Silt	Sandy Mud
29	0.220	858.5	46.7%	31.0%	22.3%	Fine Silty Sandy Coarse Gravel	Muddy Sandy Gravel
30	0.162	893.7	22.7%	70.6%	6.7%	Fine Gravelly Coarse Sand	Gravelly Sand

2.1.2 IMPACTS

30. The following potential impacts have been identified:

NE (sHRA)

- Capital and maintenance dredging indirectly impacting on intertidal and subtidal habitats and associated benthic communities through sediment particle size changes.

MMO

- Capital and maintenance dredging leading to changes in sediment conditions.

EA

- Capital and maintenance dredging leading to a reduction of Ecological Potential under WFD.
- Capital and maintenance dredging resulting in a reduction in flood protection standards.

Other

- Capital and maintenance dredging deleteriously affecting the operation of the E.ON and Centrica intake and outfall operation.

2.1.3 PRE-CONSTRUCTION REFERENCE AND BACI-TYPE ASSESSMENT (2013 ONWARDS)

31. Whilst no dedicated pre-construction seabed sediment survey is anticipated, as part of the pre-construction intertidal and subtidal benthic biological surveys, details of bathymetry and sediment characteristics will be sampled. Details of these surveys are given in Appendix 3.
32. In addition, bathymetric surveys will be undertaken to assess the effects of dredging work in the subtidal (Appendix 1) as well as LiDAR for the intertidal (Appendix 2). whilst suspended sediment will be monitored via a buoy-mounted sonde.
33. Subsequent surveys will be undertaken to allow construction and operation impacts to be assessed. Details and duration are given in the Objectives section onwards and Appendices in this document.

2.2 Intertidal Estuarine Habitat (Saltmarsh and mudflats)

2.2.1 BASELINE (2010 CHARACTERISATION)

34. Small areas of saltmarsh were identified adjacent to the proposed AMEP site (Figure 5). Further information on these can be found in EX 28.3 Prt 2 (Baseline of North Killingholme foreshore) and in Annex 11.2 to the ES (South Killingholme Phase 1 Ecology).

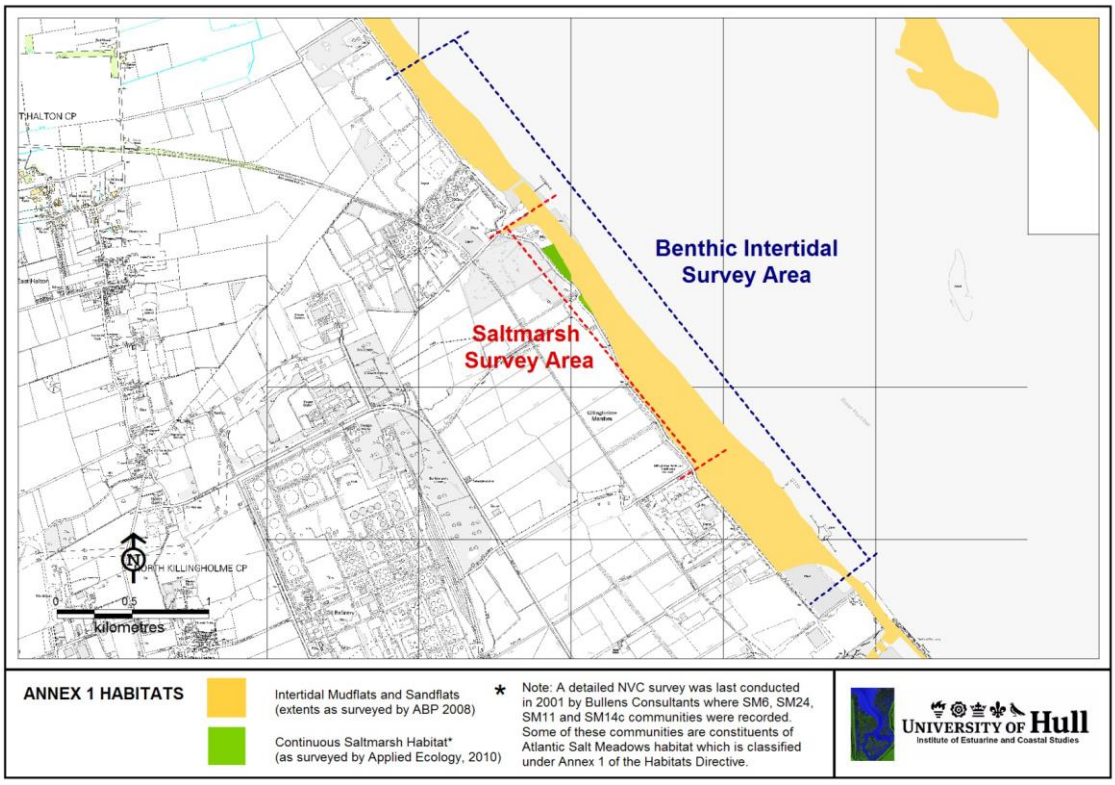


Figure 5: Saltmarsh Area (2010 Survey)

35. In the vicinity of the AMEP site a very small patch of saltmarsh was recorded on the seaward side of the seawall, close to the mouth of the main drain onto the foreshore and also adjacent to the North Killingholme Haven Pits. During the Phase 2 Survey undertaken in 2006, a number of different saltmarsh communities were identified within this area including sea couch (*Elymus pycnanthus*), saltmarsh rush (*Juncus gerardii*) and couch (*Elymus repens*).

36. Killingholme Marshes foreshore is undergoing a process of change and patches of saltmarsh are beginning to establish in certain areas due to the foreshore rising within the tidal range (EX8.9).
37. Given the potential for further change to saltmarsh extent and associated changes/impacts to adjacent habitat status, a pre-construction reference survey of saltmarsh extent and composition will be undertaken. Details are given in Section 3.2 and Appendix 3. These data will also be assessed in the context of adjacent mudflat change, using LiDAR to map mudflat extent and topography, with details in Section 3.3 and Appendix 1.

2.2.2 IMPACTS

38. The following potential impacts have been identified:

NE (sHRA)

- No direct impacts identified. However, changes to saltmarsh extent will need to be characterised to address impacts to other habitats e.g. mudflat.

MMO

- No direct impacts identified.

EA

- Capital and maintenance dredging leading to a reduction of Ecological Potential under WFD. Characterisation of saltmarsh extent and composition required as well as the need to address changes with respect to other habitats for WFD needs.

2.2.3 PRE-CONSTRUCTION REFERENCE AND BACI-TYPE ASSESSMENT (2013 ONWARDS)

39. In order to characterise the extent and composition of the saltmarsh community present, as well as any changes over time and effects on adjacent habitat status (mudflat in particular), pre-construction surveys will be undertaken, and carried forward. For saltmarsh, these will include field survey and aerial photography following EA guidance for WFD compliant methods (see Appendix 3), whilst LiDAR will be used to map mudflat extent and topography (Appendix 1).

40. Subsequent surveys will be undertaken to allow construction and operation impacts to be assessed. Details and duration are given in the Objectives section onwards and Appendices in this document.

2.3 Intertidal Estuarine Habitat (Benthos)

2.3.1 BASELINE (2010 CHARACTERISATION)

41. Baseline data are available from a site characterisation study undertaken at the AMEP site in May 2010. A total of 36 intertidal samples were taken along 12 intertidal transects with one sample taken using a 0.01m^2 corer at each of three stations along each transect. The location of sampling stations is shown in Figure 6; and the data are presented as Tables 3 and 4.

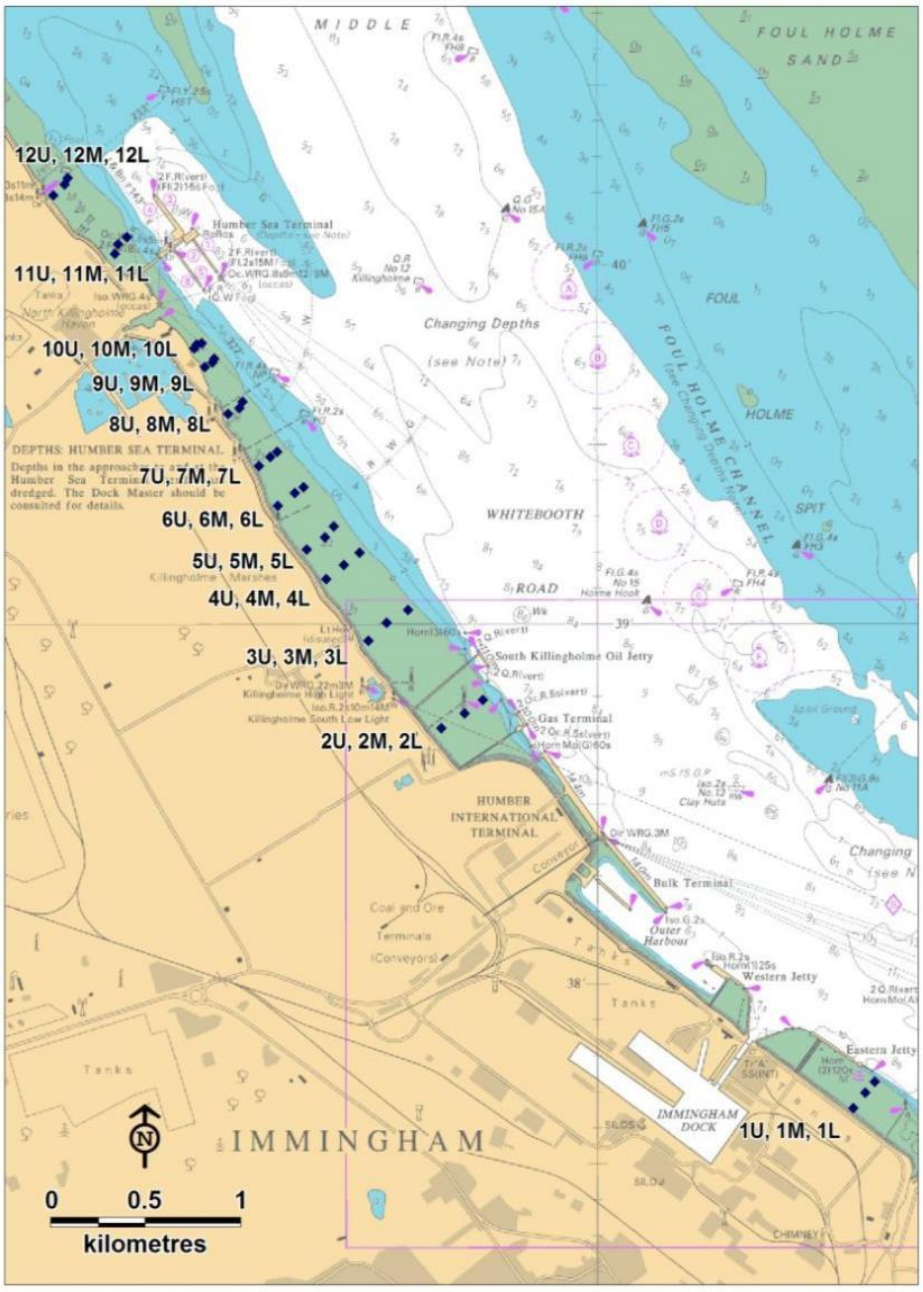


Figure 6: Intertidal benthic invertebrate sampling stations (Characterisation Study 2010)

42. The most commonly occurring species in the intertidal samples were the oligochaete *T. benedii*, Nematoda, the polychaete *Streblospio shrubsolii* and the amphipod crustacean *Corophium volutator*. These species were present in most of the samples and were present at higher abundances than all other species throughout the survey area. The bivalve *M. balthica* was widespread and the polychaete *H. diversicolor* was present at most of the upper shore stations.
43. *T. benedii* was the dominant species at the upper and mid shore intertidal stations. *S. shrubsolii* was dominant at the lower shore intertidal stations where the sediments were presumably sandier.
44. Species richness (number of species recorded) ranged from 2-9 species/sample (mean = 5.8). Abundance (number of individuals/sample) ranged from 5-197 (mean = 46.4) and biomass ranged from <0.001 to 1.37 g/sample (mean = 0.18 g/sample) and was generally higher at stations where *H. diversicolor* was found. All species found were typical for the intertidal area of the middle region of the Humber Estuary, with moderate abundance and diversity of mostly common species. There were no species of particular conservation importance although those present were key prey species for birds.
45. Furthermore, for the purposes of target setting benthic community attributes to be used in assessing the delivery of compensatory function within the Compensation Site, a further dedicated intertidal benthic 'target setting' survey was undertaken in Autumn 2015. Details of the methods, and the protocols to develop targets are provided within the CEMMP.

Table 3: Biomass data (g.m^{-2}) from North Killingholme intertidal monitoring (2010)

Biomass values per m2				1			2			3			4			5			6		
MCS Code		Taxon	Taxon Qualifier	Upper	Mid	Lower	Upper	Mid	Lower	Upper	Mid	Lower	Upper	Mid	Lower	Upper	Mid	Lower	Upper	Mid	Lower
F	2	TURBELLARIA														0.0700					
HD	1	NEMATODA		0.0100	0.0700	0.0100		0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100	0.0100			0.0100	0.0100
P	117/118	*Eteone flava/longa*																			
P	462	*Hediste diversicolor*		28.0000						136.0000						26.4000					
P	499	*Nephtys hombergii*																			
P	672	*Scoloplos armiger*							0.0100												
P	776	*Pygospio elegans*							0.0100		0.0100					0.0100				0.0100	
P	799	*Streblospio shrubsolii*		0.2900	0.1500		0.0100	0.0400		0.1400	0.0100	0.2100	0.0200	0.0500	0.0100	0.1400	0.0100	0.0100	0.1400	0.0200	0.4100
P		*Tharyx*	Sp. A														0.0100			0.0200	
P	846	*Tharyx killariensis*																			0.0100
P	907	*Capitella capitata*	Sp. Complex		0.0100																
P	931	*Arenicola*	Juvenile												0.0100			0.0100			
P	1294	*Manayunkia aestuarina*		0.0100	0.0100					0.0600						0.0100					
P	1420	*Paranais litoralis*						0.0500	0.0100	0.0100			0.0100			0.0200					
P	1479	*Heterochaeta costata*					0.0100									0.0900					
P	1490	*Tubificoides benedii*		2.7700	12.4400	0.0100	0.0500	0.2700	0.0100	0.9000	0.2000	0.0100	4.3600	0.5200	0.0100	2.1900	0.0500	0.0100	3.3900	0.3200	0.0100
P	1500	*Tubificoides swirencoides*									0.0100	0.3200		0.0100	0.0100						
P	1501	Enchytraeidae																			
S	605	*Corophium*	Juvenile								0.0100										
S	616	*Corophium volutator*					1.7800			0.1200	8.6000		8.4100	3.0000			9.0000		0.0100	1.3700	
S	1253	*Diastylis rathkei*																			
W	385	*Hydrobia ulvae*		0.3100	1.5800		0.1000														
W	1695	*Mytilus edulis*																		0.0100	
W	1906	*Mysella bidentata*																			6.0700
W	2007	TELLINACEA	Juvenile	0.1100	0.0100		0.0100		0.0100									0.0100	0.0100		
W	2029	*Macoma balthica*		9.2500	11.5300	2.7100		9.5700	8.4200		38.7300	2.5100	3.5800	0.8000						0.5100	0.0100
W	2064	*Abra tenuis*		0.0600	0.1000	0.0100															
Total Biomass				40.8100	25.9000	2.7400	1.9600	9.9400	8.4800	137.2400	47.5800	3.0600	16.3900	4.3900	0.0500	28.9400	9.0800	0.0400	3.5500	2.2700	6.5200
Quantitative Species Diversity				9	9	4	6	5	7	7	8	5	6	6	5	9	5	4	4	8	6
Qualitative Species Diversity				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Species Diversity				9	9	4	6	5	7	7	8	5	6	6	5	9	5	4	4	8	6

Table 3 (continued): Biomass data (g.m^{-2}) from North Killingholme intertidal monitoring (2010)

Biomass values per m2				7			8			9			10			11			12		
MCS Code		Taxon	Taxon Qualifier	Upper	Mid	Lower	Upper	Mid	Lower	Upper	Mid	Lower	Upper	Mid	Lower	Upper	Mid	Lower	Upper	Mid	Lower
F	2	TURBELLARIA																			
HD	1	NEMATODA		0.0100	0.0100		0.0100	0.0100	0.0100	0.0100	0.0100	0.0100		0.0100	0.0100	0.0100		0.0100	0.0100	0.0100	0.0100
P	117/118	*Eteone flava/longa*			0.2300																
P	462	*Hediste diversicolor*					34.0000			3.4100					6.7900	15.0000			42.7000		
P	499	*Nephtys hombergii*																0.0100			
P	672	*Scoloplos armiger*																			
P	776	*Pygospio elegans*									0.0100										0.0100
P	799	*Streblospio shrubsolii*		0.1400	0.2700	0.3000		0.0100	0.7300		0.0500	0.0100	0.0100	0.0100	0.2100	0.3200	0.2100	0.1400	0.0100	0.0100	0.7500
P		*Tharyx*	Sp. A		0.1300			0.0100													
P	846	*Tharyx killariensis*																			
P	907	*Capitella capitata*	Sp. Complex																		
P	931	*Arenicola*	Juvenile																		
P	1294	*Manayunkia aestuarina*		0.0100												0.0100			0.0100		
P	1420	*Paranais litoralis*		0.0100																	
P	1479	*Heterochaeta costata*					0.0100									0.0100					
P	1490	*Tubificoides benedii*		2.8400	0.7500	0.0100	0.5100	3.9700	0.1100	0.0100	0.2300			0.1500	0.1800	0.3100	0.1800			1.1000	0.2100
P	1500	*Tubificoides swirencoides*									0.0100										
P	1501	Enchytraeidae														0.0100			0.0100		
S	605	*Corophium*	Juvenile																		
S	616	*Corophium volutator*		5.2600	0.1000		2.8900	2.9300		18.6300	0.4600	0.2300		0.7500	1.6100	0.5700	15.0000		4.0300	3.2900	11.2000
S	1253	*Diastylis rathkei*																0.1400			
W	385	*Hydrobia ulvae*																			
W	1695	*Mytilus edulis*																			
W	1906	*Mysella bidentata*																			
W	2007	TELLINACEA	Juvenile												0.0100					0.0100	
W	2029	*Macoma balthica*		10.9300	16.1300		0.6200	3.2800	0.0100	0.3800	0.2900	0.0100	1.4400	1.4800		0.6500	50.7400	6.9200		22.4200	
W	2064	*Abra tenuis*																			
Total Biomass				19.2000	17.6200	0.3100	38.0400	10.2100	0.8600	22.4400	1.0600	0.2600	1.4500	2.4000	8.8100	16.8900	66.1300	7.2200	46.7700	26.8400	12.1800
Quantitative Species Diversity				7	7	2	6	6	4	5	7	4	2	5	6	9	4	5	6	6	5
Qualitative Species Diversity				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Species Diversity				7	7	2	6	6	4	5	7	4	2	5	6	9	4	5	6	6	5

Table 4: Abundance data (individuals.m^{-2}) from North Killingholme intertidal monitoring (2010)

Abundance values per m2				1			2			3			4			5			6		
MCS Code		Taxon	Taxon Qualifier	Upp	Mid	Low	Upp	Mid	Low	Upp	Mid	Low	Upp	Mid	Low	Upp	Mid	Low	Upp	Mid	Low
F	2	TURBELLARIA														1					
HD	1	NEMATODA		500	3500	100	0	1000	500	600	800	100	300	300	100	200	700			1100	300
P	117/118	*Eteone flava/longa*																			
P	462	*Hediste diversicolor*		1200						2600						500					
P	499	*Nephtys hombergii*																			
P	672	*Scoloplos armiger*							100												
P	776	*Pygospio elegans*							100		300					100				100	
P	799	*Streblospio shrubsolii*		600	900		100	400		600	400	600	200	400	200	300	200	200	400	600	1500
P		*Tharyx*	Sp. A														400			200	
P	846	*Tharyx killariensis*																			100
P	907	*Capitella capitata*	Sp. Complex		100																
P	931	*Arenicola*	Juvenile												100			100			
P	1294	*Manayunkia aestuarina*		100	100					3200						200					
P	1420	*Paranais litoralis*						600	100	500			900			600					
P	1479	*Heterochaeta costata*					200									100					
P	1490	*Tubificoides benedii*		3800	13600	100	200	1200	100	4300	400	200	5500	500	100	3800	400	100	5000	1000	100
P	1500	*Tubificoides swirencoides*									100	1500		100	100						
P	1501	Enchytraeidae																			
S	605	*Corophium*	Juvenile								100										
S	616	*Corophium volutator*					300			200	3400		1200	1000			3200		100	1000	
S	1253	*Diastylis rathkei*																			
W	385	*Hydrobia ulvae*		400	600		100														
W	1695	*Mytilus edulis*																		100	
W	1906	*Mysella bidentata*																			100
W	2007	TELLINACEA	Juvenile	1300	100		100		100									100	200		
W	2029	*Macoma balthica*		200	500	200		400	400		900	200	100	200						400	100
W	2064	*Abra tenuis*		300	300	100															
			Total Abundance	8400	19700	500	1000	3600	1400	12000	6400	2600	8200	2500	600	5801	4900	500	5700	4500	2200
			Quantitative Species Diversity	9	9	4	6	5	7	7	8	5	6	6	5	9	5	4	4	8	6
			Qualitative Species Diversity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Total Species Diversity	9	9	4	6	5	7	7	8	5	6	6	5	9	5	4	4	8	6

Table 4 (continued): Abundance data (individuals.m^{-2}) from North Killingholme intertidal monitoring (2010)

Abundance values per m2				7			8			9			10			11			12		
MCS Code		Taxon	Taxon Qualifier	Upp	Mid	Low	Upp	Mid	Low	Upp	Mid	Low	Upp	Mid	Low	Upp	Mid	Low	Upp	Mid	Low
F	2	TURBELLARIA																			
HD	1	NEMATODA		200	200		200	500	100	600	300	100		400	400	2000		100	300	500	300
P	117/118	*Eteone flava/longa*			100																
P	462	*Hediste diversicolor*					2400			400					300	1300			3000		
P	499	*Nephtys hombergii*																100			
P	672	*Scoloplos armiger*																			
P	776	*Pygospio elegans*									100										200
P	799	*Streblospio shrubsolii*		1200	600	900		100	1500		500	400	600	200	600	900	600	500	100	100	2700
P		*Tharyx*	Sp. A		200			200													
P	846	*Tharyx killariensis*																			
P	907	*Capitella capitata*	Sp. Complex																		
P	931	*Arenicola*	Juvenile																		
P	1294	*Manayunkia aestuarina*		100												500			100		
P	1420	*Paranais litoralis*		500																	
P	1479	*Heterochaeta costata*					100									300					
P	1490	*Tubificoides benedii*		3000	1600	100	600	5600	100	100	300			400	300	500	200			1900	300
P	1500	*Tubificoides swirencoides*									100										
P	1501	Enchytraeidae														200			100		
S	605	*Corophium*	Juvenile																		
S	616	*Corophium volutator*		1000	100		1300	1200		5200	400	200		200	1500	300	7000		1300	2700	7100
S	1253	*Diastylis rathkei*																100			
W	385	*Hydrobia ulvae*																			
W	1695	*Mytilus edulis*																			
W	1906	*Mysella bidentata*																			
W	2007	TELLINACEA	Juvenile												100					100	
W	2029	*Macoma balthica*		300	300		100	300	100	200	200	100	300	100		100	600	300		800	
W	2064	*Abra tenuis*																			
			Total Abundance	6300	3100	1000	4700	7900	1800	6500	1900	800	900	1300	3200	6100	8400	1100	4900	6100	10600
			Quantitative Species Diversity	7	7	2	6	6	4	5	7	4	2	5	6	9	4	5	6	6	5
			Qualitative Species Diversity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Total Species Diversity	7	7	2	6	6	4	5	7	4	2	5	6	9	4	5	6	6	5

46. Figure 7 (below) indicates the intertidal (and subtidal) biotopes and their likely spatial extent based on the sediment, benthic community and bathymetric data for the area derived from the 2010 survey. Further details are provided in document EX11.14 (Biotopes of the Intertidal and Subtidal Sediments around the AMEP site, in the Humber Estuary).

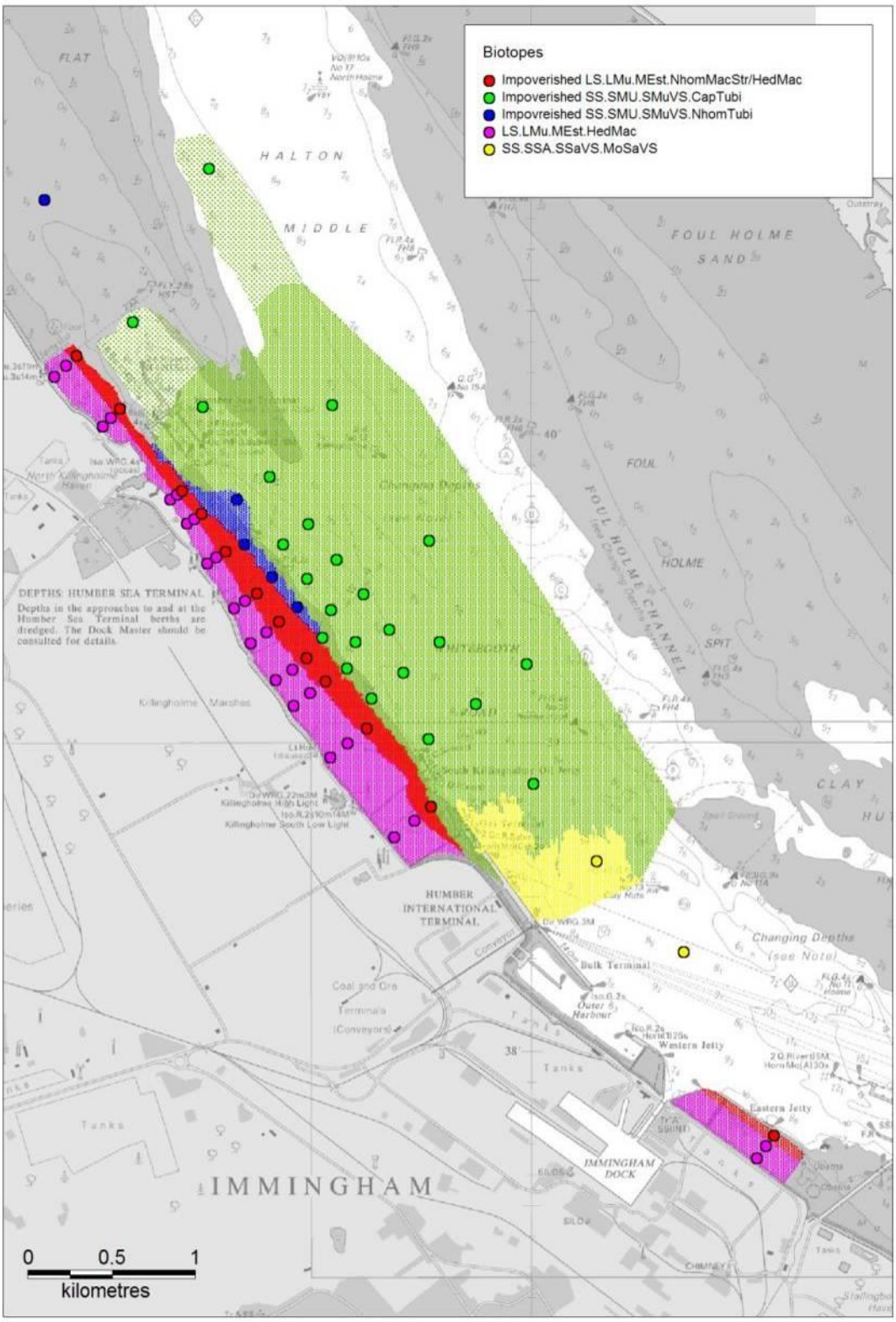


Figure 7: Biotope Location (2010 Survey) and Possible Extent based on Bathymetry

2.3.2 IMPACTS

47. The following potential impacts have been identified:

NE (sHRA)

- Medium to longer term changes to habitat arising from the quay presence (transformation of intertidal mudflat to saltmarsh).
- Permanent loss of intertidal habitat (31.5ha). Addressed within the CEMMP.
- All requirements in relation to SPA birds are addressed within the CEMMP and TEMMP.

MMO

- Capital and maintenance dredging leading to smothering of intertidal benthos.

EA

- Capital and maintenance dredging leading to a reduction of Ecological Potential under WFD.

2.3.3 PRE-CONSTRUCTION REFERENCE AND BACI-TYPE ASSESSMENT (2013 ONWARDS)

48. Pre-construction reference benthic surveys of the intertidal area (see Section 3.3) have been designed to incorporate aspects of the characterisation survey in order to allow an initial indication of inter-annual variability, as well as additional components to provide a robust Before-After Control-Impact (BACI-type) methodology against which the impacts of the AMEP can be assessed.
49. In line with the WFD assessment requirement of providing a waterbody approach, the subtidal benthic zone will also be surveyed in order to assess the benthic invertebrate communities in the vicinity of the proposed development and adjacent habitats, which corresponds to the Humber Lower waterbody (see Section 2.4 below).
50. Pre-construction surveys will use a three replicate coring methodology and follow standard methods (e.g. Ware and Kenny 2011; the Marine Monitoring Handbook, Davies et al 2001).
51. Monitoring and assessment will take into account adjacent habitats (e.g. in particular the subtidal zone) in order to provide a waterbody approach that meets

WFD assessment needs. For the AMEP development this will be the Humber Lower waterbody.

52. The status of the pre-construction intertidal benthic surveys at the time of writing of this MEMMP is as follows:

- Spring 2013 – Completed (see PMSL, 2014a);
- Autumn 2013 – Completed (see PMSL, 2014b);
- Autumn 2015 – Completed (unreported); and,
- Spring 2016 – Completed (unreported);

53. Autumn surveys have been undertaken to define bird prey targets (primarily for Black-tailed Godwit) for the Compensation Site. Further details are provided in the CEMMP.

54. Subsequent surveys will be undertaken to allow construction and operation impacts to be assessed. Details and duration are given in Section 3 and Appendix 3.

2.4 Subtidal Estuarine Habitat (Benthos)

2.4.1 BASELINE (2010 CHARACTERISATION)

55. A total of thirty subtidal benthic samples were taken across the area that will be developed as the berthing pocket, approach channel and turning circle during May 2010 using a 0.1m^2 Day grab (details of methods and results are provided in Annex 10.1 to the ES – Benthic and Fish survey report).

56. The sampling positions are shown in Figure 8 and co-ordinates are provided in Table 5.

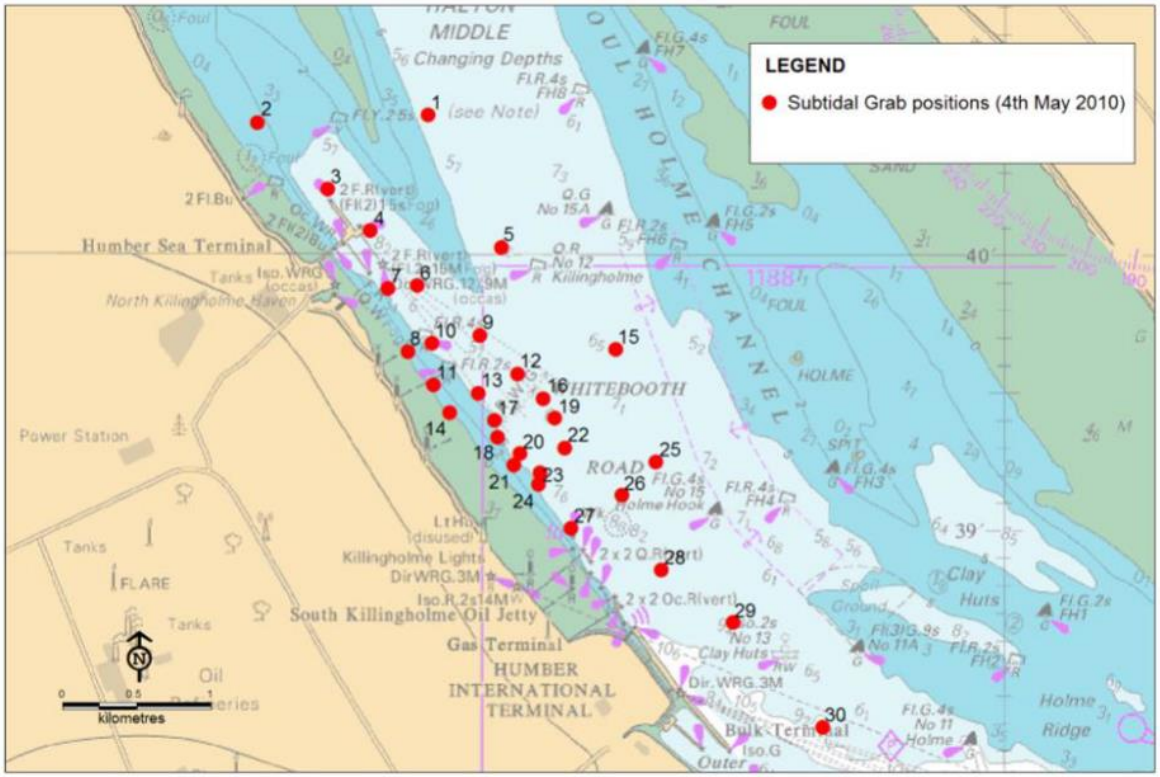


Figure 8: Subtidal Benthic Invertebrate Sampling Stations (2010)

Table 5: Subtidal Benthic Sampling Position Co-ordinates (2010)

Station No.	Date	Time	Sea State	Attempt	Depth (m)	Position (WGS 84)		Description
						Lat	Long	
1	04/05/2010	11:36	Calm	1st	10.4	53.67483	0.22367	Muddy sand
2	04/05/2010	11:44	Calm	1st	7.9	53.67433	0.24100	Mud
3	04/05/2010	11:58	Calm	2nd	14.1	53.67033	0.23383	Mud
4	04/05/2010	12:05	Calm	1st	12.6	53.66783	0.22950	Muddy sand
5	04/05/2010	12:13	Calm	1st	12.6	53.66683	0.21617	Mud & clay
6	04/05/2010	12:18	Calm	1st	11.3	53.66450	0.22467	Muddy sand
7	04/05/2010	12:25	Calm	1st	11.5	53.66433	0.22767	Mud
8	04/05/2010	12:28	Calm	1st	7.7	53.66050	0.22567	Mud
9	04/05/2010	12:43	Calm	1st	12.2	53.66100	0.22317	Clay with surface layer of sand
10*	04/05/2010	12:40	Calm	1st	12.3	53.66150	0.21833	Sandy mud
11*	04/05/2010	13:40	Calm	1st	13.6	53.65917	0.21450	Sandy mud
12*	04/05/2010	12:50	Calm	1st	10.9	53.65800	0.21850	Medium sand
13	04/05/2010	13:07	Calm	1st	8.5	53.65850	0.22300	Muddy sand
14	04/05/2010	13:22	Calm	1st	7	53.65683	0.22133	Mud
15	04/05/2010	13:44	Calm	1st	11	53.65633	0.21683	Medium sand
16	04/05/2010	13:37	Calm	1st	12.8	53.65767	0.21183	Sand with compacted clay
17*	04/05/2010	13:28	Calm	1st	11.6	53.66067	0.20450	Muddy sand
18*	04/05/2010	14:20	Calm	3rd	10.6	53.65650	0.21067	Medium sand
19*	04/05/2010	13:56	Calm	1st	10.5	53.65433	0.21417	Muddy sand
20	04/05/2010	14:09	Calm	1st	10	53.65533	0.21650	Medium sand
21	04/05/2010	14:29	Calm	3rd	9.4	53.65367	0.21483	Muddy sand
22	04/05/2010	15:02	Calm	1st	10.2	53.65250	0.21233	Sand with compacted clay
23	04/05/2010	14:58	Calm	1st	10.9	53.65317	0.21217	Muddy sand with coal fragments
24	04/05/2010	14:53	Calm	3rd	11.3	53.65467	0.20967	Muddy sand with coal fragments
25	04/05/2010	15:14	Calm	2nd	11.2	53.65383	0.20033	Sandy mud
26	04/05/2010	15:18	Calm	1st	12.5	53.65183	0.20383	Sand with coal fragments
27	04/05/2010	15:29	Calm	1st	12.9	53.64983	0.20900	Sand with coal fragments
28	04/05/2010	15:36	Calm	2nd	12.1	53.64733	0.19983	Clay with a surface layer of sand
29	04/05/2010	15:44	Calm	1st	12.9	53.64417	0.19250	Clay with a surface layer of sand
30	04/05/2010	16:03	Calm	4th	11.6	53.63783	0.18333	Sand with shell & coal fragments

* Sample collected from contaminant analysis

57. Details of the findings are given in Annex 10.1 to the ES. However Tables 6 to 8 provide abundance and biomass data for quick reference.

58. In summary, the survey results indicate a species richness that ranged from 0-17 (including colonial taxa) (mean = 4) with values of five or less being recorded from all but two stations. The most widespread species (occurring in the greatest number of samples) was the polychaete *Capitella capitata*. Although the barnacles *Balanus improvisus* and *Elminius modestus* were the most abundant species recorded from a sample, these were only present at one station, presumably from occasional hard substratum e.g. boulders, and as such this abundance dominance is not characteristic of the survey area in general.

Table 6: Abundance data from North Killingholme subtidal monitoring (2010) (per m²)

MCS Code		TAXON	TAXON Qualifier	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
D	158	Tubulariidae																								P							
D	433	*Sertularia*		P	P																					P	P		P				
D	510	*Hartlaubella gelatinosa*		P																		P		P			P						
D	662	ACTINIARIA																						30									10
F	1	PLATYHELMINTHES																	10										20			60	20
HD	1	NEMATODA			60						30		10	50			10					30			40			20					
K	45	*Pedicellina*																										P					
P	117/118	*Eteone flava/longa*	aggregate	10																													
P	499	*Nephtys hombergii*								10	10																						
P	672	*Scoloplos armiger*																			50												
P	753	*Polydora cornuta*																						130									
P	799	*Streblospio shrubsolii*			30					30	110			220			50				10												
P	845	*Tharyx*	species A								10																						
P	907	*Capitella capitata*	species complex	20		30	10					10			20	10		10		20	60		20	70		20	90	140	80	40			
P	919	*Mediomastus fragilis*			10																												
P	931	*Arenicola marina*		90		40	420			20														30				70	10	10			
P	1083	*Protodriloides chaetifer*																															10
P	1490	*Tubificoides benedii*					10			10	10			90																			
P	1498	*Tubificoides pseudogaster*																						10									
P	1500	*Tubificoides swirencoides*												30			10																
Q	53	ACARI																								10							
R	14	CIRRIPEDIA	indeterminate																														10
R	68	*Elminius modestus*																						140									
R	78	*Balanus improvisus*																						1240									
R	142	COPEPODA	indeterminate												10								10	10	30		20	100	10	10	20		
S	76	*Neomysis integer*																														10	
S	86	*Schistomysis kervillei*							10																								
S	471	*Gammarus*	juvenile																					10									
S	481	*Gammarus salinus*																											20				
S	616	*Corophium volutator*															10																
S	1197	*Bodotria scorpioides*																						10	10								
S	1253	*Diastylis rathkei typica*																						10									
W	1696	*Mytilus edulis*	juvenile							20														110				10					
W	2007	TELLINACEA	juvenile												10																		
W	2029	*Macoma balthica*				10	10				10						10																
Y	112	*Walkeria uva*																									P						
Y	137	*Bowerbankia*																								P		P	P				
Y	176	*Electra crustulenta*																						P					P				
Y	177	*Electra monostachys*		P									P	P	P			P						P		P	P	P					
Y	187	*Flustra foliacea*																						P						P			
Y	222	*Amphiblestrum auritum*		P																													
Y	255	*Bicellariella ciliata*								p			p																P				
		Quantitative		**3**	**3**	**3**	**4**	**0**	**1**	**5**	**6**	**1**	**1**	**4**	**3**	**1**	**5**	**1**	**1**	**1**	**4**	**0**	**2**	**13**	**2**	**2**	**3**	**4**	**5**	**3**	**1**	**2**	**4**
		Colonial		**4**	**1**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**2**	**1**	**1**	**0**	**0**	**1**	**0**	**0**	**0**	**1**	**0**	**4**	**0**	**4**	**4**	**3**	**4**	**1**	**0**	**0**	**0**
		Total Taxa		**7**	**4**	**3**	**4**	**0**	**1**	**6**	**6**	**1**	**3**	**5**	**4**	**1**	**5**	**2**	**1**	**1**	**4**	**1**	**2**	**17**	**2**	**6**	**7**	**7**	**9**	**4**	**1**	**2**	**4**
		Total Abundance		**120**	**100**	**80**	**450**	**0**	**10**	**90**	**180**	**10**	**10**	**390**	**40**	**10**	**90**	**10**	**10**	**20**	**150**	**0**	**30**	**1840**	**40**	**30**	**130**	**320**	**140**	**60**	**20**	**70**	**50**

Table 7: Biomass data from North Killingholme subtidal monitoring (2010) (per m^2)

MCS Code		TAXON	TAXON Qualifier	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
D	158	Tubulariidae																															
D	433	*Sertularia*																															
D	510	*Hartlaubella gelatinosa*																															
D	662	ACTINIARIA																						37.5000									0.0010
F	1	PLATYHELMINTHES																	0.0010										0.0010			0.0010	0.0010
HD	1	NEMATODA			0.0010						0.0010		0.0010	0.0010			0.0010				0.0010			0.0010			0.0010						
K	45	*Pedicellina*																															
P	117/118	*Eteone flava/longa*	aggregate	0.0080																													
P	499	*Nephtys hombergii*								0.1540	0.0300																						
P	672	*Scoloplos armiger*																			0.3010												
P	753	*Polydora cornuta*																						0.0260									
P	799	*Streblospio shrubsolii*			0.0010					0.0120	0.0280			0.0720			0.0100				0.0010												
P	845	*Tharyx*	species A								0.0010																						
P	907	*Capitella capitata*	species complex	0.0050		0.0010	0.0010					0.0010			0.0300	0.0010		0.0010		0.0230	0.0130		0.0180	0.0800		0.0100	0.0650	0.2730	0.0100	0.0310			
P	919	*Mediomastus fragilis*			0.0010																												
P	931	*Arenicola marina*		0.0410		0.0240	0.1180			0.0010														0.0010				11.0000	0.0010	0.0010			
P	1083	*Protodriloides chaetifer*																															0.0010
P	1490	*Tubificoides benedii*					0.0010			0.0010	0.0010			0.0680																			
P	1498	*Tubificoides pseudogaster*																						0.0010									
P	1500	*Tubificoides swirencoides*												0.0010			0.0010																
Q	53	ACARI																								0.0010							
R	14	CIRRIPEDIA	indeterminate																														0.0010
R	68	*Elminius modestus*																						13.6780									
R	78	*Balanus improvisus*																						101.3450									
R	142	COPEPODA	indeterminate												0.0010								0.0010	0.0010	0.0010		0.0010	0.0010	0.0010	0.0010	0.0010		
S	76	*Neomysis integer*																														0.0850	
S	86	*Schistomysis kervillei*							0.1800																								
S	471	*Gammarus*	juvenile																					0.0010									
S	481	*Gammarus salinus*																											0.6660				
S	616	*Corophium volutator*															0.0080																
S	1197	*Bodotria scorpioides*																						0.0010	0.0010								
S	1253	*Diastylis rathkei typica*																						0.0320									
W	1696	*Mytilus edulis*	juvenile							0.0010														0.1870				0.0010					
W	2007	TELLINACEA	juvenile												0.0010																		
W	2029	*Macoma balthica*				0.0430	0.0610				0.4350						0.0010																
Y	112	*Walkeria uva*																															
Y	137	*Bowerbankia*																															
Y	176	*Electra crustulenta*																															
Y	177	*Electra monostachys*																															
Y	187	*Flustra foliacea*																															
Y	222	*Amphiblestrum auritum*																															
Y	255	*Bicellariella ciliata*																															
			Quantitative	**3**	**3**	**3**	**4**	**0**	**1**	**5**	**6**	**1**	**1**	**4**	**3**	**1**	**5**	**1**	**1**	**1**	**4**	**0**	**2**	**13**	**2**	**2**	**3**	**4**	**5**	**3**	**1**	**2**	**4**
			Colonial	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
			Total Taxa	**3**	**3**	**3**	**4**	**0**	**1**	**5**	**6**	**1**	**1**	**4**	**3**	**1**	**5**	**1**	**1**	**1**	**4**	**0**	**2**	**13**	**2**	**2**	**3**	**4**	**5**	**3**	**1**	**2**	**4**
			Total Biomass	**0.054**	**0.003**	**0.068**	**0.181**	**0.000**	**0.180**	**0.169**	**0.496**	**0.001**	**0.001**	**0.142**	**0.032**	**0.001**	**0.021**	**0.001**	**0.001**	**0.023**	**0.316**	**0.000**	**0.019**	**152.854**	**0.002**	**0.011**	**0.067**	**11.275**	**0.679**	**0.033**	**0.001**	**0.086**	**0.004**

Table 8: % Dominance, abundance and biomass (subtidal survey, 2010)

MCS Code		TAXON	TAXON Qualifier	Total Abundance	%
R	78	*Balanus improvisus*		124	28
P	931	*Arenicola marina*		69	15
P	907	*Capitella capitata*	species complex	65	14
P	799	*Streblospio shrubsolii*		45	10
HD	1	NEMATODA		25	6
R	142	COPEPODA	indeterminate	22	5
R	68	*Elminius modestus*		14	3
W	1696	*Mytilus edulis*	juvenile	14	3
P	753	*Polydora cornuta*		13	3
P	1490	*Tubificoides benedii*		12	3
F	1	PLATYHELMINTHES		11	2
P	672	*Scoloplos armiger*		5	1
D	662	ACTINIARIA		4	1
P	1500	*Tubificoides swirencoides*		4	1
W	2029	*Macoma balthica*		4	1
P	499	*Nephtys hombergii*		2	0
S	481	*Gammarus salinus*		2	0
S	1197	*Bodotria scorpioides*		2	0
P	117/118	*Eteone flava/longa*	aggregate	1	0
P	845	*Tharyx*	species A	1	0
P	919	*Mediomastus fragilis*		1	0
P	1083	*Protodriloides chaetifer*		1	0
P	1498	*Tubificoides pseudogaster*		1	0
Q	53	ACARI		1	0
R	14	CIRRIPEDIA	indeterminate	1	0
S	76	*Neomysis integer*		1	0
S	86	*Schistomysis kervillei*		1	0
S	471	*Gammarus*	juvenile	1	0
S	616	*Corophium volutator*		1	0
S	1253	*Diastylis rathkei typica*		1	0
W	2007	TELLINACEA	juvenile	1	0
D	158	Tubulariidae		0	0
D	433	*Sertularia*		0	0
D	510	*Hartlaubella gelatinosa*		0	0
K	45	*Pedicellina*		0	0
Y	112	*Walkeria uva*		0	0
Y	137	*Bowerbankia*		0	0
Y	176	*Electra crustulenta*		0	0
Y	177	*Electra monostachys*		0	0
Y	187	*Flustra foliacea*		0	0
Y	222	*Amphiblestrum auritum*		0	0
Y	255	*Bicellariella ciliata*		0	0
			Total Abundance	**450**	**100**
			Total Quantitative Species	**31**	

% dominance, total abundance from the subtidal surveys (quantitative species only)

MCS Code		TAXON	TAXON Qualifier	Total Biomass	%
R	78	*Balanus improvisus*		10.135	60.79
D	662	ACTINIARIA		3.750	22.49
R	68	*Elminius modestus*		1.368	8.20
P	931	*Arenicola marina*		1.119	6.71
S	481	*Gammarus salinus*		0.067	0.40
P	907	*Capitella capitata*	species complex	0.056	0.34
W	2029	*Macoma balthica*		0.054	0.32
P	672	*Scoloplos armiger*		0.030	0.18
W	1696	*Mytilus edulis*	juvenile	0.019	0.11
P	499	*Nephtys hombergii*		0.018	0.11
S	86	*Schistomysis kervillei*		0.018	0.11
P	799	*Streblospio shrubsolii*		0.012	0.07
S	76	*Neomysis integer*		0.009	0.05
P	1490	*Tubificoides benedii*		0.007	0.04
S	1253	*Diastylis rathkei typica*		0.003	0.02
P	753	*Polydora cornuta*		0.003	0.02
R	142	COPEPODA	indeterminate	0.001	0.01
HD	1	NEMATODA		0.001	0.00
P	117/118	*Eteone flava/longa*	aggregate	0.001	0.00
S	616	*Corophium volutator*		0.001	0.00
F	1	PLATYHELMINTHES		0.000	0.00
P	1500	*Tubificoides swirencoides*		0.000	0.00
S	1197	*Bodotria scorpioides*		0.000	0.00
P	845	*Tharyx*	species A	0.000	0.00
P	919	*Mediomastus fragilis*		0.000	0.00
P	1083	*Protodriloides chaetifer*		0.000	0.00
P	1498	*Tubificoides pseudogaster*		0.000	0.00
Q	53	ACARI		0.000	0.00
R	14	CIRRIPEDIA	indeterminate	0.000	0.00
S	471	*Gammarus*	juvenile	0.000	0.00
W	2007	TELLINACEA	juvenile	0.000	0.00
D	158	Tubulariidae		0.000	0.00
D	433	*Sertularia*		0.000	0.00
D	510	*Hartlaubella gelatinosa*		0.000	0.00
K	45	*Pedicellina*		0.000	0.00
Y	112	*Walkeria uva*		0.000	0.00
Y	137	*Bowerbankia*		0.000	0.00
Y	176	*Electra crustulenta*		0.000	0.00
Y	177	*Electra monostachys*		0.000	0.00
Y	187	*Flustra foliacea*		0.000	0.00
Y	222	*Amphiblestrum auritum*		0.000	0.00
Y	255	*Bicellariella ciliata*		0.000	0.00
			Total Biomass	**16.672**	**100**
			Total Quantitative Species	**31**	

% dominance, total biomass from the subtidal surveys (quantitative species only)

59. Overall abundance ranged from 0-184 individuals/sample (mean = 15) with abundance in most samples being less than 20 individuals. Excluding barnacle records, peak abundance reduced to a maximum of 46 individuals (Station 21). Biomass ranged from <0.001 to 15.5 g/sample (mean = 0.56) with the barnacle component of Station 21 contributing 11.5g of the 15.5g total and with values at most stations being <0.05g.
60. The subtidal biotope extent and distribution around the development area (from the 2010 survey) is given in Figure 7.

2.4.2 IMPACTS

61. The following potential impacts have been identified:

NE (sHRA)

- The effects of capital and maintenance dredging and disposal on subtidal habitat and benthic communities.
- Loss of 13.5ha of subtidal habitat. Addressed within the Compensation EMMP (CEMMP).

MMO

- Capital and maintenance dredging leading to smothering of subtidal benthos.

EA

- Capital and maintenance dredging leading to a reduction of Ecological Potential under WFD.

2.4.3 PRE-CONSTRUCTION REFERENCE AND BACI-TYPE ASSESSMENT (2013 ONWARDS)

62. Pre-construction reference benthic surveys of the subtidal area have been designed to incorporate aspects of the characterisation survey in order to allow an initial indication of inter-annual variability, as well as additional components to provide a robust Before-After Control-Impact (BACI-type) methodology against which the impacts of the AMEP can be assessed..
63. These surveys will use a three replicate Day grab methodology and follow standard methods e.g. Ware and Kenny 2011; the Marine Monitoring Handbook, Davies et al 2001). Operational instructions for sampling and sample processing for macrobenthic invertebrates in TraC waters (EA, 2013) have been followed in order to collect data that can be used for WFD assessment purposes.
64. In line with the WFD assessment requirement of providing a waterbody approach, the intertidal benthic zone will also be surveyed in order to assess the benthic invertebrate communities in the vicinity of the proposed development and adjacent habitats, which corresponds to the Humber Lower waterbody (see Section 2.3 above).

65. The status of the pre-construction subtidal benthic surveys at the time of writing of this MEMMP is as follows:
    - Spring 2013 – Completed (see PMSL, 2014a);
    - Spring 2016 – To be completed.
66. Subsequent surveys will be undertaken to allow construction and operation impacts to be assessed. Details and duration are given in Section 3 and Appendix 3.

2.5 Fish Communities

2.5.1 BASELINE (2010 CHARACTERISATION)

Intertidal

67. Two intertidal fish and shellfish surveys were conducted in the immediate area around the project site in May/June and October/November 2010, each comprising four fixed fyke net positions in the intertidal and eight 2m beam trawls over subtidal habitat (details of methods and results are provided in Annex 10.1 to the ES – 2010 May/June Benthic and Fish Surveys Report : January 2011 and 2010 October/November Benthic and Fish Surveys Report: February 2011).
68. Figure 9 and Table 9 provide details of the fish community sampling locations with further details provided in Annex 10.1 to the ES.

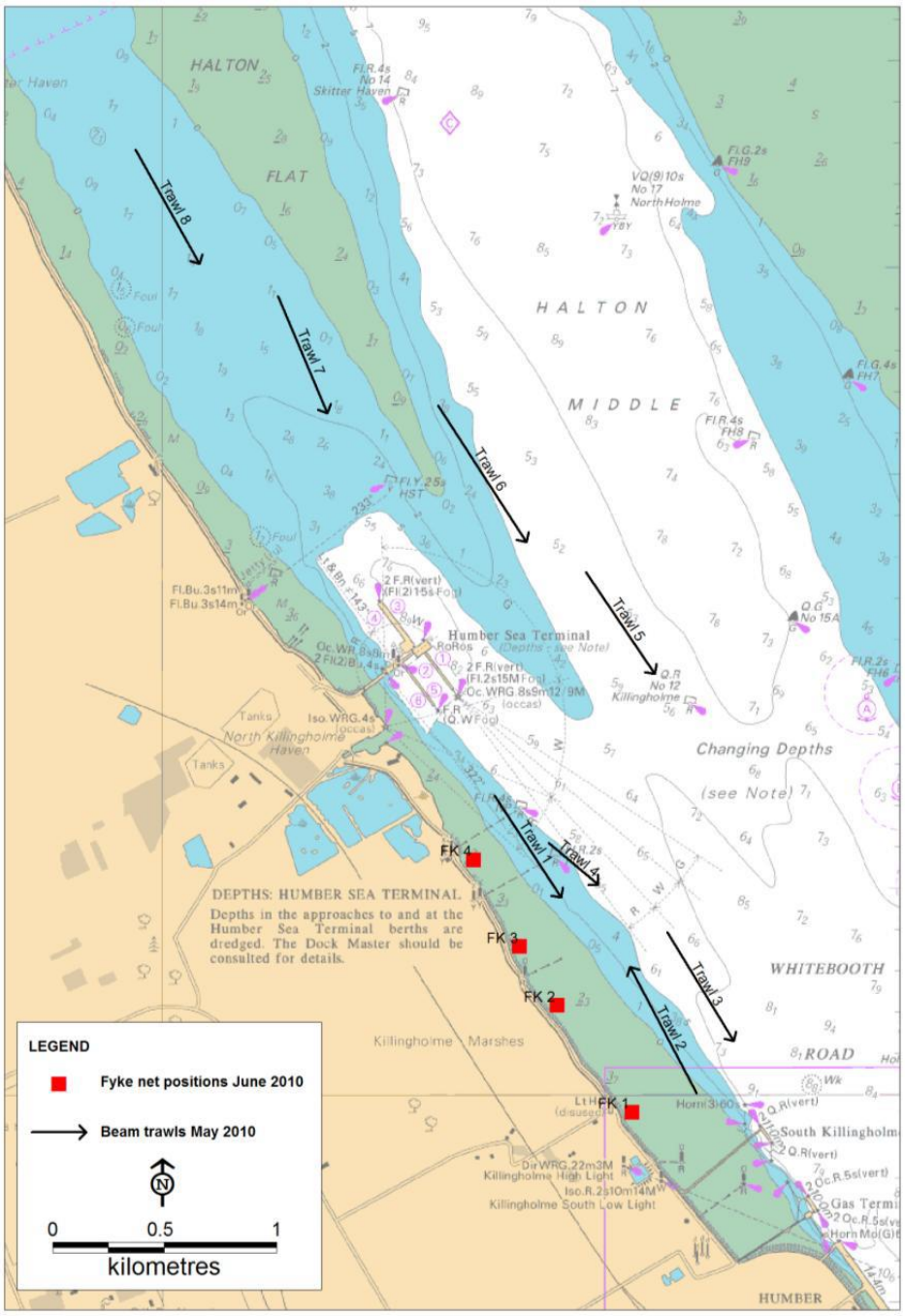


Figure 9: Location of the Intertidal and Subtidal Fish Sampling Positions (2010)

Table 9: Intertidal and Subtidal Sampling Locations (2010)

Site No.	Position (WGS 84)		Deployment		Retrieval		
	Lat (N)	Long (W)	Date	Time	Date	Time	
FK 1	53.64932	0.2182	08/06/2010	17:00	09/06/2010	17:30	Intertidal sampling locations
FK 2	53.65362	0.22324	08/06/2010	17:41	09/06/2010	18:15	
FK 3	53.65599	0.22579	08/06/2010	18:30	09/06/2010	19:00	
FK 4	53.65948	0.22891	08/06/2010	19:16	09/06/2010	19:48	

Weather conditions: Overcast and breezy with showers

Trawl No.	Start Position		End Position		Date	Time in	Time Out	Water depth (m)	Sea state	
	Lat	Long	Lat	Long						
T 1	53.66217	0.22750	53.65800	0.22300	05/05/2010	09:00	09:10	12	Calm	Subtidal sampling locations
T 2	53.65017	0.21383	53.65517	0.21833	05/05/2010	09:17	09:30	11.3	Calm	
T 3	53.65667	0.21583	53.65217	0.21133	05/05/2010	09:42	09:53	10.2	Calm	
T 4	53.66017	0.22383	53.65850	0.22050	05/05/2010	10:01	10:13	12.1	Calm	
T 5	53.67117	0.22133	53.66700	0.21667	05/05/2010	10:26	10:36	12.2	Calm	
T 6	53.67233	0.22533	53.67783	0.23133	05/05/2010	10:45	10:55	10	Calm	
T 7	53.68217	0.24217	53.67750	0.23883	05/05/2010	11:01	11:10	8.9	Calm	
T 8	53.68817	0.25183	53.68350	0.24750	05/05/2010	11:20	11:29	8.3	Calm	

Weather conditions: Dry with sunny spells and light breeze

69. The summer catch was dominated by benthic flatfishes (flounder and sole) most probably year class 1+ flounder (born the year before) and mostly year class 0+ sole (born in present year), which highlights the role of the area (typical mudflat) as a flatfish nursery. Sand goby was recorded but due to the small size of this fish it is normally misrepresented in fyke net catches.
70. Whiting, common sole, five-bearded rockling and flounder dominated the fyke net catches (intertidal) during the autumn survey. Common sole juveniles and whiting were also present.
71. Given the background information available for the Humber Estuary and adjacent coastal area, and the gear selectivity profile of fyke nets, the fish and shellfish assemblage found during the surveys was considered normal. However, the summer abundance was low compared to previous survey programs (e.g. HARBASINS Report Chapter 4[1]).

Subtidal

72. Two subtidal beam trawl surveys were conducted in the subtidal area in the vicinity of the project site in May/June 2010 and October/November 2010.

[1]Harmonised River Basins Strategies North Sea: [redacted]

73. Sole caught in the summer subtidal assessment were substantially larger than those found in the fyke nets, showing a segregation of sole year classes and indicating a distinct habitat dependency between 0+ sole and older juveniles. This segregation was not observed in autumn, although juvenile sole were present.
74. Similar to the intertidal assessment, the subtidal assemblage is consistent with previous results for the area with a real dominance of sand goby in both the summer and autumn surveys. Interestingly flounder (the more abundant species in the intertidal catch) was recorded only once in the summer survey and six times in the autumn survey. This observation suggests the greater importance of the intertidal zone for flounder. Whiting were also common in the autumn survey, although not so in the summer survey. Common sole juveniles and whiting were also present.

2.5.2 IMPACTS

75. The following potential impacts have been identified:

NE (sHRA)

- Lamprey movements concluded to not be impacted so not included specifically in this document.

MMO

- Capital and maintenance dredging leading to smothering of subtidal benthos.

EA

- Capital and maintenance dredging leading to a reduction of Ecological Potential under WFD.

2.5.3 PRE-CONSTRUCTION REFERENCE AND BACI-TYPE ASSESSMENT (2013 ONWARDS)

76. Pre-construction reference fish surveys across the intertidal and subtidal environments have been designed to incorporate aspects of the characterisation survey in order to allow an initial indication of inter-annual variability, as well as additional components to provide a robust Before-After Control-Impact (BACI-type) methodology against which the impacts of the AMEP can be assessed.

77. The survey included the use of seine netting and beam trawling in the intertidal, and otter trawling in the subtidal in order to cover the main aspects of fish ecology in the area, and incorporate features identified within the EA's guidance for WFD monitoring (EA, 2013).
78. The status of the pre-construction intertidal fish surveys at the time of writing of this MEMMP is as follows:
    - Spring 2013 – Completed (see PMSL, 2014a);
    - Autumn 2013 – Completed (see PMSL, 2014b);
    - Autumn 2015 – Completed (unreported); and,
    - Spring 2016 – Completed (unreported); and,
79. The status of the pre-construction subtidal fish surveys at the time of writing of this MEMMP is as follows:
    - Autumn 2013 – Completed (see PMSL, 2014b); and,
    - Autumn 2015 – Completed (unreported);
80. Surveys are undertaken in both the spring and autumn in order to capture seasonal variability in assemblage etc, and the biological data are augmented by a suite of environmental parameters including dissolved oxygen (DO), temperature and salinity.
81. Subsequent surveys will be undertaken to allow construction and operation impacts to be assessed. In addition, sub-surface monitors will be deployed to provide data on temperature, DO and underwater noise. Details and duration are given in Section 3 and Appendix 3.

2.6 Temperature, DO and Suspended Sediments

2.6.1 BASELINE

82. No baseline data were collected, but there is provision for specific impact monitoring (see Section 3). Some relevant baseline information is available relating to a series of water quality parameters.
83. A survey of water quality to inform the EIA process was conducted in May-July 2010 within the Humber Estuary with sampling locations across the intertidal and subtidal zone in the vicinity of the AMEP development (presented as Annex 7.2 to the Environmental Statement – Water and Sediment Quality).
84. Data were collected throughout the day covering the full range of tidal conditions, ebb, flood and slack water.
85. Derived temperature data showed little variability e.g. with surficial temperature sampled in mid July 2010 showing a variation of less than 1 C (17.8–18.7°C). However, the proximity of the E.ON and Centrica discharges to the sampling area may have produced elevated surficial temperature readings as a continuous reading near-bed monitor deployed in the vicinity of the AMEP site in May 2010 indicated a temperature range of c. 11-16°C, the location of the monitor being c. 100m south-south-west (inshore) of the discharge point. As such, it is probable that the AMEP development and adjacent waters may fall within the mixing zone of these outfalls. Temperature will also vary naturally over the year outwith these parameters.
86. The baseline bathymetry and hydrography study (Annex 9.1 to the Environmental Statement – Bathymetry and Hydrography Survey) indicates that typical suspended sediment concentrations near to AMEP measured in September 2010 range from 100 mg/l at slack water on a neap tide to 400-500 mg/l during the neap tide ebb flow. Concentrations during the spring tides reached 1,600 mg/l during peak flood flow and were in excess of 800 mg/l on the ebb flow. Again, these values will vary on an intra-annual basis due to natural processes.

2.6.2 MONITORING

87. Temperature and DO data will be monitored in relation to DCO requirements (Schedule 8 (DML), part 4, para. 39) and particularly concerning percussive piling

activity mitigation for fish (no adverse effect on fish with agreed mitigation measures, as specified in the DML, applied). There is an additional suspended sediments monitoring requirement (DCO Schedule 11, para 36, 38, 39) in relation to potential impacts on local water intakes/outfalls, and these data will also be available to assist in the assessment of the continuing suitability of the area for utilisation by the fish community.

88. It will be necessary for compliance to specific condition criteria provided in the DML to be reported and addressed as necessary.

89. There is a requirement for recording to be provided on a continuous basis during the percussive piling phase, and a second monitoring device will be employed to ensure data availability were equipment failure to occur.

2.6.3 REFERENCE & COMPLIANCE SURVEYS (2013 ONWARDS)

90. AHPL will undertake surveys as required within the DML, and as such, these will include aspects associated specifically with the percussive piling operation, as well as in relation to intake and discharge infrastructure.

3. OBJECTIVES

3.1 Introduction

91. Objectives and targets have been derived with reference to a number of information sources, including the SoCG, the DCO/DML and dialogue with the Regulatory Authorities and tables to action these are presented in the following sections.

3.2 Sediment Parameters

3.2.1 RATIONALE & OBJECTIVES

92. Rationale: Monitoring is necessary to ensure that elevated levels of suspended solids arising from the capital and maintenance dredging activities are identified within the EX8.10 (Morphological assessment of changes south-east of development), as these have the potential to affect subtidal and intertidal conditions and communities (e.g. mudflat elevation).
93. They also have the potential to impact on the operation and maintenance of the adjacent E.ON and Centrica cooling water intake and outfall. Accretion rates along the pipeline relating to elevated suspended solids will also require monitoring.
94. Legal Requirement (1): E.ON and Centrica have cooling water intake and discharge points immediately north of the proposed quay and have expressed concerns regarding the level of suspended sediment caused by the development which may have an impact upon the operation of their cooling water pipelines and systems. The requirement to monitor the accretion of suspended solids is included within Schedule 11 to the DCO, necessitating that a bathymetric monitoring scheme be established for monitoring sedimentation along the lines of and in front of the E.ON and Centrica cooling water intake and outfall facilities.
95. Legal Requirement (2): There are requirements under WFD compliance monitoring (Schedule 11, para 15) as well as the Humber Estuary EMS Conservation Objectives relating to changes to subtidal and intertidal conditions and communities (e.g. mudflat elevation) as well as fish utilisation.
96. Objective(s): During dredging ensure sediment levels remain within limits agreed with Centrica and E.ON. Provide suitable data to ensure predictions within the EIA process regarding Humber Estuary EMS Conservation Objectives and WFD

requirements (e.g. relating to changes to subtidal and intertidal conditions and communities (e.g. mudflat elevation) as well as fish utilisation are correct.

3.2.2 MONITORING

Suspended Solids and Accretion Monitoring (E.ON and Centrica Requirements)

97. Suspended solids monitoring will be undertaken using automatic monitoring equipment installed on the same specialised 1250mm diameter buoy as used for the water quality monitoring.
98. Turbidity (suspended solids) monitoring will be carried out using a YSI 6600 multi sonde which will also be used to monitor temperature & dissolved oxygen (as above).
99. The sensor within the sonde can monitor turbidity within a range from -0 to 1000 NTU with an accuracy of. ± 2% of reading or 0.3 NTU whichever is greater.
100. Suspended solids monitoring will be carried out for a prolonged period prior to the start of dredging and percussive piling works to give sufficient time to ascertain suspended solids levels and from which to agree trigger levels with both E.ON and Centrica. The monitoring will continue up to and including first maintenance dredging or 12 months after completion of the marine piling works.
101. A specific sedimentation monitoring scheme will be drafted for this purpose and will be submitted in writing to the Marine Management Organisation for approval, in consultation with the Environment Agency, Centrica and E.ON UK plc.
102. Depending on the outcomes of the monitoring programme, agreed triggers will determine any requirement for remedial actions to be initiated in relation to the E.ON and Centrica cooling water intake and outfall facilities.

Suspended Solids and Accretion Monitoring (Humber Estuary EMS and WFD requirements)

103. Suspended solids information as described above will be utilised to assess the continuing suitability of conditions for fish utilisation around the AMEP site.
104. Accretion monitoring will also be undertaken to identify change in the intertidal mudflat elevation, with a monitoring scheme to be established for the monitoring of the foreshore and sediment levels around the quay. A default duration for this

monitoring will be 10 years, with any requirement for subsequent continuance to be discussed and agreed by the Steering Group.

105. It should be noted that a monitoring scheme specific to the requirements of E.ON UK plc & Centrica (and subject to the approval of the MMO and EA) will be submitted to the MMO as above. However, in principle it is anticipated that the monitoring for Humber Estuary EMS and WFD requirements will primarily be based around bi-annual LiDAR surveys of the area, as these will provide the best coverage at a suitable accuracy.
106. In terms of Humber Estuary EMS and WFD requirements, the purpose of such surveys will not be to identify remedial actions on the NKM site, as gross changes in mudflat elevation would be difficult to address. Rather the surveys will inform the Steering Group of any elevation change, with the information also being incorporated into analysis of change from other components e.g. benthos.

Elevation Change Monitoring

107. Elevation changes in the intertidal zone are covered under the Intertidal Habitat (Saltmarsh) objectives section.

Bathymetric Change Monitoring

108. EA requirements associated with changes to the bathymetry and associated sediment characteristics are covered in the Subtidal Benthos objectives section.

3.3 Intertidal Habitat (Saltmarsh and mudflat)

3.3.1 RATIONALE & OBJECTIVES

109. Rationale: Monitoring is necessary to identify any changes to saltmarsh community and extent in the wider AMEP area of impact. Impacts may arise from modification to erosion and deposition patterns on the intertidal zone relating to the influence of the quay and from capital and maintenance dredging.
In particular, extension of saltmarsh area into existing mudflat habitat will be of interest/concern as this will impact on other ecological aspects such as carrying capacity for waterbirds.
110. Legal Requirement: WFD compliance and the Humber Estuary EMS Conservation Objectives.

111. Objective(s): To record changes in extent and composition of saltmarsh in association with other adjacent habitat e.g. mudflat.

3.3.2 MONITORING

Survey

112. A suite of field and aerial photography techniques will be used to address saltmarsh status (detailed further in Appendix 3), whilst mudflat status (extent and topography) will be surveyed using LiDAR (Appendix 1), together with quality (benthos) through invertebrate coring (Appendix 3).
113. Saltmarsh extent, community, zonation and diversity will be ascertained following EA WFD guidance e.g. OI 200_07 or any subsequent relevant revisions.
114. In advance of each annual survey the most recent available aerial images will be requested from the EA. Where the data are current then depending on coverage, it may be unnecessary to undertake an additional survey flight.
115. When such images are unavailable, then a survey flight will be undertaken, with aerial colour images captured. These images will be:
    - of resolution of at least 25cm
    - 3 band red green blue (RGB) imagery
    - taken in daylight at low water around a spring tide
    - taken under stable lighting conditions (little or no cloud shadow)
    - taken between June and September each year, with timing to be standardised to a single month per year where possible
    - taken on an annual basis for a minimum of 10 years, the requirements for subsequent surveys to be determined by the Steering Group
116. Detailed ground-truthing will be undertaken on-foot within the saltmarsh using transects and quadrats to determine community zonation and taxa diversity as well as DGPS to ascertain location.
117. Each transect will cover both the seaward and landward extent of the saltmarsh and transition points between zones will be mapped with two quadrat samples taken to characterise the major community changes, recording species, cover, sward height etc following OI 200_07 procedures.

Analysis

118. The saltmarsh will then be assessed for the following metrics in accordance with the WFD Saltmarsh Index Tool:
    - saltmarsh extent as proportion of "historic saltmarsh"
    - saltmarsh extent as proportion of the intertidal
    - change in saltmarsh extent over two or more time periods
    - proportion of saltmarsh zones present (out of five)
    - proportion of saltmarsh area covered by the dominant saltmarsh zone
    - proportion of observed taxa to historical reference value **or** proportion of observed taxa to 15 taxa
119. Analysis of LiDAR output and integration with saltmarsh findings including aerial photographs to characterise mudflat change along the remaining NKM frontage.

3.4 Intertidal Habitat (Benthos)

3.4.1 RATIONALE & OBJECTIVES

120. Rationale: Monitoring is necessary at North Killingholme Marshes (NKM) to identify any changes to the intertidal area and extent in the wider AMEP area of impact, and in particular, the associated benthic community as defined during the characterisation and reference surveys. Direct loss from the AMEP footprint is addressed in the CEMMP, however indirect impacts may arise from modification to erosion and deposition patterns on the intertidal zone relating to the influence of the quay and from capital and maintenance dredging. These impacts may take the form of actual habitat loss through erosion (or accretion to a level that the zone becomes saltmarsh), but may also occur in the form of a substantial shift in community attributes (both physical and biological), above natural variation. Further monitoring will be necessary on Cherry Cobb Sands (CCS), around the location of the breach for the compensation scheme, as variation in flow and other factors have the potential to alter the current benthic community in this area.
121. Legal Requirement: WFD compliance and the Humber Estuary EMS Conservation Objectives.
122. Objective(s): To identify deleterious change to intertidal benthic invertebrate fauna.

123. It should be noted that a comprehensive Black-tailed Godwit prey survey has also been undertaken pre-construction, and the metrics associated with this study used to update the characterisation data and to populate specific monitoring metrics for the CEMMP. This survey focus on foraging potential on NKM pre construction i.e. two surveys, one in 2013 (completed, see PLMS, 2014b) and one in 2015 (Completed, unreported), and timed for the August / September in order to characterise prey availability during the peak period of importance for Black-tailed Godwit foraging in the vicinity of the AMEP development.

3.4.2 MONITORING

General

124. Samples taken to support the intertidal benthic invertebrate monitoring programme will be collected by means of hand coring.
125. Guidelines used in the design and subsequent reporting of benthic monitoring for the AMEP development have included *Guidelines for the Conduct of Benthic Studies at Marine Aggregate Extraction Sites* (Ware and Kenny, 2011), the Marine Monitoring Handbook (Davies *et al*, 2001) and the Environment Agency's Operational Instructions for sampling and sample processing for macrobenthic invertebrates in TraC waters (EA, 2013), the latter to ensure that methods and derived data are suitable for WFD assessment purposes.

Survey Methods (BACI-Type Methods for North Killingholme Marshes and Cherry Cobb Sands)

126. The intertidal areas that remain to the north and to the south of the quay development (i.e. at Killingholme Marshes foreshore adjacent to North Killingholme Haven Pits and the foreshore near to South Killingholme Haven) will comprise the survey area; effectively Sectors A and E (as monitored for the reference assessments); and a non-impacted south bank control area will also be surveyed (e.g. within 2 km of the quay development).
127. A further intertidal benthic survey will be undertaken on the Cherry Cobb Sands in the vicinity of the compensation site breach.
128. The survey details for the NKM site are summarised in Table 10 and the sample locations shown in Appendix 3.

129. Ongoing BACI-type monitoring surveys of the intertidal benthos will be carried out at the same time of year as the reference survey (at NKM). If the same month cannot be accommodated then sampling in the same season will at least be ensured.
130. The intertidal survey at CCS will be undertaken at around the same time as the NKM survey, survey timing designed to be within the acceptable period defined for WFD compliance. Sampling and analysis methods employed for the CCS survey programme will be the same as those for the NKM survey.

Table 10: NKM Intertidal Invertebrate Sample Summary

				Number of replicate benthic		
Survey areas		**area code**	**Transect**	**Upper**	**Mid**	**Lower**
Impact	Under direct footprint of quay development	**DI**	DI.1	3	3	3
			DI.2	3	3	3
			DI.3	3	3	3
	Under the area of indirect impact north of the quay development	**IIN**	IIN.1	3	3	3
			IIN.2	3	3	3
			IIN.3	3	3	3
	Under the area of indirect impact south of the quay development	**IIS**	IIS.1	3	3	3
			IIS.2	3	3	3
			IIS.3	3	3	3
Control	Control area north of NKM	**CN**	CN.1	3	3	3
			CN.2	3	3	3
			CN.3	3	3	3
	Control area south of NKM	**CS**	CS.1	3	3	3
			CS.2	3	3	3
			CS.3	3	3	3

131. As part of the overall quality assurance strategy the continued validity of stations selected as representative of impacted and reference conditions will be ensured through regular evaluations. Therefore, some allowance will be made for the possible modification in locations in response to unanticipated anthropogenic or natural influences.
132. All surveys will be logged in a pre-designed field log or electronic datasheet. Each log-sheet will be clearly laid out, providing prompts for all the information required.
133. For each area, sampling will be undertaken at three stations along transects across the foreshore, effectively covering the upper, mid- and lower-intertidal. Three transects will be surveyed within each impact zone (direct impact, secondary impact and control areas), with a total of nine sampling stations surveyed within each zone.
134. Four replicate samples will be taken at each station, three of which will be subsequently analysed for species composition, abundance, size class and biomass etc with the fourth being used for an assessment of sediment particle size and organic content.
135. Sampling will be carried out using hand-held corers (e.g. 0.01m^2 sampling area) to a depth of c.15cm. Sample locations along transects will be recorded using DGPS to allow for greater station fidelity between years.

136. In addition to core sampling, observational monitoring will be conducted at each sampling station:

- Recording obvious sediment surface conditions (e.g. algae coverage, evidence of drying, casts, etc.);
- Recording the character and composition of surface sediments; and
- Providing a photographic record of the sampling station.

137. All sites will be monitored on an annual basis; with monitoring in the spring to comply with WFD requirements
138. An additional reference intertidal invertebrate survey will be undertaken in the last week of August or first week in September at the NKM site (pre-construction) to quantify the prey characteristics for Black-tailed Godwit using the AMEP area. This survey will incorporate a modified methodology to address this specific foraging issue and the derived data will be used to set invertebrate community targets for the CEMMP. Details of the methods for this survey are provided in Appendix 3.
139. A full (spring) pre-construction reference survey of the Cherry Cobb Sands intertidal area will also be carried out using a similar methodology to augment existing reference characterisation data. Station locations are shown in Appendix 3.
140. Monitoring will continue at the NKM and CCS sites using the same reference methods for a period of at least ten years following completion of the works.
141. Further details of the methodologies to be employed for the North Killingholme Marshes and Cherry Cobb Sands BACI-type intertidal invertebrate surveys are given in Appendix 3, together with a methodology to identify the prey characteristics for Black-tailed Godwit at North Killingholme Marshes.

Analysis

142. In order to provide analytical quality assurance, invertebrate identification, biomass and particle size analysis will be performed by laboratories that are members of the NMBAQC scheme.
143. Laboratory analyses will include species (identified to highest taxonomic detail), abundance, and wet weight tissue blotted (WWTB) biomass.
144. Sediment particle size analysis and organic content will also be measured.

145. In line with WFD requirements, the IQI (infaunal quality index) will be calculated for benthic samples, the three parameters which feed into this are:
    - number of taxa;
    - AZTI* Marine Biotic Index (AMBI); and
    - Simpson's Evenness.
146. Analysis of variance will be applied at univariate and multivariate level (Permanova routine can be used in both cases, using a pseudo-F statistic and permutations, thus avoiding assumptions of the parametric F-statistics) to assess the significance of possible impacts. The analysis will be carried out on univariate descriptors of the community (e.g., abundance, biomass, species richness, diversity) as well as on the multivariate structure of the assemblages. The main aim of the analysis is to test for interactions between periods (before and afters) and treatment (controls and impacts) in order to assess whether temporal changes in the impacted areas are in line with changes at control areas (if not, i.e. an interaction exists, then an impact is assumed). Contrast between levels of the factors (e.g. impact sites and control sites) will be assessed. The interaction of these factors with shore location will be taken into account to highlight possible impacts that might manifest only at certain shore levels.
147. The analysis of the invertebrates will also include for the use of LiDAR data to derive the elevation at which the samples were obtained, since elevation change can influence benthic community structure.
148. Furthermore, in order to provide an approach to address waterbody effects in compliance with the WFD approach (Humber Lower waterbody), findings from the intertidal survey programmes will be assessed in the context of those from the subtidal survey programme described below.
149. The analysis methods described above will be used for both the NKM an CCS BACI-type survey programmes (see Appendix 3 for details). In addition, further analysis will be undertaken as part of the prey characterisation survey in order to inform the setting of benthic targets for the compensation site (see CEMMP for details).

3.5 Subtidal Habitat (Benthos)

3.5.1 RATIONALE & OBJECTIVES

150. Rationale: Monitoring is necessary to identify any changes to the subtidal area and extent in the wider AMEP area of impact, and in particular, the associated benthic community as defined during the characterisation and reference surveys. Direct loss from the AMEP footprint is addressed in the CEMMP, however indirect impacts may arise from modification to erosion and deposition patterns on the subtidal zone relating to the influence of the quay and from capital and maintenance dredging. These impacts may take the form of actual habitat loss through erosion but may also occur in the form of a substantial shift in community attributes (both physical and biological), above natural variation.
151. Legal Requirement: WFD compliance monitoring and Humber Estuary EMS Conservation Objectives.
152. Objective(s): To identify deleterious change to subtidal benthic invertebrate fauna due to dredging and dredge disposal e.g. including WFD compliance. To derive reference for dredging and disposal impacts and to validate boundaries of disposal grounds.

3.5.2 MONITORING

General

153. The subtidal benthic monitoring will be carried out using the same framework as defined for benthic intertidal samples in the relevant Objectives section.
154. Guidelines to be used in the design and subsequent reporting of benthic monitoring are the *Guidelines for the Conduct of Benthic Studies at Marine Aggregate Extraction Sites* (Ware and Kenny, 2011), the Marine Monitoring Handbook (Davies *et al*, 2001) and the Environment Agency's Operational Instructions for sampling and sample processing for macrobenthic invertebrates in TraC waters (EA, 2013), the latter to ensure that methods and derived data are suitable for WFD assessment purposes.
155. As such, samples for the subtidal invertebrate monitoring will be taken using a 0.1m^2 Day grab..

Survey

156. The initial impact of operational dredging on the subtidal benthic invertebrate assemblages within the berthing pocket, approach channel and turning circle will be monitored.
157. A total of 30 stations will be monitored in the vicinity of the development, with stratification of the design based on impact zones (impact and control areas) and on depth levels.
158. Details on the survey design and an example of the location of the sampling stations are shown in Appendix 3.
159. Samples will be collected using a 0.1m^2 Day grab.
160. Three replicate benthic samples will be collected from each station for subsequent invertebrate analysis, with a further replicate for particle size analysis and organic content. Each sample will be analysed for species composition, abundance and biomass together with an assessment of sediment particle size and organic content. Dedicated sediment particle size and organic content will be carried out on the fourth replicate.
161. Monitoring of subtidal benthos will only cover the first round of maintenance dredging. Any longer-term monitoring requirements will be determined by the Steering Group.
162. In addition, and prior to the commencement of any marine disposal activities, in order to be meet WFD compliance, a scheme for the protection and enhancement of benthic invertebrates through the monitoring and management of disposal activities within, and immediately surrounding, the disposal sites of the Lower Humber water body, will be submitted to and agreed in writing with the EA. The scheme will include the following:
    - A timetable for when monitoring shall be undertaken;
    - A detailed monitoring methodology;
    - An evaluation of the contribution the disposal activities make to the overall ecological potential of the Lower Humber water bodies.
163. Details on dredge disposal will be provided within the dredge and disposal strategy (requirement of DCO Sch. 8, Part 4, para 45(1)), and further detail will be included in this MEMMP close to the timing of disposal.

Analysis

164. In order to provide analytical quality assurance, invertebrate identification, biomass and particle size analysis will be performed by laboratories that are members of the NMBAQC scheme.
165. Laboratory analyses will include species (identified to highest taxonomic detail), abundance, and biomass (WWTB). Sediment particle size analysis and organic content will also be measured.
166. Standard univariate statistical analyses, either parametric (e.g., ANOVA, t-test) or non-parametric (e.g., Kruskal-Wallis test, Mann-Whitney test, PERMANOVA) will then be applied to the data of abundance, richness, biomass, eveness, diversity and biomass-to-abundance ratio.
167. In line with WFD requirements, the IQI (infaunal quality index) will be calculated for benthic samples, the three parameters which feed into this are:
    - number of taxa;
    - AZTI* Marine Biotic Index (AMBI); and
    - Simpson's Evenness.
168. Analysis of variance will be applied at univariate and multivariate level (Permanova routine can be used in both cases, using a pseudo-F statistic and permutations, thus avoiding assumptions of the parametric F-statistics) to assess the significance of possible impacts. The analysis will be carried out on univariate descriptors of the community (e.g., abundance, biomass, species richness, diversity) as well as on the multivariate structure of the assemblages. The main aim of the analysis is to test for interactions between periods (before and afters) and treatment (controls and impacts) in order to assess whether temporal changes in the impacted areas are in line with changes at control areas (if not, i.e. an interaction exists, then an impact is assumed). Contrast between levels of the factors (e.g. impact sites and control sites) will be assessed. The interaction of these factors with depth level will be taken into account to highlight possible impacts that might manifest only at certain depth levels.
169. Multivariate analysis will be also carried out using cluster analysis (combined with similarity profile routine, SIMPROF) and ordination techniques (e.g., MDS, PCO) in order to identify different community types and gradients in the assemblage

distribution/variation, as well as applying the SIMPER routine to identify the species which contribute most to the differentiations between groups. Multivariate statistical analysis (e.g., ANOSIM, PERMANOVA) will be applied to detect changes in community structure and composition. Bio-Env routine and linkage trees (BEST) in Primer will be used to explore the relationship between biotic (community) patterns and substrate characteristics.

Bathymetric Survey

170. Additional bathymetric surveys will be taken to assess potential impacts at dredge disposal sites and across the wider estuary. These will be as laid out in the Environment Agency's proposals (reproduced as Appendix 1 to this document) with the surveys to ensure WFD compliance.

3.6 Fish Communities

3.6.1 RATIONALE & OBJECTIVES

171. Rationale: Monitoring is necessary to identify any changes to the fish communities in the vicinity of the AMEP in relation to the characterisation and pre-construction references. Impacts may arise from percussive piling during construction, from capital and maintenance dredging, changes to habitat type and elevation relating to the presence of the quay. These impacts may take the form of a change in community attributes (e.g. species composition and size class abundance), above natural variation.
172. Legal Requirement: WFD compliance monitoring and Humber Estuary EMS Conservation Objectives. Also Section 6 of the Environment Act 1995 (transferring from the Salmon and Freshwater Fisheries Act, 1975) in order to 'maintain, improve and develop' salmon fisheries, trout fisheries, freshwater fisheries and eel fisheries in England and Wales.
173. Objective(s): That there is no significant change to reference community attributes resulting from the AMEP development within a degree of natural variability.

3.6.2 MONITORING

General

174. Fish sampling on the intertidal will be undertaken by seine netting and beam trawling whilst subtidal fish sampling will be by means of otter trawling. In both instances WFD compliant methods will be employed as detailed in the Environment Agency's Operational Instructions for WFD transitional fish surveillance monitoring (EA, 2013) to ensure that methods and derived data are suitable for WFD assessment purposes. Below a general description of the survey monitoring design and methods is provided, whereas further details are provided in Appendix 3.

Intertidal

175. Bi-annual (six-monthly) seine net and beam trawl surveys of the intertidal mudflat will be undertaken. This monitoring will continue for an initial period of ten years.
176. For each survey seine net will be deployed at low slack tide at each of four sites (2 in the impact area, 2 in the control area north of the development site), with each deployment including two hauls. Also a 1.5m beam trawl will be deployed at high slack tide (to allow boat access to the intertidal area), taking into account all the health and safety issues deriving from operating this net from a boat on intertidal areas. Each trawl will be deemed to commence from the point at which the gear reaches the seabed after the warp length is paid out and the winch is locked. Trawling will be conducted with a warp length of three times the depth at constant speed (3 knots) following a straight path (towards or away from the station fix) to a predetermined finish point to allow a towing length of 200m.
177. All sampling will be carried out in daylight in order to mitigate against the influence of diurnal variations in the fish assemblage.
178. Following retrieval of the nets, the catch will be collected and processed on site (identification, enumeration and measurement), with only fishes that are not identifiable in the field (e.g., juveniles) being preserved in 60% Ethanol for identification in the laboratory using appropriate keys.

179. Monitoring will be undertaken during the spring and autumn, but with consideration to key periods of waterbird sensitivity (i.e. avoiding the main winter period and the autumn passage as a minimum).

Subtidal

180. Subtidal fish monitoring will be undertaken annually (autumn) by means of a 8m-wide otter trawl fitted with a 10mm cod end sleeve.
181. Sampling locations will utilise those used in the reference study, but will be extended to also cover nearby WFD sampling locations in the Humber Lower waterbody.
182. Each trawl will be deemed to commence from the point at which the gear reaches the seabed after the warp length is paid out and the winch is locked. Trawling will be conducted with a warp length of three times the depth at constant speed (2 knots) following a straight path (towards or away from the station fix) against the rising tide, with towing duration of 30 minutes.
183. All relevant details (including, for each tow: station and tow number; start & end times and positions; shooting & hauling times and positions; any significant changes in tow direction; depth; length of warp; speed over ground; tidal state; weather and sea conditions; and shipping activity, together with date and gear type) will be recorded. Positions to be recorded using DGPS.
184. After the completion of the sampling run, the trawl will be quickly hauled to the vessel's deck and the sample will be recovered into a container. The net will then be checked for any remaining epifauna and fish, before the cod end is refastened, prior to redeployment at the next station.
185. After completion of the sampling run and hauling up to survey vessel's deck, samples will be cleared of large debris and the total catch shall be photographed. Fish species will be sorted from epifaunal invertebrates, divided into species groups, counted and measured (total length) to the closest millimetre.
186. Any species not identified on board will be coded and preserved in 10% buffered formaldehyde solution in seawater or frozen and identified on return to the laboratory.

187. Analysis of variance will be applied at univariate and multivariate level (Permanova routine can be used in both cases, using a pseudo-F statistic and permutations, thus avoiding assumptions of the parametric F-statistics) to assess the significance of possible impacts. The analysis will be carried out on univariate descriptors of the community (e.g., abundance, biomass, species richness, diversity) as well as on the multivariate structure of the assemblages. The main aim of the analysis is to test for interactions between periods (before and afters) and treatment (controls and impacts) in order to assess whether temporal changes in the impacted areas are in line with changes at control areas (if not, i.e. an interaction exists, then an impact is assumed). Contrast between levels of the factors (e.g. impact sites and control sites) will be assessed.
188. Due to the difference sampling gear (with different selectivity) used in the intertidal and subtidal zones, the data collected in the two zones will be analysed separately and the patterns in the results will be compared.

Underwater Percussive Piling Noise

189. A series of timing and other restrictions for percussive piling are identified within the DML.
190. Data loggers on piling rigs along with visual observation and recording will demonstrate that restrictions on percussive piling laid out with the DML are complied with.
191. The exact details of the controls and procedures will be set out in the active Monitoring Plan (AMS) part 3 – Piling Method Statement and will be in accordance with DCO Sch 8 Condition 39(c)
192. Noise monitoring will be carried out in advance of piling activities to establish the baseline, it will be carried out during piling activities to verify the ES predictions, in accordance with the DCO Sch 8 condition 39(g)
193. Noise monitoring will be undertaken based on a mobile and adaptable method. Based on a radial grid system. The exact detail will be set out in the Active monitoring scheme (AMS) Part 2 – Noise monitoring.
194. The location of the monitoring buoy in relation to the intake and outfall locations and the AMEP development is provided in Figure 10.

Figure 1: Location of floating platform and fixed monitoring stations.

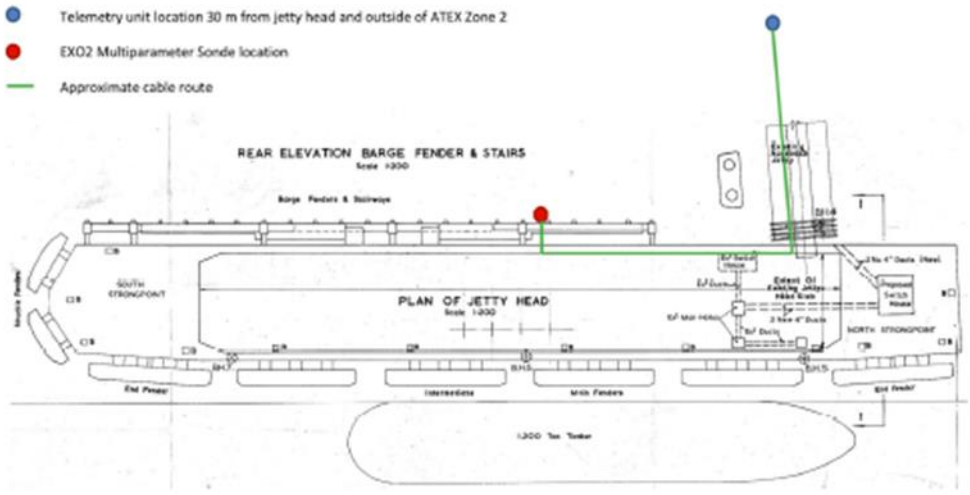


Figure 2: EXO2 Sonde and telemetry unit locations on South Killingholme Jetty.

Figure 10: Proposed Buoy and Jetty Monitoring Location (Taken from AMS Part 21)

195. An additional monitor will be deployed to ensure that were the first monitor to fail, monitoring would continue be achieved. The location of this second monitor will be downstream of the proposed site, as shown on the location plan.
196. Able will carry out noise monitoring prior to commencement of the percussive piling works in accordance with AMS Part 2.
197. Additional monitoring of parameters relating to the conditions of the DML will be undertaken with automatic monitoring equipment installed on the pontoon (see below).

Temperature Monitoring

198. Temperature monitoring will be carried out using a YSI 6600 multi sonde installed onto the buoy.
199. The sensor within the sonde can monitor temperatures within a range from -5°C to +50°C with an accuracy of ±0.15°C.
200. Temperature monitoring will be carried out by default when the suspended solids are monitored.

Dissolved Oxygen Monitoring

201. Dissolved oxygen monitoring will be carried out by installation of an additional sensor onto the YSI 6600 multi sonde which is used to monitor temperature and suspended solids.
202. The sensor within the sonde can monitor dissolved oxygen within a range from -0 to 50mg/L with an accuracy of. ± 0.2mg/L or 2% of reading whichever is greater for 0 to 20mg/L range and ±6% of reading for 20 to 50mg/L range.
203. Able propose to carry out dissolved oxygen monitoring approximately two weeks prior to commencement of the percussive piling and dredging works and throughout the duration of the works.

3.7 Marine Mammals

3.7.1 RATIONALE & OBJECTIVES

204. Although no reference data were collected, potential impacts to marine mammals from percussive piling activity on the AMEP were identified, although with no adverse effect with mitigation measures applied.

205. Legal Requirement: Percussive piling conditions are identified within the DML, with a requirement to undertake 'soft start' piling techniques. Furthermore, there is a requirement for a qualified Marine Mammal Observer to be present.
206. Objectives(s): Ensure compliance with percussive piling restrictions and to restrict or remove potential impacts on sensitive marine mammal receptors.

3.7.2 MONITORING

207. As per the percussive piling conditions detailed within the DML, 'soft start' techniques will be employed.
208. A Marine Mammal Observer will be present (within 100 metres of the pile being driven) during marine percussive piling works.
209. The Marine Mammal Observer will operate standard protocols to ensure that percussive piling work is not undertaken when a marine mammal is in the vicinity of the works.

3.8 Waterbirds

3.8.1 RATIONALE & OBJECTIVES

210. As part of the assessment of percussive piling impacts, it was identified that disturbance to waterbirds could occur from percussive piling which would have an elevated impact during periods of extended cold weather.
211. Legal Requirement: Percussive piling conditions are identified within the DML, with a requirement to ensure that this activity is not carried out during periods of extended cold weather.
212. Objectives(s): Ensure compliance with percussive piling restrictions to restrict or remove potential impacts on sensitive bird receptors.

3.8.2 MONITORING

213. Air temperature will be monitored at three points within the Humber Estuary. Percussive piling will not be permitted during extended periods of cold weather.
214. The details of the location of the monitoring points Are shown on the drawing corresponding to M12 and M14, AME-009-00092. The threshold details for the necessary temporary cessation of piling are provided in the DCO and set out in the AMS Part 3.

215. These primarily require temporary cessation following 7 consecutive days of zero or sub-zero temperature, but with additional detail as provided in the DCO.

3.9 Target Setting and Triggers

216. As noted above, objectives and targets have been derived with reference to a number of information sources, including the SoCG, the DCO/DML and dialogue with the Regulatory Authorities and tables to action these are presented in the followingsection.

4. TABULATED ACTION PLANS

217. For the broad Objectives identified in the preceding text, the following Action Plans summarise Targets, Actions (or Monitoring) to achieve those Targets and the Responsible Body to undertake the Actions (or Monitoring). Timing for the Action (or Monitoring) is provided, as well as Limits of Acceptable Change (LACs) against which any change from baseline conditions can be identified. Finally, potential types of Intervention are identified where LACs have been exceeded.

218. As described within the Steering Group section earlier in text, the findings from the monitoring programmes will be submitted to the Steering Group, and required actions will be identified where necessary, based on baseline data and compliance with agreed targets and triggers.

TOPIC: SEDIMENT PARAMETERS

Objective M1: During dredging ensure sediment levels remain within limits agreed under the DML in relation to Centrica and E.ON intake/outfall operation

Target	Ensure sediment levels remain within ranges identified and agreed through pre-construction monitoring at automatic monitoring buoy. NB existing baseline data suggest typical range of 100-1600 mg/l within the Humber Estuary
Management	n/a
Monitoring	As part of each of the bathymetric surveys to be undertaken a survey line will be sailed along the full route of each of the intakes and outfalls and parallel survey lines will be sailed along either side of each of the intakes / outfalls at a range of 10m upstream and downstream (all where safe navigation allows). The target vertical accuracy of each survey will be +/- 0.05m. Given the relatively small size of the intake/outfall structures a hit count of somewhat greater than 10 hits per square metre will need to be achieved to clearly resolve the levels of sedimentation around the structures themselves. In terms of data deliverables, the bathymetric date for this survey component will be presented as a 0.5m x 0.5m grid rather than at the coarser level used for the survey areas presently covered in the MEMMP.
Who	AHPL
When	Continuous monitoring: initial pre-construction monitoring survey will be used to develop new reference; monitoring will continue up to, and including, the first maintenance dredging. Monitoring may cease when the power station ceases operation
Limits of Acceptable Change	Within the results of any single bathymetric survey, bed elevation at an intake rises to within 1.5m of the bottom of the inlet or bed elevation at an outfall rises to within 0.25m the level of the bottom of the outlet.To be agreed following collection of reference data and included within the monitoring scheme submitted to, and approved by, the MMO, in consultation with the EA, Centrica and E.ON
Remedial Action	Subject to all the necessary licencing / permissions being in place, dredging will return the bed profile around the intake / outfall which has triggered the

	action to its bassline level (its level as measured prior to the works commencing). The dredging will be carried out within 2 weeks of the survey triggering the action. The method used will be that for outfall maintenance dredging set out in the projects Dredging Strategy (Report Ex 7.8, October 2012, or any subsequent approved revision). The dredging will be carried out in such a way that suspended sediment concentrations at the intakes do not rise significantly above those permissible for their successful operation.As set out in the DML, to be agreed and included within the monitoring scheme submitted to, and approved by, the MMO, in consultation with the EA, Centrica and E.ON
Notes	Details of scheme to be developed and agreed prior to development commencing Intake maintenance dredging along the intake/outfalls shall be carried out on the downstream side during an ebb tide and on the upstream side during a flood tide to minimise the amount of sediment affecting the water intakes.

Objective M2: To corroborate predictions on intertidal accretion/erosion from EX11.24 (Medium and long term quantum of habitat loss)

Target	No target – impact verification
Management	n/a
Monitoring	LiDAR
Who	AHPL appointed consultant/contractor
When	Detail of monitoring dates laid out in Appendix 1; to include pre- and post-construction for a period of at least ten years
Limits of Acceptable Change	n/a
Remedial Action	Dredging if required, specifically in relation to the ongoing operational requirements of the Centrica and E.ON intakes/outfalls. Wider changes to mudflat elevation across the NKM will not require dredging work
Notes	Wider elevation changes referred to above relate to Humber Estuary EMS and WFD issues

TOPIC: INTERTIDAL ESTUARINE HABITAT (SALTMARSH AND MUDFLATS) - WFD / HUMBER ESTUARY EMS MONITORING

Objective M3: To record changes in extent and composition of saltmarsh

Target	No target; ongoing monitoring to address WFD and Humber Estuary EMS Conservation Objectives issues
Management	n/a
Monitoring	Methods to be WFD compliant following EA Guidance OI 200_07. Aerial RGB photographic survey (potential to utilise EA images if timing is appropriate). Field survey using transects and quadrats following OI200_07. Subsequent analysis in accordance with the WFD saltmarsh index tool.
Who	Environmental Manager and suitably qualified surveyor in consultation with the Environment Agency
When	Annually during June to September (ideally July); for at least ten years
Limits of Acceptable Change	No deleterious change to WFD/EMS status.
Remedial Action	n/a
Notes	

TOPIC - INTERTIDAL ESTUARINE HABITAT (BENTHOS)

Objective M4: To identify deleterious change to intertidal benthic invertebrate fauna

Target	No impact on WFD status (status currently assessed as Moderate for Humber Lower (2014), and predicted as being Moderate in 2015 for Humber Lower; no assessments for Humber Middle) – WFD assessments include number of taxa; AZTI* Marine Biotic Index (AMBI); and Simpson's Evenness Quantitative targets to be defined and agreed following completion of full reference (pre-construction) surveys. BACI-type surveys at NKM and CCS.
Management	refer to CEMMP for details of targets etc
Monitoring	Intertidal survey using hand-held corers (standard methods – including species and community analysis, particle size analysis, organic content)
Who	AHPL appointed consultant/contractor
When	Annual (spring) BACI-type surveys beginning with establishing new reference pre-construction and continuing for ten years post-construction. One-off late summer/autumn bird prey characterisation survey at NKM.
Limits of Acceptable Change	To be based on uni- and multi-variate statistical analysis of temporal and spatial community variability and change
Remedial Action	n/a (provided by CEMMP)
Notes	Full targets to be defined and agreed following agreement of analysis methods and completion of full reference (pre-construction) surveys

Objective M5: To record and identify changes in intertidal topography & extent

Target	To meet EA monitoring requirements and to validate model predictions of changes in topography to the south-east of the AMEP quay as described in EX 8.9 (Assessment of changes to morphology (particularly intertidal) between the Humber International Terminal (HIT) and Humber Sea Terminal (HST)). Also to inform NE of any topographic or extent changes to intertidal mudflat.
Management	n/a

Monitoring	LiDAR survey of intertidal between the flood defence wall and MLWN or -2m ODN (whichever is the greater) and between CPK and HIT (area shown in Appendix 2).
Who	AHPL appointed consultant/contractor
When	• Once during month prior to commencement of construction works; • Biannual surveys for ten years post-construction
Limits of Acceptable Change	n/a
Remedial Action	n/a
Notes	Further details as per Environment Agency monitoring requirements attached as Appendix 1

TOPIC - SUBTIDAL ESTUARINE HABITAT (BENTHOS)

Objective M6: To identify deleterious change to subtidal benthic invertebrate fauna due to dredging and dredge disposal e.g. including WFD Compliance

Target	To identify potential impact on WFD status (status currently assessed as Moderate for Humber Lower (2014), and predicted as being Moderate in 2015 for Humber Lower; no assessments for Humber Middle) – WFD assessments includes number of taxa; AZTI* Marine Biotic Index (AMBI); and Simpson's Evenness Quantitative targets to be defined and agreed following completion of full reference (pre-construction) surveys. Possible metrics to include: • Abundance and biomass dominance; • Overall benthic invertebrate biomass (wet weight / m^2) to exceed agreed thresholds; • Biotope composition and extent to remain unaffected.
Management	n/a
Monitoring	Subtidal benthic invertebrate survey of (maintenance) dredge areas using Hamon grab (standard methods – including species and community analysis, particle size analysis, organic content); Subtidal benthic invertebrate survey of areas within, and immediately surrounding, dredge disposal sites.
Who	AHPL appointed consultant/contractor

When	Dredge sites: annual (spring) surveys beginning with establishing new reference pre-construction and continuing for ten years post-construction Disposal sites: scheme for monitoring and management of disposal activities to be submitted to, and agreed with, the EA; the scheme shall include: • timetable for when monitoring shall be undertaken; • detailed monitoring methodology; • evaluation of the contribution the disposal activities make to the overall ecological potential of the Humber Lower water body
Limits of Acceptable Change	To be based on uni- and multi-variate statistical analysis of temporal and spatial community variability and change
Remedial Action	n/a
Notes	Full targets to be defined and agreed following completion of full reference (pre-construction) surveys. Further details regarding disposal site monitoring as per Environment Agency monitoring requirements attached as Appendix 1

Objective M7: To derive references for dredging and disposal impacts and to validate boundaries of disposal grounds

Target	Derive references for dredging/disposal impacts and to validate assumptions on boundaries of disposal grounds
Management	n/a
Monitoring	Bathymetric survey of dredge areas and disposal sites and of the intertidal area between CPK and HIT
Who	AHPL appointed consultant/contractor
When	Once during month prior to commencement of construction works; Fortnightly during capital dredging and the month following; Annual surveys for ten years post-construction
Limits of Acceptable Change	Sedimentation patterns indicating greater levels of erosion in comparison to those defined in Chapter 8 of ES or subsequent revision
Remedial Action	As noted below, the annual surveys will provide the information needed to either validate the boundaries of the deposit grounds, or trigger the need for them to be amended, and will also allow ongoing management of the dredge and disposal.
Notes	• The first surveys shall provide the reference for determining the impacts of dredge and disposal works, and should allow natural variability to be accounted for in any assessment. • The subsequent surveys shall provide the information needed to either validate the boundaries of the deposit grounds, or trigger the need for them to be amended. It shall also allow ongoing management of the dredge and disposal. • Surveys will be undertaken on similar tidal ranges and state of tide wherever possible. This will allow volumetric differences to be roughly compared, meaning the approximate portion of sediment retained and dispersed may be deducted. Further details as per Environment Agency monitoring requirements attached as Appendix 1

TOPIC – FISH COMMUNITIES

Objective M8: To identify deleterious change to intertidal fish populations

Target	To identify potential impact on WFD status (status currently assessed as Good for Humber Middle and Lower (2014), and predicted as being Good in 2015 for Humber Middle and Lower) and Humber Estuary EMS Conservation Objectives
Management	n/a
Monitoring	Intertidal seine net and beam trawl surveys
Who	AHPL appointed consultant/contractor
When	By-annual (Spring and Autumn), beginning with establishing new reference pre-construction and continuing for ten years post-construction
Limits of Acceptable Change	To be based on uni- and multivariate statistical analysis of temporal and spatial community variability and change
Remedial Action	n/a
Notes	

Objective M9: To identify deleterious change to subtidal fish populations

Target	To identify potential impact on WFD status (status currently assessed as Good for Humber Middle and Lower, and predicted as being Good in 2015 for Humber Middle and Lower) and Humber Estuary EMS Conservation Objectives
Management	n/a
Monitoring	Subtidal otter trawl surveys
Who	AHPL appointed consultant/contractor
When	Annual (Autumn), beginning with establishing new reference pre-construction and continuing for ten years post-construction
Limits of Acceptable Change	To be based on uni- and multivariate statistical analysis of temporal and spatial community variability and change
Remedial Action	n/a
Notes	

Objective M10: Ensure compliance with percussive piling restrictions to restrict or remove potential impacts on sensitive fish receptors. To be monitored via controls set out in the agreed AMS

Target	Percussive piling only to take place when dissolved oxygen levels are above defined threshold value as specified within the DCO
Management	n/a
Monitoring	Automatic monitoring buoy equipped with YSI 6600 multi Sonde
Who	AHPL
When	Continuous monitoring: to include pre-construction monitoring and subsequent monitoring throughout construction phase
Limits of Acceptable Change	Dissolved oxygen to be at, or in excess of, 5 mg/l
Remedial Action	No percussive piling to take place whilst dissolved oxygen is below 5 mg/l
Notes	All details as per DML

Objective M11: Ensure compliance with percussive piling restrictions to restrict or remove potential impacts on sensitive fish receptors. To be monitored via controls set out in the agreed AMS

Target	Percussive piling only to take place when water temperature is below the threshold value as specified within the DCO
Management	n/a
Monitoring	Automatic monitoring buoy equipped with YSI 6600 multi Sonde
Who	AHPL
When	Continuous monitoring: to include pre-construction monitoring and subsequent monitoring throughout construction phase
Limits of Acceptable Change	Water temperature to be at, or below, 21.5 °C
Remedial Action	No percussive piling to take place whilst water temperature exceeds 21.5 °C
Notes	All details as per DML

Objective M12: Ensure compliance with percussive piling restrictions to restrict or remove potential impacts on sensitive fish receptors. To be monitored via controls set out in the agreed AMS

Target	Piling only to take place at times specified within the DCO
Management	n/a
Monitoring	Monitoring of piling timetable restrictions will be set out in detail in the Active Monitoring Scheme – Part 2 – Piling Method statement. This will comprise data loggers on the piling rigs in association with a quality assurance system controlling the activity. This aspect will also be incorporated into the required 24 hours a day, 7 days per week monitoring. The acoustic system will be designed to identify piling rig operations
Who	AHPL
When	to include pre-construction monitoring and subsequent monitoring throughout the construction phase
Limits of Acceptable Change	No percussive piling shall take place between 7 April and 1 June inclusive in any calendar year. No percussive piling shall take place before 0600hrs or after 2200hrs on any day. Percussive piling shall be restricted at other times as follows: • from 2 June to 22 July inclusive in any year, the maximum amount of percussive piling permitted within any four-week period shall not exceed: ○ 101 hours where a single piling rig is in operation, or ○ a total of 168 hours where two or more rigs are in operation; • from 23 July to 10 September inclusive in any year, the maximum amount of percussive piling permitted within any week-long period shall not exceed: ○ 25 hours where a single piling rig is in operation, or ○ a total of 42 hours where two or more rigs are in operation; • from 11 September to 31 October inclusive in any year, the maximum amount of percussive piling permitted within any four-week period shall not exceed: ○ 134 hours where a single piling rig is in operation, or

	• a total of 224 hours where two or more rigs are in operation. • from 1 November in any year to 6 April in the following year inclusive, the maximum amount of percussive piling permitted within any eight-week period shall not exceed: ○ 336 hours where a single piling rig is in operation, or ○ a total of 560 hours where two or more rigs are in operation. ○ The measurement of time during each work-block shall begin at the start of each timeframe, roll throughout it, then cease at the end, where measurement will begin again at the start of the next timeframe, such process to be repeated until the end of piling works.
Remedial Action	Piling to cease outside of permitted times.
Notes	All details as per DML

TOPIC: MARINE MAMMALS

Objective M13: Ensure compliance with percussive piling restrictions to restrict or remove potential impacts on sensitive marine mammal receptors. . To be monitored via controls set out in the agreed AMS

Target	To ensure no marine mammal presence in vicinity of percussive piling activity when it commences
Management	Soft start percussive piling as detailed in the DML
Monitoring	Direct observation by Marine Mammal Observer using standard protocols (e.g. JNCC guidance, 2010)
Who	AHPL appointed consultant/contractor
When	Whenever marine percussive piling is being undertaken
Limits of Acceptable Change	No marine mammal within 100 metres of the pile being driven
Remedial Action	No percussive piling to commence if marine mammals are within 100 metres of the pile being driven
Notes	All details as per DML

TOPIC: WATERBIRDS

Objective M14: Ensure compliance with percussive piling restrictions to restrict or remove potential impacts on sensitive bird receptors. . To be monitored via controls set out in the agreed AMS

Target	To ensure no percussive piling activity during extended periods of cold weather
Management	n/a
Monitoring	Temperature monitoring at sites to be agreed
Who	AHPL appointed consultant/contractor
When	Whenever percussive piling is being undertaken
Limits of Acceptable Change	Range of temperature-based restrictions set out in DCO
Remedial Action	Cessation of piling when cold-weather thresholds are breached
Notes	No operations consisting of piling shall commence until a cold weather piling restriction strategy is submitted and agreed with the MMO, following consultation with Natural England. .

TOPIC: SUBTIDAL – FLOOD RISK ASSESSMENT

Objective M15: To assess longer-term impacts of AMEP within the wider estuary on standard of protection of EA defences

Target	Validation of predicted changes in sedimentation patterns, as defined in Chapter 8 of ES or subsequent revision
Management	n/a
Monitoring	Bathymetric and LiDAR surveys within the area shown in Appendix 2.
Who	AHPL appointed consultant/contractor
When	Once during month prior to commencement of construction works; Annual surveys post-construction to 2033 (Humber Strategy Period)
Limits of Acceptable Change	Sedimentation patterns indicating greater levels of erosion in comparison to those defined in Chapter 8 of ES or subsequent revision
Remedial Action	Monitoring frequency increased to biannual until either: • there are two confirmed surveys indicating erosion - which will trigger a Standard of Protection (SoP) Review to be undertaken for affected locations; or • there is no further evidence of erosion and a pattern of stabilisation can be detected; at which point the monitoring may return to annual frequency
Notes	Further details as per Environment Agency monitoring requirements attached as Appendix 1

TOPIC: SUBTIDAL – FLOOD RISK ASSESSMENT

Objective M16: To assess longer-term impacts of AMEP within the wider estuary on standard of protection of EA defences

Target	Validation of predicted changes in sedimentation patterns, as defined in Chapter 8 of ES or subsequent revision
Management	n/a
Monitoring	Bathymetric and LiDAR surveys within the area shown in Appendix 2.
Who	AHPL appointed consultant/contractor
When	Once during month prior to commencement of construction works; Annual surveys post-construction to 2033 (Humber Strategy Period)
Limits of Acceptable Change	Sedimentation patterns indicating greater levels of erosion in comparison to those defined in Chapter 8 of ES or subsequent revision
Remedial Action	Monitoring frequency increased to biannual until either: • there are two confirmed surveys indicating erosion - which will trigger a Standard of Protection (SoP) Review to be undertaken for affected locations; or • there is no further evidence of erosion and a pattern of stabilisation can be detected; at which point the monitoring may return to annual frequency
Notes	Understood to be addressed within a separate Flood Risk Management Plan; Further details as per Environment Agency monitoring requirements attached as Appendix 1

5. REFERENCES

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6. APPENDICES

Appendix 1: Agreed Monitoring for Able Marine Energy Park (AMEP) Capital Dredging and Disposal Activities

A. Bathymetric Monitoring

Able shall undertake bathymetric surveys (as defined in Section E) at the following locations and for at least 500 metres up and down the estuary

1. AMEP berth pocket dredge (bounded by co-ordinates (517488.989E, 419460.856N), (517454.211W, 419439.954N), (517435.893E, 419475.602N), (517531.037E, 419519.186N), (518378.171E, 418490.982N) and (518328.443E, 418441.438N));
2. AMEP approach channel dredge (bounded by co-ordinates (517531.037E, 419519.186N), (517698.908E, 419600.314N), (518741.000E, 418726.000N), (518446.000E, 418462.000N) and (518378.171E, 418490.982N));
3. AMEP turning area dredge (bounded by co-ordinates (518069.000E, 419289.000N), (518475.000E, 419314.000N), (518779.000E, 418761.000N) and (518741.000E, 418726.000N));
4. HU080 Disposal site down estuary (bounded by co-ordinates (53° 36.5520 N, 00° 00.4320 E), (53° 36.3000 N 00° 00.6180 W), (53° 36.4680 N, 00° 02.3220 W), (53°36.9481 N, 00° 03.4680 W) and (53° 36.5520 N, 00° 00.4320)) ;
5. HU082 Disposal down estuary (bounded by co-ordinates (53° 37.5000 N, 00° 02.2698 W), (53° 37.2480 N, 00° 00.7980 W), (53° 36.9702 N, 00° 00.8100 W), (53° 37.1220 N, 00° 02.2920 W) and (53° 37.5000 N, 00° 02.2698 W))

The first surveys shall be undertaken and completed within the month prior to the commencement of any marine construction, dredge or disposal works. Surveys shall thereafter be repeated no less than once a fortnight unless otherwise agreed, during the capital dredge programme (as defined in the dredge and disposal strategy, clause 45 (1) Schedule 8 of the Development Consent Order dated 29 October 2014). Upon completion of the capital dredge programme, surveying shall continue at the agreed frequency for one month.

Within 2 weeks of the completion of each survey, Able shall:-

- Supply the results of each report to the EA via email to humber.strategy@environment-agency.gov.uk, unless otherwise advised in writing by the EA.

Able shall notify the EA of the commencement of monitoring and produce a report collating and analysing the monitoring undertaken to date:-

- Every 6 months from the commencement of monitoring; and

- Supply a copy of each report to the EA via email to humber.strategy@environment-agency.gov.uk, unless otherwise advised in writing by the EA.

Note:

- The first surveys shall provide the reference for determining the impacts of dredge and disposal works, and should allow natural variability to be accounted for in any assessment.
- The subsequent surveys shall provide the information needed to either validate the boundaries of the deposit grounds, or trigger the need for them to be amended. It shall also allow ongoing management of the dredge and disposal.
- Surveys shall be undertaken on similar tidal ranges and state of tide wherever possible. This shall allow volumetric differences to be roughly compared, meaning the approximate portion of sediment retained and dispersed may be deducted.

B. LiDAR Monitoring Upstream and Downstream of AMEP

Able shall undertake LiDAR surveys (as defined in Section E) at the following locations

6. Between the top of the flood defence wall and MLWN or -2m ODN (whichever is the greater) upstream of AMEP, from quay wall to CPK (as defined in drawing AME-06114 revC);
7. Between the top of the flood defence wall and MLWN or -2m ODN (whichever is the greater) downstream of AMEP, from quay wall to HIT (as defined in drawing AME-06114 revC);

Able shall survey locations 6 and 7 as defined above and identified with green diagonal lines in drawing AME-06 114 rev C in the month prior to the commencement of any marine construction, dredge or disposal works under the Development Consent and thereafter one month from completion of the quay construction. These surveys shall be repeated at six month intervals unless otherwise agreed, for a period of 10 years in order to record the level of sedimentation taking place upstream and downstream of the quay.

Within 2 weeks of the completion of each survey, Able shall:-

- Supply the results of each report to the EA via email to humber.strategy@environment-agency.gov.uk, unless otherwise advised in writing by the EA.

Able shall produce a report collating and analysing the monitoring undertaken to date:-

- Every 12 months from the commencement of monitoring; and
- Within 6 weeks of each six month survey; and
- Compare the results to the modelling results presented in Chapter 8 of the ES and all technical appendices and subsequent supplementary information submitted with the application; and
- Supply a copy of each report to the EA via email to humber.strategy@environment-agency.gov.uk, unless otherwise advised in writing by the EA.

If sedimentation differs to that predicted in the ES, in location 6 or 7, and such change, if it continues over 2 consecutive surveys, and is likely to impede any existing surface water outfall or increase the risk of overtopping, Able shall increase the frequency of monitoring to every 12 weeks until such time that a pattern of stabilisation can be detected. In that event, the monitoring may return to the 6 monthly frequency identified above.

If sedimentation that is attributable to AMEP interferes with any surface water outfalls within locations 6 and 7, Able shall undertake appropriate remedial action.

If there is any indication of significant erosion of sediment attributable to AMEP (which shall be defined as a level change of more than 500mm from the reference survey recorded in the month prior to the commencement of marine works) or sedimentation differs in either location 6 or 7 and there is a credible risk of the Flood Defences being overtopped, Able shall:

Increase the frequency of monitoring to every 12 weeks until such time that either:

- there is no further evidence of erosion and a pattern of stabilisation can be detected; at which point the monitoring may return to the 6 monthly frequency identified above; OR
- there are two confirmed surveys indicating erosion in which event Able shall carry out within 14 days of the later survey a Standard of Protection Review, at Able's cost, which shall be completed as soon as reasonably practicable for all flood defences identified in the monitoring results showing a change in sedimentation patterns. The Standard of Protection that is provided by the current defence line against flooding from the sea shall be reviewed at Able's cost using those parameters in use by the EA and which have been notified to Able in writing by the EA. If the results show a reduction in the Standard of Protection, Able shall, at its own cost, undertake improvement works to restore the affected lengths of defence to the Standard of Protection. The Standard of Protection Review shall extend over the entire area of locations 6 and 7 as defined above. Prior to any improvement works being undertaken by Able, the methodology shall be agreed in writing with the EA.

If there is any indication of significant erosion of the estuary bed at the toe of the flood defences attributable to AMEP (which shall be defined as a level change of more than 300mm from the reference survey recorded in the month prior to the

commencement of marine works) in either location (6 or 7) and there is a risk of the Flood Defences being undermined, Able shall, at its own cost:

- Prepare a design for improvement works to protect the toes of the flood defences from scour.
- Obtain EA approval for the scheme.
- Undertake the improvement works to restore the affected lengths of defence.

C. Longer term Monitoring of Impacts of AMEP within the Wider Estuary on Standard of Protection of EA Defences

Able shall undertake the following surveys;-

Bathymetric surveys (as defined in Section E) at not greater than 500 metre line spacing:-

- In the area upstream and adjacent to AMEP as highlighted yellow and defined in drawing AME-06114 revB, across the width of the estuary up to MLWN; and
- In the area upstream and downstream of the disposal grounds as highlighted yellow and defined in drawing AME-06115 revB, across the estuary from MLWN at the north bank to the northern edge of the Sunken Dredged Channel

LiDAR surveys (as defined in Section E in this Schedule) at not greater than 50 metre line spacing:-

- In the areas upstream and opposite to AMEP as highlighted with red lines and defined in drawing AME-06114 revB, between the top of the flood defence wall and MLWN or -2m ODN (whichever is the greater) at both the north and south river banks; and
- In the area upstream and downstream of the disposal grounds as highlighted with red lines and defined in drawing AME-06115 revB, , between the top of the flood defence wall and MLWN or -2m ODN (whichever is the greater) at the north river bank

These surveys shall be undertaken on a 12 monthly basis for 10 years, commencing one month after completion of the marine and capital dredging works under the Development Consent. At the end of the 10 year period the EA shall review the results; which may include a Standard of Protection review (as defined in Section B in this Schedule) at Able's cost if there is a significant change in the surveyed levels (which shall be defined as a level change of more than 500mm from the reference survey recorded) which demonstrates that erosion is occurring that will impact upon the flood defences and such erosion is attributable to AMEP. If the EA shall so request, Able shall carry out monitoring for a further 10 years if the EA considers this to be reasonably necessary and justifiable following the SoP review.

Within 2 weeks of the completion of each survey, Able shall:-

- Supply the results of each report to the EA via email to humber.strategy@environment-agency.gov.uk, unless otherwise advised in writing by the EA.

Able shall produce a report collating and analysing the monitoring undertaken so far:-

- Every 12 months from the commencement of monitoring; and
- Within 6 weeks of the each annual survey; and
- Compare the results to the modelling results presented in Chapter 8 of the ES and all technical appendices and supplementary information submitted with the application; and
- Supply a copy of each report to the EA via email to humber.strategy@environment-agency.gov.uk, unless otherwise advised in writing by the EA.

If sedimentation differs to that predicted in the ES, and such sedimentation, if it continues, is likely to impede any existing surface water outfall, Able shall increase the frequency of monitoring to every 12 weeks until such time that there is no further evidence of sedimentation or a pattern of stabilisation can be detected. In that event, the monitoring may return to the 6 monthly frequency identified above.

If sedimentation that is attributable to AMEP interferes with any surface water outfalls within locations 6 and 7 or within the areas marked pink on drawings AME – 06114 revC and AME – 06115 revB, Able shall reinstate the effective discharge of water into the estuary

If there is any indication of significant erosion of the estuary bed at the toe of the flood defences attributable to AMEP (which shall be defined as a level change of more than 300mm from the reference survey recorded in the month prior to the commencement of marine works) in either location (6 or 7, or the areas marked pink on drawings AME -06114 revC or AME – 06115 revB) and there is a risk of the Flood Defences being undermined or the erosion protection in front of the flood defences being impacted, Able shall, at its own cost:

- Prepare a design for improvement works to protect the toes of the flood defences from scour.
- Obtain EA approval for the scheme.
- Undertake the improvement works to restore the affected lengths of defence.

D. Benthic Invertebrates

Prior to the commencement of any marine disposal activities, a scheme for the protection and enhancement of benthic invertebrates through the monitoring and management of disposal activities within, and immediately surrounding, the disposal sites of the Lower Humber water body ('the BI Scheme'), shall be submitted to and agreed in writing with the EA. The BI Scheme shall include the following:-

i. A timetable for when monitoring shall be undertaken, including monitoring before, during and after marine disposal activities are undertaken;
ii. A detailed methodology for the monitoring;
iii. An evaluation of the contribution the marine disposal activities make to the overall ecological potential of the Humber Lower water body as assessed by the biological elements, supporting elements, supporting conditions and ecological potential assessment as set out in Annex B of the Humber River Basin Management Plan;

If the evaluation of i)-iii) shows that marine disposal activities contribute to, or are likely to contribute to, a failure of the water body in achieving its Water Framework Directive objectives, ABLE shall submit a Remedial Action Plan to the EA that details measures to ensure marine disposal activities are amended such that, as far as is reasonably practicable, they do not contribute towards a deterioration of the Humber Lower water body status (including deterioration within existing status class), should such arise. The Remedial Action Plan may include variations to marine disposal activities to reduce their impact and/or specific measures to protect and enhance benthic invertebrates.

Within 2 weeks of the completion of each piece of monitoring, Able shall:-

- Supply the results of each report to the EA via email to humber.strategy@environment-agency.gov.uk, unless otherwise advised in writing by the EA.

Able shall notify the EA of the commencement of monitoring and shall produce a report collating and analysing the monitoring undertaken to date:-

- Every 6 months from the commencement of monitoring; and
- Within 6 weeks of each annual survey; and
- Supply a copy of each report to the EA via email to humber.strategy@environment-agency.gov.uk, unless otherwise advised in writing by the EA.

Should a Remedial Action Plan be deemed necessary as a result of the BI Scheme, Able shall:-

- As soon as reasonably practicable, submit a Remedial Action Plan to the EA for approval,

- As soon as reasonably practicable following the approval of the Remedial Action Plan, implement any actions agreed in it together with any other remedial actions which the EA shall reasonably require

Definitions

MHWS- Mean High Water Springs

MHWN- Mean High Water Neaps

MLWS- Mean Low Water Springs

MLWN – Mean Low Water Neaps

E. Bathymetric Survey

All survey work shall be undertaken in accordance with the EA survey specification v3.2 (May 2013), relating directly to Section VII (Hydrographic Surveys of River channels and other Water Areas using Swathe Bathymetry), or shall be provided in accordance with an agreed alternative method.

A multibeam echo sounder should be used. The system measures water depths across a wide swathe perpendicular to the vessel track, thus giving greater coverage of bed features along the line than traditional single beam. The additional horizontal coverage shall vary depending upon the water depths, but should approximate between 3 to 8 times the water depth, and produce wide channels of data capture, and ultimately complete coverage of the river channel.

The results need to include the methodology used to collect the data; the equipment deployed, including but not limited to Echo Sounder, Motion Sensor, Sound Velocimeter; position fixing equipment and processing. The software used to collect and process the data and the software used to produce charts and digital x,y,z outputs.

All surveys are to be referenced to UK National Grid, and any vertical datum shall be referenced to Ordnance Datum Newlyn.

The following data shall be supplied.

i) ASCII raster format *.asc 1m gridded data set supplied per OS Grid Square

ii) XYZ data *.txt 1m gridded data set per study reach

iii) Survey report.

Following the initial reference survey, all subsequent data shall be compared to the reference for the identification of river bed and bank movement.

F. LiDAR Survey

A LIDAR Digital Surface Model (DSM) and Digital Terrain Model (DTM) in ArcView ASCII Grid file in 0.25m x 0.25m and 0.5m x 0.5m file sizes for each polygon

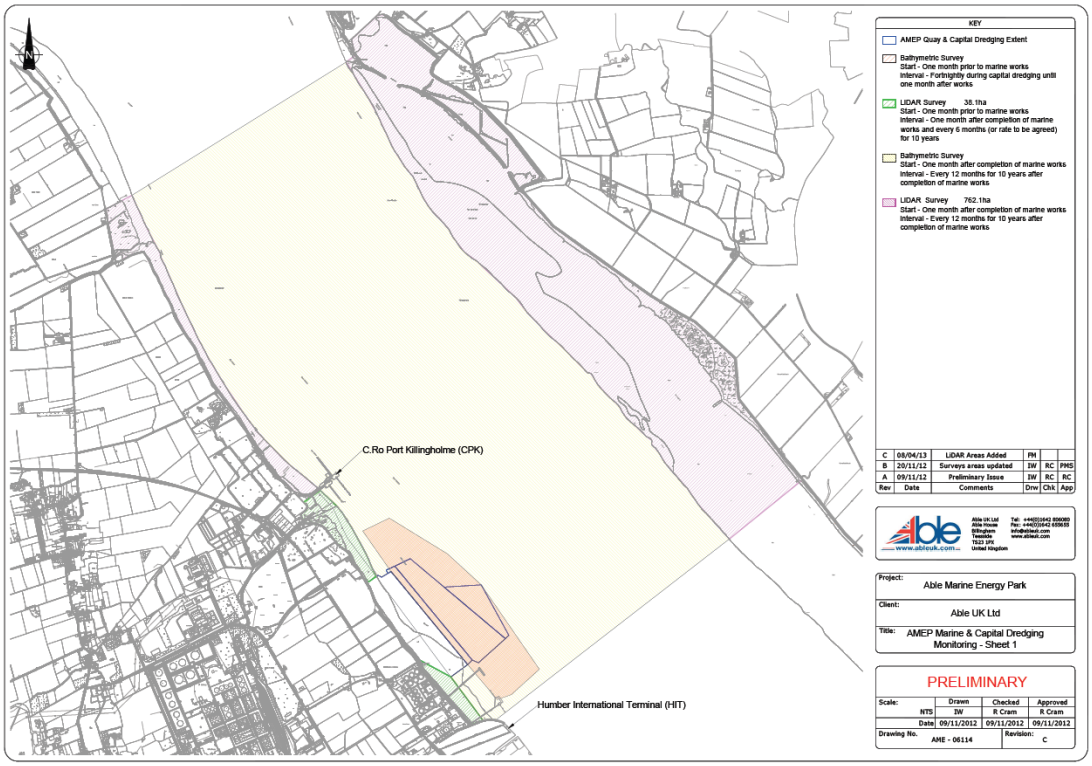
defined. Also supplied shall be last return XYZI point cloud data in LAS format and DSM XYZ ASCII TXT.
Data shall be collected during tidal windows in the order of 1 hour either side of Low Water, or suitable agreed time period.

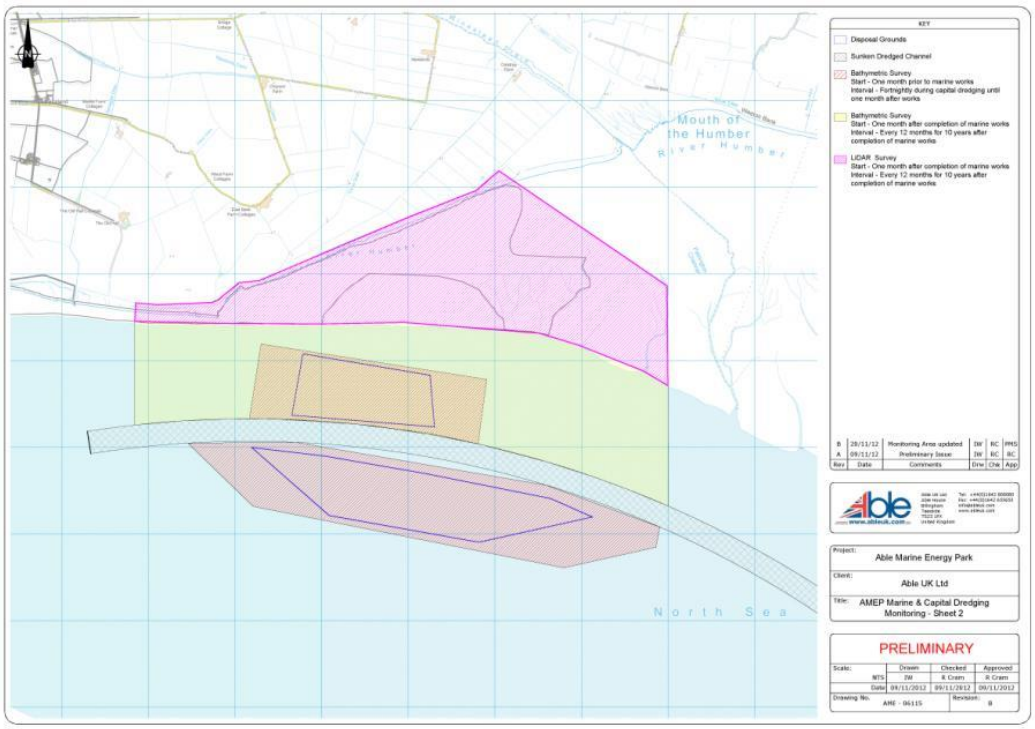
The error specification for LIDAR surveys shall be an RMSE of +/- 15cm.
Ground truth surveys for the checking of LIDAR height accuracy shall be carried out within each polygon.

A full quality control report shall be supplied to the EA on completion of each survey. This shall include at least the following:

- A plot of all data indicating polygon coverage and aircraft navigation lines.
- A copy of the flight log for all polygons.
- Data processing procedures.
- A report on the comparison of these data with available ground truth data.

Appendix 2: LiDAR and Bathymetric Survey Locations





Appendix 3: Saltmarsh, Benthic Invertebrate and Fish Sampling Methods

1. Reference and ongoing impact audit survey methods for the saltmarsh component of NKM, inc. WFD compliance

Saltmarsh extent, community, zonation and diversity will be ascertained following EA WFD guidance e.g. OI 200_07 or any subsequent relevant revisions.

In advance of each annual survey the most recent available aerial images will be requested from the EA (although it is noted that not every year will be updated by the EA), this information providing additional data and informing the survey process. Where the data are current (e.g. the year of image is current to the year of survey, then depending on coverage, it may be unnecessary to undertake an additional survey flight.

When such images are unavailable, then a survey flight will be undertaken, with aerial colour images captured. These images will be:

- of resolution of at least 25cm
- 3 band red green blue (RGB) imagery
- taken in daylight at low water around a spring tide

- taken under stable lighting conditions (little or no cloud shadow)
- taken between June and September each year, with timing to be standardised to a single month per year where possible
- taken on an annual basis for a minimum of 10 years, the requirements for subsequent surveys to be determined by the Steering Group

In addition to the annual aerial image survey, field survey of the saltmarsh habitat will be undertaken on an annual basis, again following guidelines in the EA's OI 200_07

This will include a series of transects of sufficient frequency to adequately describe the communities, their zonation and extent (see OI 200_07 for details). Each transect will cover both the seaward and landward extent of the saltmarsh. Transition points will be mapped and two quadrat samples taken to characterise the major community changes, recording species, cover, sward height etc following OI 200_07 procedures. Analysis will include zonal area and diversity as well as NVC community, with the field survey data collated with the aerial imagery.

The saltmarsh will then be therefore assessed for the following metrics in accordance with the WFD Saltmarsh Index Tool:

- saltmarsh extent as proportion of "historic saltmarsh"
- saltmarsh extent as proportion of the intertidal
- change in saltmarsh extent over two or more time periods
- proportion of saltmarsh zones present (out of five)
- proportion of saltmarsh area covered by the dominant saltmarsh zone
- proportion of observed taxa to historical reference value **or** proportion of observed taxa to 15 taxa

2. Reference and ongoing impact audit survey methods for the intertidal benthos component of NKM, inc. WFD compliance

Survey rationale: the survey is designed primarily to allow detection of possible impacts on intertidal benthic infauna by comparison of impact monitoring with reference data. The characterisation of the reference (pre-construction) benthic community in the intertidal area will allow also possible wider comparison with data collected during a previous characterisation survey (May 2010) in order to highlight natural temporal variability in benthic assemblages in the area.

The survey design and methods have been devised based on existing guidelines (Guidelines for the Conduct of Benthic Studies at Marine Aggregate Extraction Sites - Ware and Kenny 2011; the Marine Monitoring Handbook, Davies et al 2001). Also the operational instructions for sampling and sample processing for macrobenthic invertebrates in TraC waters (EA, 2013) have been taken into account in order to collect data that can be used for WFD assessment purposes.

Sampling method: hand held corer (0.01 m^2), sediment sampled to a depth of c.15 cm.

Sampling period: monitoring to be carried out annually, in Spring (possibly May, to allow better comparison with previous data; in any case, between February and June), during pre-construction (2 years, 2013 and 2016), construction (where sampling sites can be still accessible in safe conditions) and for 10 years post-construction.

Sampling design: A beyond BACI (Before-After Control-Impact) gradient design is suggested. The BACI gradient design will take into account the existence of different zones of impact (namely, primary (or direct) impact, under the direct footprint of the quay development, and secondary (or indirect) impact) as well as control (i.e., no impact) zone.

Also, a stratification of the design by shore level (upper, middle and lower shore strata) is suggested to account for the variability of communities that occur at different shore levels (hence the variability of possible impacts, due, e.g., to different sensitivity of species), hence reducing the degree of unexplained variance (with consequent increase in the power of the analysis).

If possible, multiple control areas should be chosen to represent the mudflat benthic assemblages in natural conditions. The criteria below should be followed in the choice of control areas:

- Mudflats outside the influence of impacts from the proposed development or other anthropogenic activities, in order to reflect natural conditions;
- Mudflats located in the vicinity of the impact area (e.g., along the southern bank of the estuary and within 2 km from the development area), in order to limit the natural variability of mudflat assemblages and to increase the

probability that the communities surveyed under "control" conditions are similar to those naturally present in the impact area (before construction).

It is of note that, under these conditions and based on the information available to date, only one control area could be identified *a priori* for intertidal mudflats. In fact, suitable natural mudflats are too far from NKM (hence more likely to show naturally different environmental conditions and communities) or those within the 2 km range are likely to be under the influence of other anthropogenic activities (hence unlikely to represent natural conditions).

However, considering the benefit of including multiple control sites to allow assessment of impacts at NKM, it is noted that two control areas for mudflat communities will be surveyed during the pre-construction reference monitoring at CCS (see section 3 of this Appendix). The information available to date does not allow the determination as to whether these control sites would be suitable controls for the mudflats at NKM. It is proposed that, if the data obtained during the pre-construction reference at CCS confirms the suitability of these control areas for the mudflat at NKM (i.e. similar communities present), then these will be included in the impact assessment design for intertidal mudflat at NKM.

The proposed survey design is summarised in the Table A3.1 below. It should be noted that additional control areas (not included in the table and figure below) might be included in the survey design, provided their availability and suitability as controls, as mentioned above.

				Number of replicate benthic		
Survey areas		**area code**	**Transect**	**Upper**	**Mid**	**Lower**
Impact	Under direct footprint of quay development	**DI**	DI.1	3	3	3
			DI.2	3	3	3
			DI.3	3	3	3
	Under the area of indirect impact north of the quay development	**IIN**	IIN.1	3	3	3
			IIN.2	3	3	3
			IIN.3	3	3	3
	Under the area of indirect impact south of the quay development	**IIS**	IIS.1	3	3	3
			IIS.2	3	3	3
			IIS.3	3	3	3
Control	Control area north of NKM	**CN**	CN.1	3	3	3
			CN.2	3	3	3
			CN.3	3	3	3
			12 transects			
			3 locations x transect = 36 locations			
			3 repl x location = 108 samples = n			

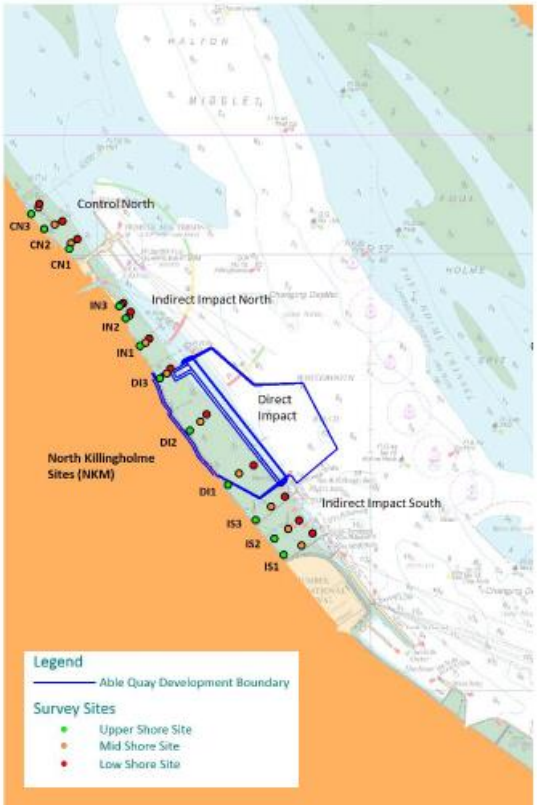
It is of note that the area under the direct footprint of the quay development (DI) would be lost, hence would not be included in the post-construction monitoring and in the BACI-type design. Nevertheless, a reference characterisation of its assemblages is considered relevant (i) to confirm previous observations (2010) and the temporal (inter-annual) natural variability of invertebrate communities in this area; (ii) to identify (statistically) similarities with communities nearby (in remaining impact areas and control areas); (iii) to assess seasonal variability of

communities in the area by comparison with data from autumn survey (for transects overlapping with "bird food" survey design).

Sampling stations (i.e., locations at different transects and shore levels) are to be intended as boxes (10 x 10m) with 3 replicate samples collected randomly within each box. Multiple locations are selected for each stratum, as defined by the treatment (controls/impacts) and the shore position. In addition to replication of locations within each stratum, also replication within each location (triplicate samples) is proposed in order to reduce the residual variance of the data and increase the power of the analysis. Randomization will be applied to the selection of replicates (core samples) at each location, thus limiting the pseudo-replication. Re-sampling of the same locations is suggested as it increases the power compared to the collection of the same number of samples reallocating sites every year (Green, 1989[2]). It is of note that modifications in the shore profile over the years might lead to changes in the shore level of a certain location. Re-sampling the same location each year would allow to assess changes in the benthic community also due to this factor. In addition to the 3 replicate samples collected at each station for benthic invertebrate analysis, a fourth sample will be collected at each station to characterise sediment (PSA and organic matter).

The characterisation survey carried out in May 2010 has been used to inform suitable sample locations, within the constraints of the sampling design proposed here. Survey locations used in Spring 2013 are shown in the following Figure A3.2.

[2] Green RH, 1989. Power analysis and practical strategies for environmental monitoring. Environmental Research 50, 195-205.



Sample locations along transects will be recorded using DGPS to allow for greater station fidelity between years.

In fact, it is suggested that post-construction monitoring will use a "resampling of sites" approach, rather than a "reallocation of sites" approach, as it will allow a higher power of the analysis (Green 1989). However, it is acknowledged that possible small-scale morphological modifications might occur in the site in response to unanticipated anthropogenic or natural influences and this might lead to changes in the representativeness of the station of a particular stratum (e.g., a station located at mid shore one year could be located at low shore another year due to changes in the foreshore profile). In these cases, some allowance will be made for small-scale changes in the station location in order to maintain its representativeness of the shore level stratum.

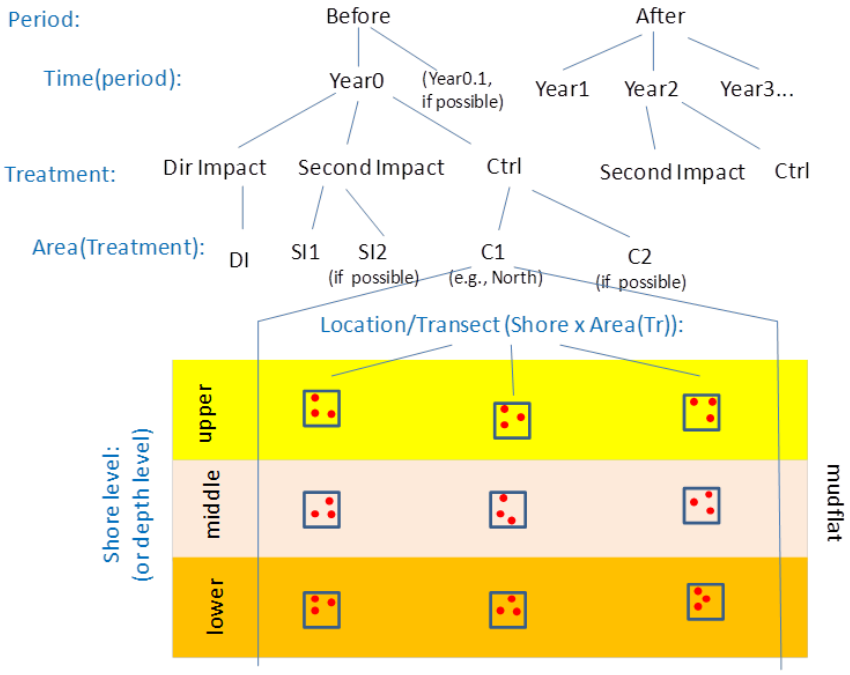
Sample processing: Samples from different replicates should be kept separate. Benthic samples are to be sieved through a 0.5mm sieve. Laboratory analysis will include species (identified to highest taxonomic detail), abundance and biomass.

Supporting parameters: Sediment particle size analysis and organic content will also be measured in the additional sediment sample. Additional supporting parameters recorded on site will include the recording of the character and composition of surface sediments (type, colour, smell), depth of RPD layer, texture

and presence of surface features. A photographic record of the sampling station and of the sediment will be also collected.

Data analysis: Data checking and exploratory analysis will be carried out before formal statistical testing. Analysis of variance will be applied at univariate and multivariate level (Permanova routine can be used in both cases, using a pseudo-F statistic and permutations, thus avoiding assumptions of the parametric F-statistics) to assess the significance of possible impacts. The analysis will be carried out on univariate descriptors of the community (e.g., benthic abundance, biomass, species richness, diversity) as well as on the multivariate structure of the assemblages.

A schematisation of the analysis design, with indication of all the factors involved, is provided in the Diagram A3.3 below:



The main aim of the analysis is to test for interactions between periods (before and afters) and treatment (controls and impacts) in order to assess whether temporal changes in the impacted areas are in line with changes at control areas (if not, i.e. an interaction exists, then an impact is assumed). Contrast between levels of the factors (e.g. secondary impact sites and control sites). The interaction of these factors with shore location/depth level will be taken into account to highlight possible impacts that might manifest only at certain shore/depth levels.

It is of note that the primary impact intertidal area will be sampled only before the construction as it will be lost under the quay footprint – therefore in this case the statistical analysis over time (before/after) will involve the testing changes

only at control and secondary impact areas. Both the p-values and size of any changes will be reported.

In addition, modifications in the shore profile over the years might lead to changes in the shore level of a certain location, hence leading to the need of re-allocating the location to the proper a different stratum if a relevant change in the beach morphology has occurred, in order to correctly account for the shore level stratification in the analysis.

3. Reference and ongoing impact audit survey methods for the intertidal benthic component of CCS area around the compensation site

Survey rationale: the general survey rationale is similar to that one for the reference survey and ongoing impact audit at NKM, with the impact in this case being ascribed to the opening of the breach at the RTE/CCSWG site.

Sampling method: hand held corer (0.01 m^2), sediment sampled to a depth of c.15 cm.

Sampling period: monitoring to be carried out annually, in Spring (possibly May, to allow better comparison with previous data; in any case, between February and June) during pre-construction (1 or 2 years, depending on when the construction works will start), construction (where sampling sites can be still accessible in safe conditions) and for 10 years post-construction.

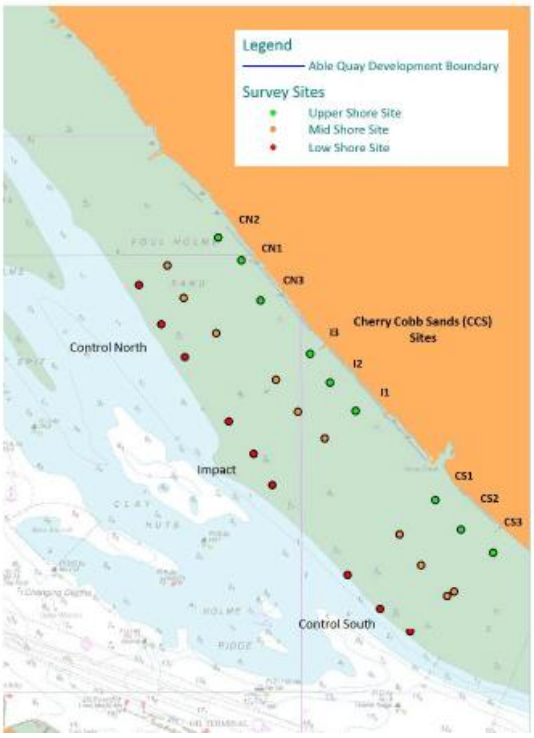
Sampling design: Similarly to the intertidal survey at NKM, a beyond BACI design is suggested, with stratification by shore level (the same considerations on control areas, locations and replication as from the intertidal survey at NKM apply here). In this case the impact zone has been identified in correspondence of the breaching area whereas two control areas have been identified South and North of the impact zone. The proposed survey design is summarised in Table A3.4 below.

				Number of replicate benthic cores by shore level stations		
Survey areas	**Area location**	**area code**	**Transect**	**Upper**	**Mid**	**Lower**
Impact	Under direct footprint	**I**	I.1	3	3	3
			I.2	3	3	3
			I.3	3	3	3
Control	North	**CN**	CN.1	3	3	3
			CN.2	3	3	3
			CN.3	3	3	3
	South	**CS**	CS.1	3	3	3
			CS.2	3	3	3
			CS.3	3	3	3

9 transects
3 locations x transect = 27 locations
3 repl x locations = 81 samples

In addition to the 3 replicate samples collected at each station for benthic invertebrate analysis, a fourth sample will be collected at each station to characterise sediment (PSA and organic matter).

Sampling stations utilised in 2013 spring survey are shown in the following map Figure A3.5 (impact and control areas are indicated; names of transects are as per table above).



Considerations on re-sampling of same locations as per description provided for the intertidal design at NKM apply here.

Sample processing / supporting parameters / data analysis: as for intertidal survey at NKM.

4. Reference and ongoing impact audit survey methods for the subtidal benthos of NKM, inc. WFD compliance

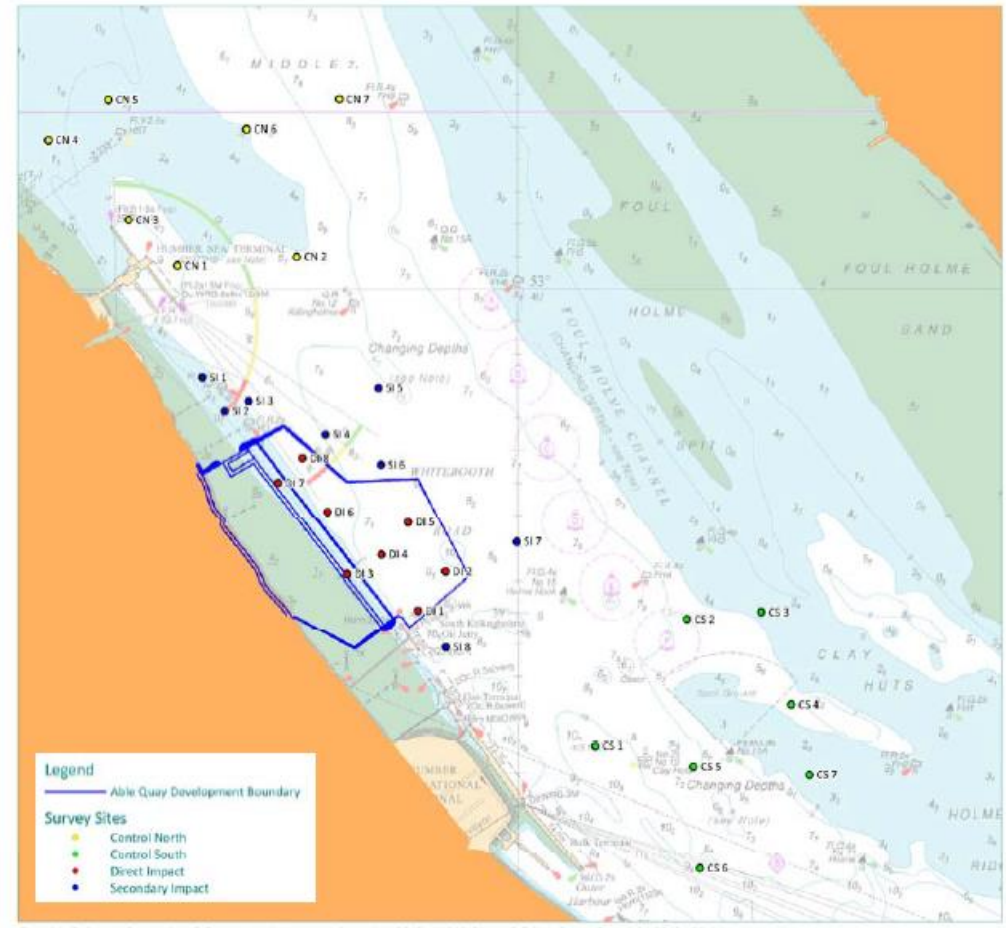
Survey rationale: the rationale of the survey is similar to that of the reference intertidal survey at NKM, aiming at allowing detection of possible impacts on subtidal benthic infauna following dredging activities at the quay development area. Also the operational instructions for sampling and sample processing for macrobenthic invertebrates in TraC waters have been taken into account to allow for WFD compliance.

Sampling method: 0.1 m2 Day grab; although this method is suited to survey estuarine sediments (WFD compliant method), it is of note that it would not as efficient where sediments are coarser/more compact. With limitation to only these cases, it is suggested the use of a 0.1m2 Hamon grab. Sample acceptance criteria will be used as defined in WFD operational instructions (i.e., sediment depth in the grab >7cm for mud, >5cm for coarser sediments). However, sample volumes will be checked prior to the grab sample being accepted with the sediment sample measures by depth of sample.

Sampling period: monitoring to be carried out annually, in Spring (possibly May, to allow better comparison with previous data; in any case, between February and June) during pre-construction (2 years, 2013 and 2016), construction (where sampling sites can be still accessible in safe conditions) and for 10 years post-construction.

Sampling design: Similarly to the intertidal benthic survey at NKM (described in previous sections), a beyond BACI gradient design is suggested. The BACI-type gradient design will take into account the existence of different zones of impact (namely, primary (or direct) impact, within the combined area of the proposed berthing pocket, approach channel and turning circle, and secondary (or indirect) impact) as well as control (i.e., no impact) zone. In this case, a stratification of the design by depth level is suggested to account for the variability of communities with habitat, as described by depth, hence reducing the degree of unexplained variance (with consequent increase in the power of the analysis).

The location of proposed stations has been selected also trying to matching (as much as possible) the location of existing stations (2010 survey) to allow a temporal comparison. The location of sampling stations used in 2013 spring surveys is presented in the Figure A3.6 below and table Table A3.7 below.



Number of grab locations:

depth level (m OD)	Impact		Control		Total
	Primary	Second.	North	South	
>-8	2	2	2	2	8
-8 to -12	3	3	3	3	12
<-12	3	3	2	2	10
Total	8	8	7	7	30

4 areas (2 impacts + 2 ctrls)
3 depth levels per area = 12 levels
2-3 locations per level = 30 locations
3 repl per location = 90 samples

In each station, 3 replicate grab samples will be collected for benthic invertebrate analysis to allow statistical comparison within the BACI-type design. A small subsample of the retrieved sediments sub-sample will be obtained from the faunal samples for PSA and organic content analysis, as recommended by Cefas.

Sample processing: Samples from different replicates should be kept separate. Benthic samples are to be sieved through a 0.5mm sieve. Laboratory analysis will include species (identified to highest taxonomic detail), abundance and biomass.

Supporting parameters: Sediment particle size analysis and organic content will also be measured in the additional sediment sample.

Data analysis: Data checking and exploratory analysis will be carried out before formal statistical testing. Analysis of variance will be applied at univariate and multivariate level (Permanova routine can be used in both cases, using a pseudo-F statistic and permutations, thus avoiding assumptions of the parametric F-statistics) to assess the significance of possible impacts. The analysis will be carried out on univariate descriptors of the community (e.g., benthic abundance, biomass, species richness, diversity) as well as on the multivariate structure of the assemblages.

The main aim of the analysis is to test for interactions between periods (before and afters) and treatment (controls and impacts) in order to assess whether temporal changes in the impacted areas are in line with changes at control areas (if not, i.e. an interaction exists, then an impact is assumed). Contrast between levels of the factors (e.g., secondary impact sites and control sites). The interaction of these factors with depth level will be taken into account to highlight possible impacts that might manifest only at certain depth levels. Both the p-values and size of any changes will be reported

5. Reference and ongoing impact audit survey methods for the fish component of NKM, inc. WFD compliance

Survey rationale: the survey is designed primarily to allow detection of possible impacts on fish fauna by comparison of impact monitoring with reference data. The characterisation of the reference (pre-construction) fish community will allow also possible wider comparison with data collected during a previous characterisation survey (2010) in order to highlight natural temporal variability in fish assemblages in the area. The survey design and methods have been amended following the operational instructions on data requirements for WFD transitional fish surveillance monitoring in order to collect data that can be used for WFD assessment purposes.

Sampling method: A combination of gear types and replicated sampling locations are included in the design and follows the methods developed by the EA for the WFD TraC fish monitoring (EA, 2013). Seine net and 1.5m beam trawl will be used in the intertidal area, and otter trawl in the subtidal area. The seine net will be deployed at low slack tide, whereas the beam trawl will be towed for 200m at high slack tide to allow boat access to the intertidal area. The otter trawl will be deployed in the subtidal area, with tows of a minimum of 15 min. carried out against the rising tide. Sampling will be carried out in daylight in order to mitigate against the influence of diurnal variations in the fish assemblage.

Sampling period: Spring (May/June) and Autumn (September/October) in the intertidal area; Autumn only in the subtidal area.

Sampling design: Survey design is based on a beyond BACI (Before-After Control-Impact) approach, while also considering the characterisation survey carried out in 2010 to inform suitable sample locations.

A stratified design is devised, with strata defined based on intertidal/subtidal area and impact areas (impact zone around the development and control areas). The impact area is located in the intertidal and subtidal zone between the Humber Sea Terminal (North) and the Humber International Terminal (South).

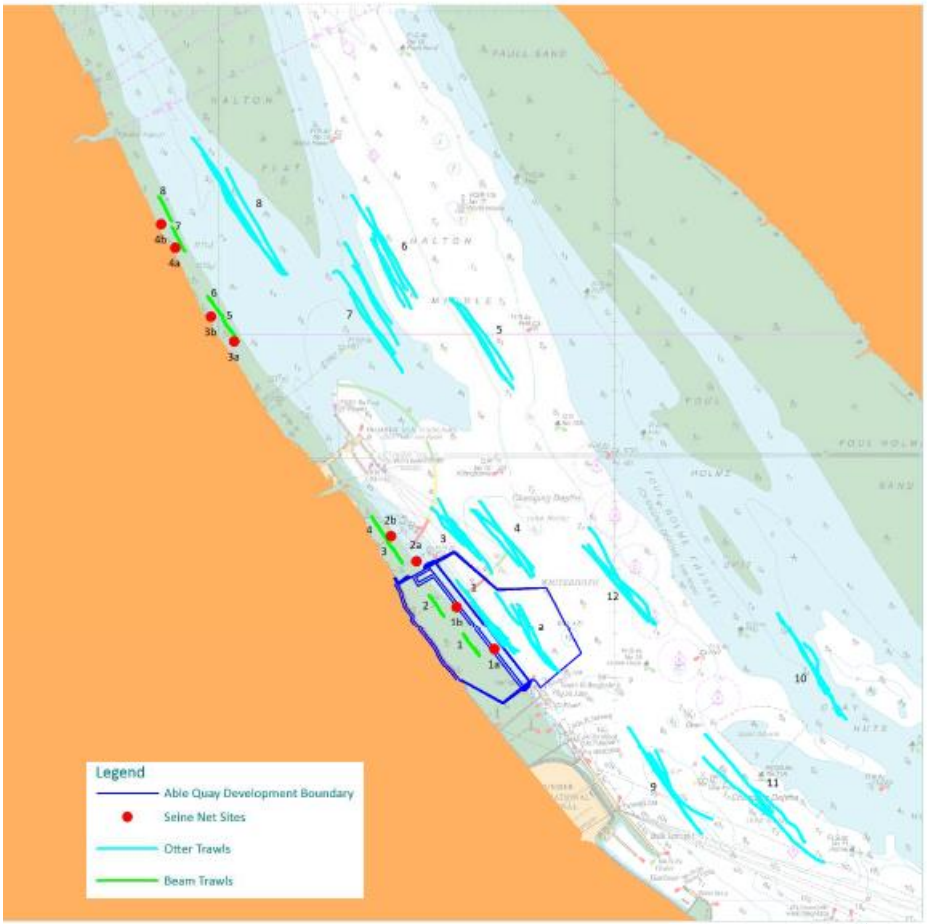
If possible, at least two control areas should be chosen to represent the fish assemblages in natural conditions. The criteria below should be followed in the choice of control areas:

- Intertidal and subtidal areas outside the influence of impacts from the proposed development or other anthropogenic activities, in order to reflect natural conditions;
- Intertidal and subtidal areas possibly along the southern bank of the estuary and within 2 km from the development area, in order to limit the natural variability of fish assemblages and to increase the probability that the communities surveyed under "control" conditions are similar to those naturally present in the impact area (before construction).

As highlighted for the intertidal benthic survey at NKM, due to local constraints, only one control area (north of the development site) can be identified in the intertidal mudflats around the development site.

At each area, two sites will be surveyed with seine net (with two hauls undertaken per site) and 4 sites with beam trawl in the intertidal area. In the subtidal area, two control areas and one impact area will be surveyed with otter trawl, with four hauls undertaken per area.

The location of proposed stations should be selected also trying to match (where possible) the location of existing stations (2010 survey) to allow a temporal comparison, although a certain variability is allowed, considering also the mobility of fish fauna. The position of sampling stations utilised in Autumn 2013 is shown in the following Figure A3.8 and the survey design is summarised in Table A3.9 below, showing the number of hauls per sampling area and method. A control area south of the development site could not be identified in the intertidal area given the criteria described above, therefore subtidal stations are only shown for that area.



Number of hauls:

		Impact area				
method	**zone**	**Impact**	**Control**	**Control S**	**Season**	**Total/year**
Seine net	intertidal	4	4		Spring and Autumn	16
Beam trawl	intertidal	4	4		Spring and Autumn	16
Otter trawl	subtidal	4	4	4	Autumn only	12
	Total	12	12	4		44

The proportion of samples obtained with the different methods in the impact and control areas has been devised also based on the WFD guidelines. Sample locations will be recorded using DGPS to allow for greater station fidelity between years.

Sample processing: Field notes, haul information and species identification, abundance, size and weight records will be noted on site. Following EA Transitional Waters Guidelines, for each sample, up to 50 individuals of each fish species will be measured (total length, nearest mm), with the remainder identified and counted. However, fishes that are not identifiable in the field (e.g., 0+ fishes) will be preserved in 60% Ethanol for identification in the laboratory using appropriate keys.

Supporting parameters: Discrete water-quality measurements (water temperature, dissolved oxygen, and salinity, including bottom salinity data

alongside grab samples, as well as interstitial salinity data at core stations) will be taken at each sampling event. Also qualitative appraisals of substratum composition, vegetation and other proximate structures, and a location (DGPS coordinates) of each sample will be taken.

Data analysis: Data checking and exploratory analysis will be carried out before formal statistical testing. Analysis of variance will be applied at univariate and multivariate level (Permanova routine can be used in both cases, using a pseudo-F statistic and permutations, thus avoiding assumptions of the parametric F-statistics) to assess the significance of possible impacts. The analysis will be carried out on univariate descriptors of the community (e.g., fish abundance, species richness, diversity, fish size) as well as on the multivariate structure of the assemblages.

The main aim of the analysis is to test for interactions between periods (before and afters) and treatment (controls and impacts) in order to assess whether temporal changes in the impacted areas are in line with changes at control areas (if not, i.e. an interaction exists, then an impact is assumed). Contrast between levels of the factors (e.g., impact sites and control sites). Both the p-values and size of any changes will be reported. Due to the difference sampling gear (with different selectivity) used in the intertidal and subtidal zones, the data collected in the two zones will be analysed separately and the patterns in the results will be compared.

6. 'Bird food' benthic target survey of NKM

Survey rationale: this survey has a completely different rational compared to the previously described surveys. The primary aim of this survey, in fact is not to allow the impact assessment of the development, but it is to quantify the benthic invertebrate food availability at the main bird feeding areas (particularly for Black-tailed Godwit) within the development area at NKM in order to set a benthic target for the compensation area.

The survey has been designed with three main objectives:

Obj. 1- To allow identification of an average benthic target for the compensation site reflecting the overall bird food availability at the mudflat area that will be lost or possibly affected by indirect impacts following the quay development at NKM.

Obj. 2- To better characterise higher value feeding grounds for Black-tailed Godwit (i.e. supporting higher numbers of feeding birds, according to the bird monitoring survey) present in sectors C and D at NKM, hence allowing the weighting of benthic targets based on hot spot feeding areas.

Obj. 3- To take into account natural inter-annual variability in food resources, in order to allow temporal adjustment of the target.

Sampling method: hand held corer (0.01 m^2), with sediment sampled to a depth of c.15 cm. Four replicate samples are collected at each station, 3 for benthic invertebrate analysis and 1 to characterise sediment (PSA and organic matter).

Sampling period: monitoring to be carried out annually, in late summer-early autumn (possibly between the last week of August and first week of September, just before the October peak use of the site by Black-tailed Godwit for feeding) during pre-construction (1 or 2 years, depending on when the construction works will start), construction (in control sites) and for 10 years post-construction (in control sites).

Sampling design: A stratified systematic design is suggested in order to take account of different shore elevation (upper, mid and low shore strata). Systematic design is devised as the best way to estimate population size of clustered (patchy) populations, allowing also to obtain data better suited for spatial analysis (Ware and Kenny 2011[3], Mier and Picquelle 2008[4] and references therein). In order to capture the patchiness of the benthic distribution in intertidal mudflats at NKM (target setting survey), the survey design aims at optimising the spatial resolution of the sampling, whereas replication at a single location is considered less

[3] Ware and Kenny 2011. Guidelines for the Conduct of Benthic Studies at Marine Aggregate Extraction Sites.

[4] Mier KL and Picquelle SJ, 2008. Estimating abundance of spatially aggregated populations: comparing adaptive sampling with other survey designs. Can. J. Fish. Aquat. Sci. 65, 176-197.

important in this instance (*sensu* Ware and Kenny 2011). The survey has been designed considering the three objectives highlighted above:

Obj. 1 – Stations are located on a regular grid on the mudflat area under the direct footprint of the developments and in adjacent areas possibly affected by it (sectors A to E). Nine transects are regularly spaced over the area (ca. 250m apart), and 9 stations are sampled at each transect (covering the high, mid and low shore levels) (tot. 81 stations). This design allows partial overlapping of stations with the reference (spring) intertidal survey at NKM, thus allowing also the identification of seasonal variability in benthic assemblages. The availability of reference spring and autumn data could be used to obtain not only standing stock data (B) but also a rough estimate of benthic secondary production (P) and productivity (P/B ratio) for target species (albeit it would be referred only to season between the two surveys), which characterise the functioning (dynamic) of the feeding area. However, in order to allow a better understanding of reference seasonal variability, additional transects might need to be added to the whole design to grant complete overlapping with existing transects from the spring reference. In addition, post-construction monitoring of the remaining stations that will not be lost under the footprint of the quay development would allow to identify changes in the benthic food availability in secondary feeding grounds and to relate them to any change in bird usage that might be observed during post-construction monitoring, thus supporting also the validation of predictions in the ES with regards to changes in sediment/benthos etc.

Obj. 2 – Four additional transects will be surveyed in sectors C and D, with stations distributed across three shore levels, as described above (tot. 36 stations). This would lead to a finer-meshed sampling grid in this area (with transects 125m apart, and a total of 117 stations surveyed over the whole NKM mudflat) for a more detailed characterisation of the spatial distribution and variability of benthic prey in this main feeding ground.

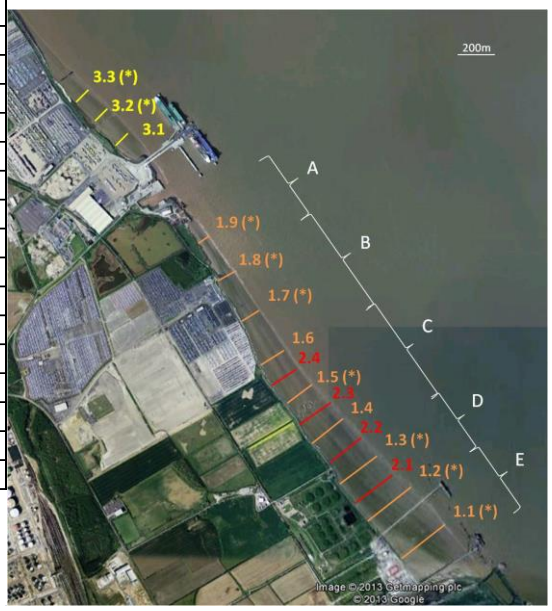
Obj. 3 – three transects regularly spaced (ca. 150m apart) will be surveyed in the control area located on the foreshore north of North Killingholme Haven Pits, with stations distributed across three shore levels, as described above (tot. 27 stations). This is also an area where Black-tailed Godwit have been seen feeding (Nick Cutts, pers. obs.) and the assessment of bird food availability in this feeding area during the 2013 survey and the monitoring of this area over the years (post-construction) would allow to identify natural background inter-annual fluctuations in benthic populations hence could be used to derive a correction factor for the target values to take into account this source of temporal variability. Similarly, control areas that would allow for the assessment of the temporal variability of mudflat benthic communities in the middle estuary are identified at CCS, these stations being included as reference stations in the monitoring of the compensation site (see Compensation EMMP).

The proposed survey design is summarised in Table A3.10 below and the indicative position of the sampling transects is shown on map Figure A3.11 (asterisk

indicates possible overlap with spring reference survey; white letters indicate the bird sectors). Control stations at CCS are not shown here, but their indicative location would be along the control transects identified in the intertidal impact assessment monitoring at CCS (with autumn monitoring, in this case).

	Number of stations by shore level stations				
Transect	Upper	Mid	Lower	Survey Objective	2010 monitoring zone
1.1	3	3	3	1	E
1.2	3	3	3	1 and 2	D
1.3	3	3	3	1 and 2	D
1.4	3	3	3	1 and 2	C
1.5	3	3	3	1 and 2	C
1.6	3	3	3	1	B
1.7	3	3	3	1	B
1.8	3	3	3	1	B
1.9	3	3	3	1	A
2.1	3	3	3	2	D
2.2	3	3	3	2	C
2.3	3	3	3	2	C
2.4	3	3	3	2	C
3.1	3	3	3	3	na
3.2	3	3	3	3	na
3.3	3	3	3	3	na

16 transects
3 strata (shore level) per transect = 48 sections
3 stations per section = 144 stations
1 sample per station = 144 samples



One sediment sample will be taken at each station for faunal analysis and an additional sample will be collected for PSA and organic matter analysis. Sample locations along transects will be recorded using DGPS.

Sample processing: Samples from different replicates should be kept separate. Benthic samples are to be sieved through a 0.5mm sieve. Laboratory analyses will include species (identified to highest taxonomic detail), abundance, size class and biomass (WWTB), with standard AFDW conversion factors applied (using, for example, Rumohr et al., 1987; Ricciardi and Bourget, 1998; and Eleftheriou and Basford, 1989).

Supporting parameters: Sediment particle size analysis and organic content will also be measured in the additional sediment sample. Additional supporting parameters recorded on site will include the recording of the character and composition of surface sediments (type, colour, smell), depth of RPD layer, texture and presence of surface features. A photographic record of the sampling station and of the sediment will be also collected.

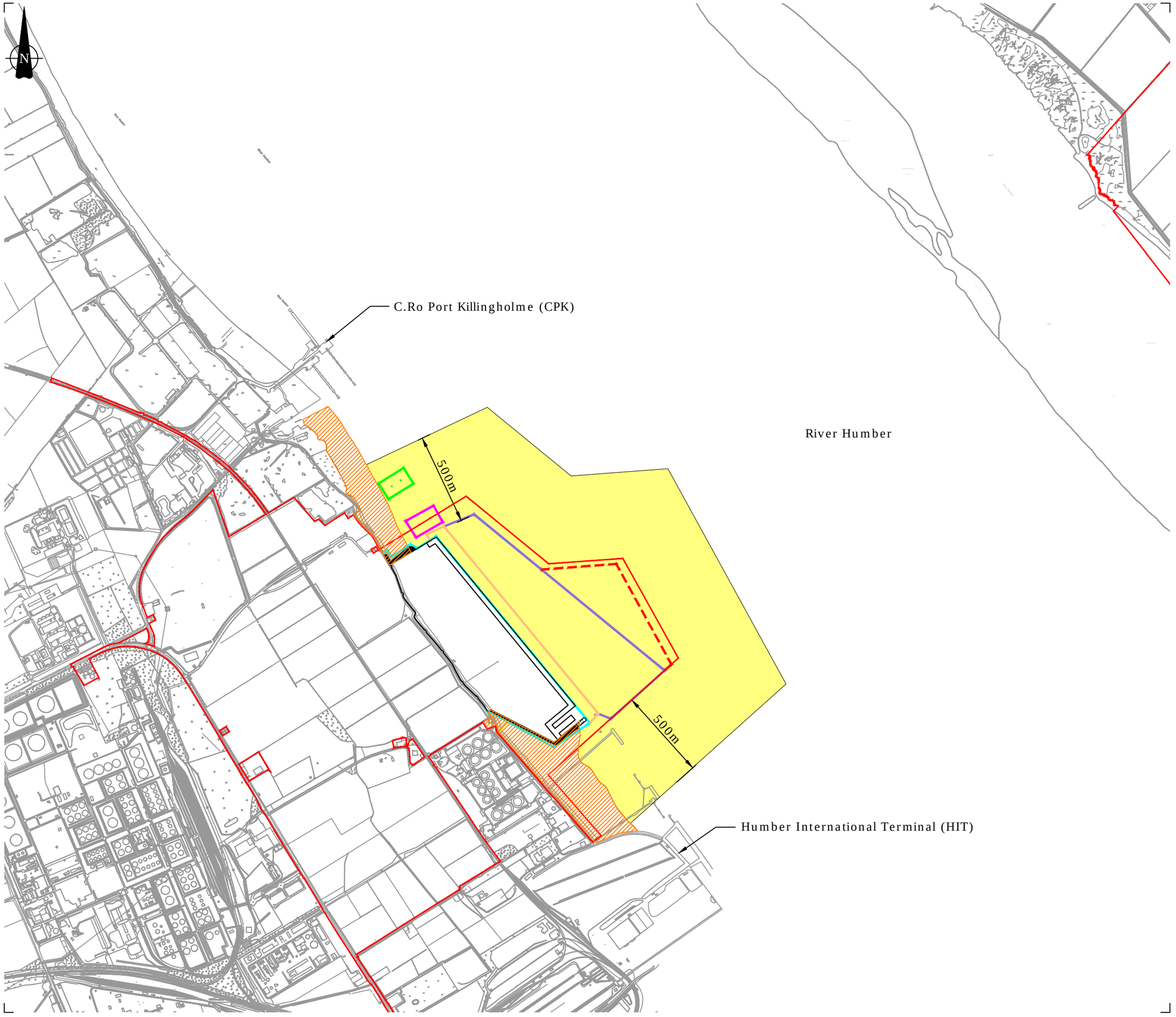
Data analysis: Data checking and exploratory analysis will be carried out before formal statistical testing. Standard univariate statistical analyses, either parametric (e.g., ANOVA, t-test) or non-parametric (e.g., Kruskal-Wallis test,

Mann-Whitney test, PERMANOVA) will then be applied to the data of abundance, richness, biomass, evenness, diversity and biomass-to-abundance ratio.

Multivariate analysis will be also carried out using cluster analysis (combined with similarity profile routine, SIMPROF) and ordination techniques (e.g., MDS, PCO) in order to identify different community types and gradients in the assemblage distribution/variation, as well as applying the SIMPER routine to identify the species which contribute most to the differentiations between groups. Multivariate statistical analysis (e.g., ANOSIM, PERMANOVA) will be applied to detect changes in community structure and composition. Bio-Env routine and linkage trees (BEST) in Primer will be used to explore the relationship between biotic (community) patterns and substrate characteristics. Based on these analyses, the main biotope(s) present in the site will be identified and their distribution over the NKM area will be presented in a biotope map to highlight the broad scale homogeneity in terms of MNCR biotopes. Also GIS methods will be used to present maps of the distribution of biomass/abundance/species diversity (e.g., using kernel density interpolation) in order to provide information on the spatial extent of what may be the hotspots of each parameter (biomass etc). Analysis will also be integrated with the findings of the intertidal LiDAR surveys as elevation change can influence benthic community structure hence food availability to bird species. Both the p-values and size of any changes will be reported.

Additional details on suggested methods to set and assess the targets are provided in Annex 3 of the CEMMP.

Appendix 4: Objectives Reference drawings



Key & Notes

Objective M7

Bathymetric Survey area

Intertidal area

Dredging Area

Centrica Outfall Maintenance Dredge Area

E.ON Outfall Maintenance Dredge Area

Pumping Station Outfall

Quay Limits

Berthing Pocket

Approach Channel

Turning Area

AMEP DCO Boundary

Scope of works

Bathymetric survey of the area shown at the following times:

Pre-construction: 1 month before commencement of marine construction works.

Construction: Fortnightly during capital dredging & 1 month after completion of capital dredge.

Post construction: Annually for 10 years post construction.

Rev.	Date	Comments	Drn	Chk	App
A	01.06.2015	For Approval	SDW	JM	RC

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Project: ABLE Marine Energy Park

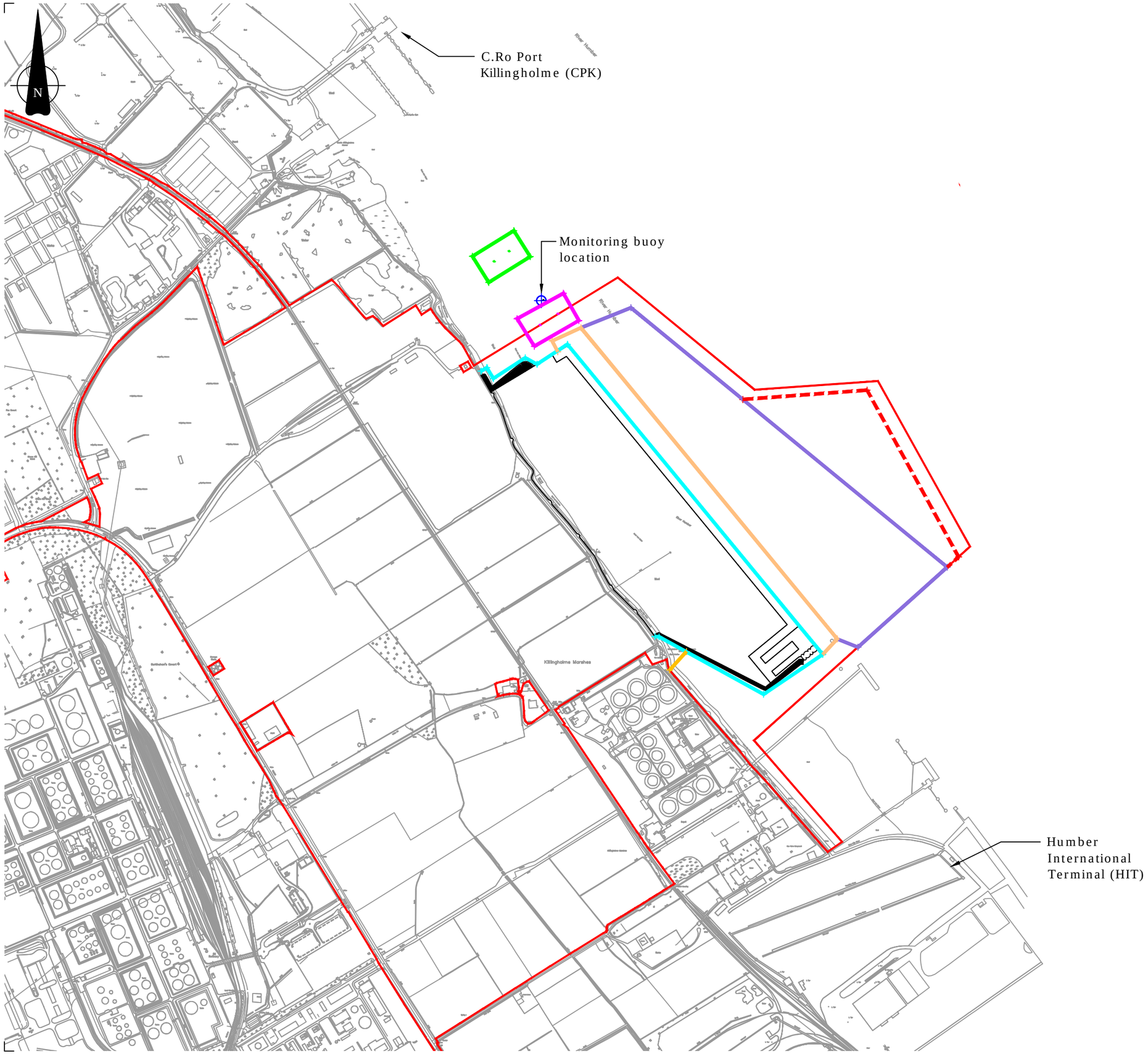
Client: ABLE Humber Ports Limited

Drawing Title: MEMMP Bathymetric Survey Area For AMEP Dredging (1 of 2)

FOR APPROVAL

Scale:	Drawn By	Checked By	Approved By
1:20,000 @A3	S. Walton	J. Monk	R. Cram
Date:	28.05.2015	28.05.2015	28.05.2015

Drawing No: AME-009-00088 Revision: A



Key & Notes

Objectives M1, M10 & M11

- Monitoring Buoy (water temperature, suspended solids, dissolved oxygen)
- Centrica Outfall Dredge Area
- E.ON Outfall Dredge Area
- AMEP DCO Boundary
- Berthing Pocket
- Approach Channel
- Turning Area

Scope of works

Monitoring buoy to be installed during 2016 following consultation with the Harbour Master and approval from the MMO.

Buoy to be retained until after the first maintenance dredge of the berthing pocket.

Rev.	Date	Comments	Drn	Chk	App
A	01.06.2015	For Approval	SDW	JM	RC

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Project: ABLE Marine Energy Park

Client: ABLE Humber Ports Limited

Drawing Title: Monitoring Buoy Location

FOR APPROVAL

Scale:	Drawn By	Checked By	Approved By
1:12,500 @A3	S.Walton	J. Monk	R. Cram
Date:	28.05.2015	28.05.2015	28.05.2015

Drawing No: AME-009-00079 Revision: A

APPENDIX 4 – PARTRAC 12 MONTH MONITORING REPORT

AMEP 'Limits of Acceptable Change' Assessment

March 2018

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David Sargent		x	
Neil Jarvis		x	
Holders of controlled copies will automatically be provided with subsequent approved versions of this document when they become available.			

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FIGURES

TABLES

ABBREVIATIONS

AMEP	Able Marine Energy Park
BGS	British Geological Survey
BODC	British Oceanographic Data Centre
DCO	Development Consent Order
DO	Dissolved Oxygen
EA	Environment Agency
EC	European Council
EIA	Environmental Impact Assessment
EMS	European Marine Site
HAT	Highest Astronomical Tide
H_{m0}	Significant wave height
LAT	Lowest Astronomical Tide
MMO	Marine Management Organisation
MEMMP	Marine Environmental Monitoring and Mitigation Plan
MHWS	Mean High Water Springs
MLWS	Mean Low Water Springs
NE	Natural England
NTSLF	National Tidal Sea Level Facility
UK	United Kingdom
SAC	Special Area of Conservation
SMP	Shoreline Management Plan
SPA	Special Protected Area
SSC	Suspended Sediment Concentration
SSSI	Site of Special Scientific Interest
TSS	Total Suspended Solids
Tz	Wave period (zero crossing)
WFD	Water Framework Directive

UNITS OF MEASUREMENT

Time	GMT
Position (geographical)	WGS84
Distance	Metres (m)
Total Suspended Solids (TSS)	Milligrams per litre (mg l^{-1})
Dissolved Oxygen (DO)	% Saturation or milligrams per litre (mg l^{-1})
Temperature (T)	Degrees Celsius
Salinity	Practical Salinity Units (PSU)

1. INTRODUCTION

The Able Marine Energy Park (AMEP) will provide a bespoke port facility designed to support the rapidly evolving marine renewable energy sector. The AMEP development, located on the south shore of the Humber Estuary, on the east coast of the United Kingdom (UK), comprises a marine energy park, logistics park and a quay development (Figure 1).

Figure 1. The ABLE Marine Energy Park development area positioned on the south shore of the Humber Estuary, East Coast of the United Kingdom. Source: ABLE UK (2018).

Though the development is now fully consented, there remains regulatory and stakeholder concern regarding the potential impact of capital and maintenance dredging activities required variously during the construction of the development. Firstly, there is broad concern regarding the impact of the development on conservation objectives (related to the Humber Estuary European Marine Site [EMS]) and Water Framework Directive (WFD) requirements; secondly, the potential impact of these activities on subtidal and intertidal conditions (e.g. mudflat elevation) and local communities (e.g. benthos and fish); and, finally the potential for these activities to impact upon the operation and maintenance of the E.ON UK and Centrica cooling water intake and outfall infrastructure. Due to these concerns, a compliance monitoring programme (AMEP, 2016) was developed to ensure predictions made in the Environmental Impact Assessment (EIA), were correct.

As part of the monitoring programme, Partrac was commissioned by ABLE UK to characterise the 'baseline' conditions pre-construction. To do this, a year-long monitoring campaign, utilising two strategically positioned monitoring systems, was conducted to collect continual measurements of several parameters associated with overall water quality, being:

- Dissolved Oxygen (DO)
- Water Temperature
- Total Suspended Solids (TSS)
- Salinity

Following completion of pre-construction monitoring ABLE UK commissioned Partrac to assess 'limits of acceptable change' in order to propose reasonable limiting thresholds for each

parameter against which the impact of capital and maintenance dredging activities can be measured/monitored.

1.1 Scope of Work

The overarching aim of this assessment was to propose reasonable limiting thresholds for each measured parameter for the purpose of regulatory and stakeholder review. The following key objectives were identified:

1. To assess the broader system and coastal setting to best understand the data collected during the monitoring campaign.
2. To review the measured data collected.
3. To assess how representative the data collected are.
4. Based on the foregoing analysis, recommend reasonable limiting thresholds for regulatory/stakeholder review.

2. THE HUMBER ESTUARY

The Humber Estuary is one of the largest estuaries in the UK and forms part of the boundary between the East Riding of Yorkshire on the north bank and Lincolnshire on the south bank (Figure 2). The estuary is formed at Trent Falls, Faxfleet at the confluence of the river Ouse and river Trent and extends from there to the mouth at the North Sea between Cleethorpes on the Lincolnshire coast and Spurn Head to the North. The Humber estuary drains an extensive catchment area, through numerous rivers and tributaries (e.g. the Aire, Derwent, Don, Ouse, Trent and Wharf) providing the largest single input of freshwater from Britain into the North Sea (Winn, no date). The estuary is navigable for even the largest of ocean-going vessels and thus is one of the UK's most important trade gateways with an average of 40,000 ship movements per year. Its ports and wharves handle 14% of the UK's international trade. As such much of the local area is industrialised and the estuary host's several large ports including Port of Hull, Port of Grimsby and Port of Immingham.

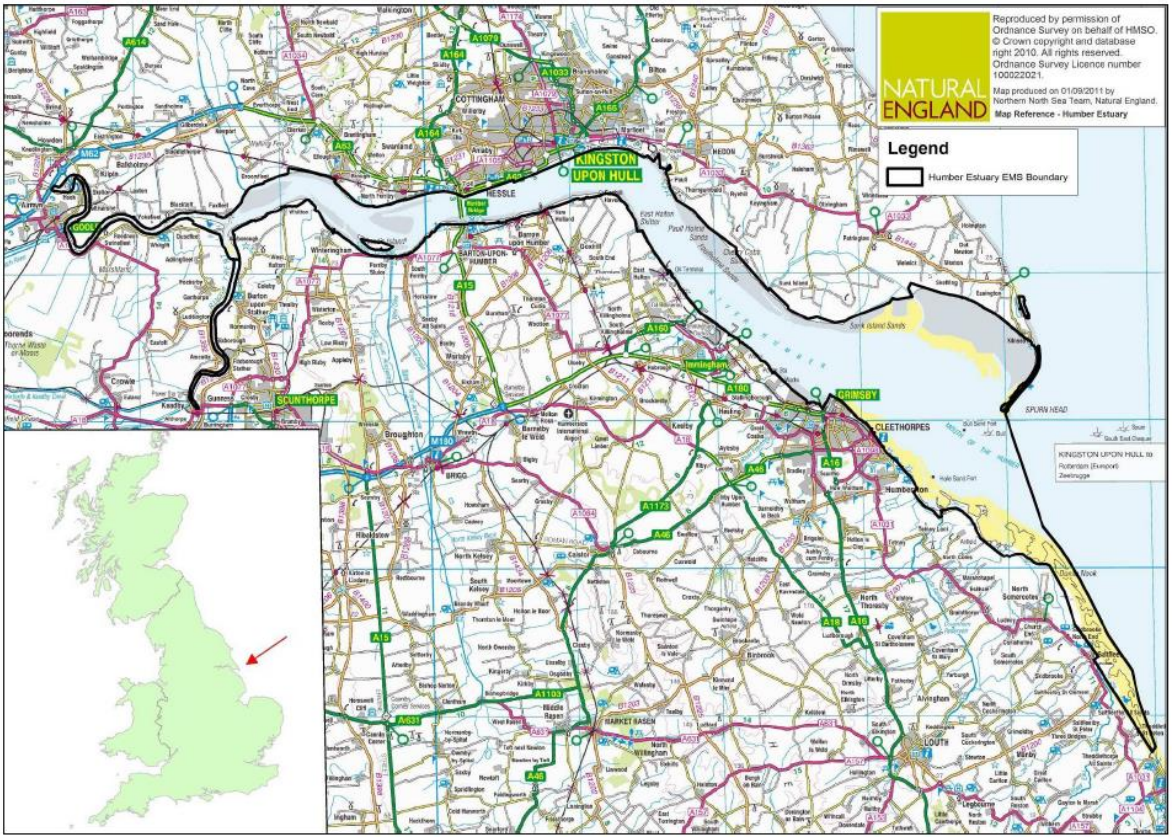

Figure 2. Humber Estuary. source: Humber Nature Partnership (no date)

The AMEP development is found within Sub-cell 2b according to the classification of Motyka and Brampton (1993) in their mapping of littoral cells report, delimited in the west by Immingham and in the east by Donna Nook (Figure 3). Within the local Shoreline Management Plan (SMP) [1], which covers the coastline from Flamborough Head to Gibraltar Point (including the outer

[1] The SMP provides a short, medium and long-term plan for managing coastal flood and erosion risk for a particular stretch of coastline.

Humber Estuary) the area of interest lies within Area 12: East Immingham to Grimsby Docks (Scott Wilson, 2010).

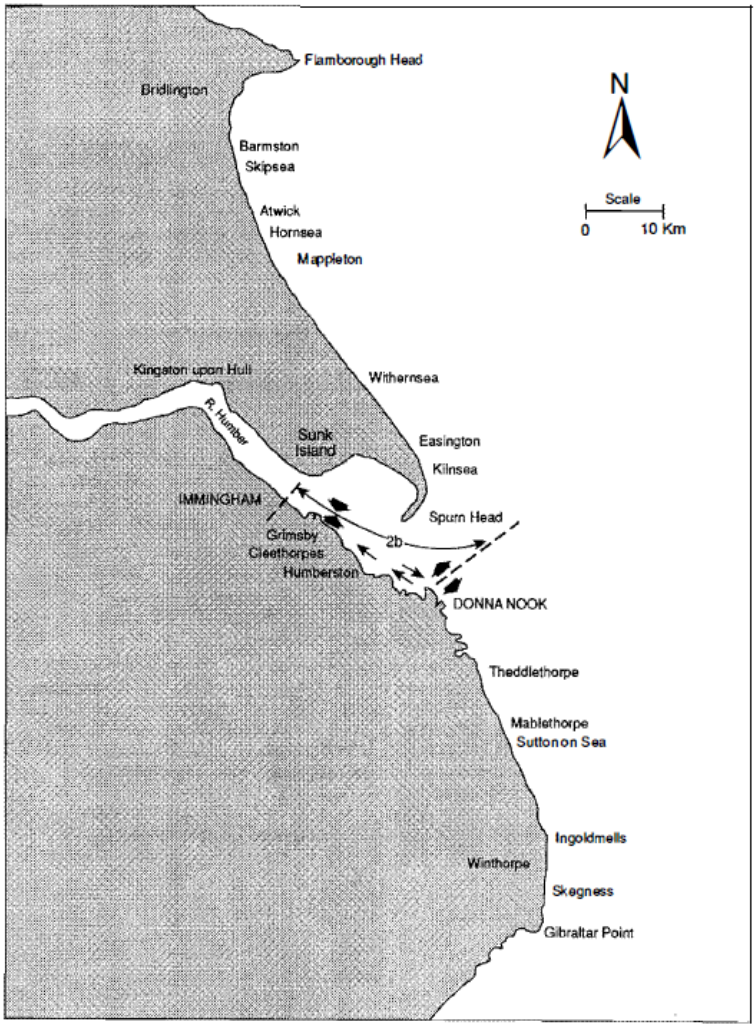

Figure 3. Coastal cell 2. Sub-cell 2b Immingham to Donna Nook. Source: Motyka and Brampton (1993).

Motyka and Brampton (1993) and the SMP (Scott Wilson, 2010) refer to the heavily industrialised nature of this section of coastline on the low-lying, south shore of the Humber Estuary. Broadly, within the estuary, the site is characterised by mud and sand shoreline and intertidal mudflat. Moving towards the mouth broad stretches of sand beaches appear backed by areas of saltmarsh. The areas of sand (which are generally accreting) towards Donna Nook provide a limited source of sand into the Humber Estuary via littoral drift (Motyka and Brampton, 1993). Variously, local waves and tidal flows mobilise and redistribute sediments within the estuary.

2.1 Local Geology and Surficial Sedimentology

Coastal plain estuaries are formed when pre-existing valleys were flooded at the end of the last period of glaciation. Broadly, the rivers of England and Wales flow into estuaries formed by Holocene submergence of their late Pleistocene valleys where subsequent fluvial deposition formed floodplains (Bird and Schwartz, 1985). In general, the Humber Estuary is characterised by surface soils and drift deposits overlaying bands of sedimentary rocks. However, in certain areas,

surface glacial till and/or boulder clay is underlain by a narrow chalk band (BGS, no date). Extensive areas of the estuary are exposed as mud- or sand-flats at low tide.

The Humber's 'famous' muddy appearance is due to the high suspended sediment load principally derived from the eroding boulder clay cliffs along the Holderness coast and multiple fluvial inputs. It has been estimated 1,500 tonnes of sediment are mobilised and transported during each tidal cycle (Humber Nature partnership, no date). The generally high suspended sediment concentrations observed within the system is principally the result of two mechanisms; being, 1) net sediment transport is landwards transporting sediments into the system and trapping fluvially derived sediments within the system; and, 2) a proportion of the suspended load (the smallest particles) are not deposited within the system, rather they remain in suspension. The Humber Estuary is infilling, but the source of these sediments is generally poorly understood (Winn, no date). Three potential sediment sources exist, and these include sediments from fluvial inputs, sediments derived from coastal erosion and marine sediments from the North Sea. A sediment fingerprinting[2] study conducted by Cox (1999) estimated source contributions of ~ 90 % Holderness till and ~ 10% fluvial inputs, whilst Townend and Whitehead (2003) suggested fluvial inputs accounted for closer to 5% of the total sediment load.

2.2 Hydraulic Processes

An understanding of the hydrodynamic regime in the area is afforded through inspection of the outputs of the Atlas of UK Marine Renewable Energy Resources (ABPmer, 2008). The 'atlas' is a coarse hydrodynamic wave model which was originally developed to define the marine renewable energy resource at a regional scale. In addition, variously, other data sources have been utilised (i.e. British Oceanographic Data Centre [BODC], National Tidal and Sea Level Facility [NTSLF]).

2.2.1 Water Level

The tidal cycle experienced in Sub-cell 2b has a period of ca. 12.4 hours. The Humber Estuary is macro-tidal, the mean spring tidal range and neap tidal range at Immingham (the nearest permanent tide gauge operated by NTSLF), being ca. 6.2m and 3.2m, respectively. Tidal levels garnered from the NTSLF tide gauge are detailed in Table 1. It is of note, during extreme events (i.e. surges generated by meteorological forcing or high rainfall in the catchment) water levels can increase by up to ca, 3 m (Winn, no date). For example, Figure 4 shows the latest (at time of writing) surge forecast for Immingham, showing tide height was forecast to increase by > 0.5 m on the 1st February 2018.

Table 1. Tidal Levels (m) at Immingham 2008 - 2026. Source: National Tidal Sea Level Facility (2018a).

Gauge location	LAT (m)	MLWS (m)	MLWN (m)	MHWN (m)	MHWS (m)	HAT (m)
Immingham (Humber Estuary)	0.16	1.04	2.60	5.78	7.22	7.99

[2] Sediment fingerprinting techniques can distinguish the sediment source based upon the distinctive properties of the sediment source (i.e. geochemical or mineralogical properties). This enables the broad sediment source to be determined.

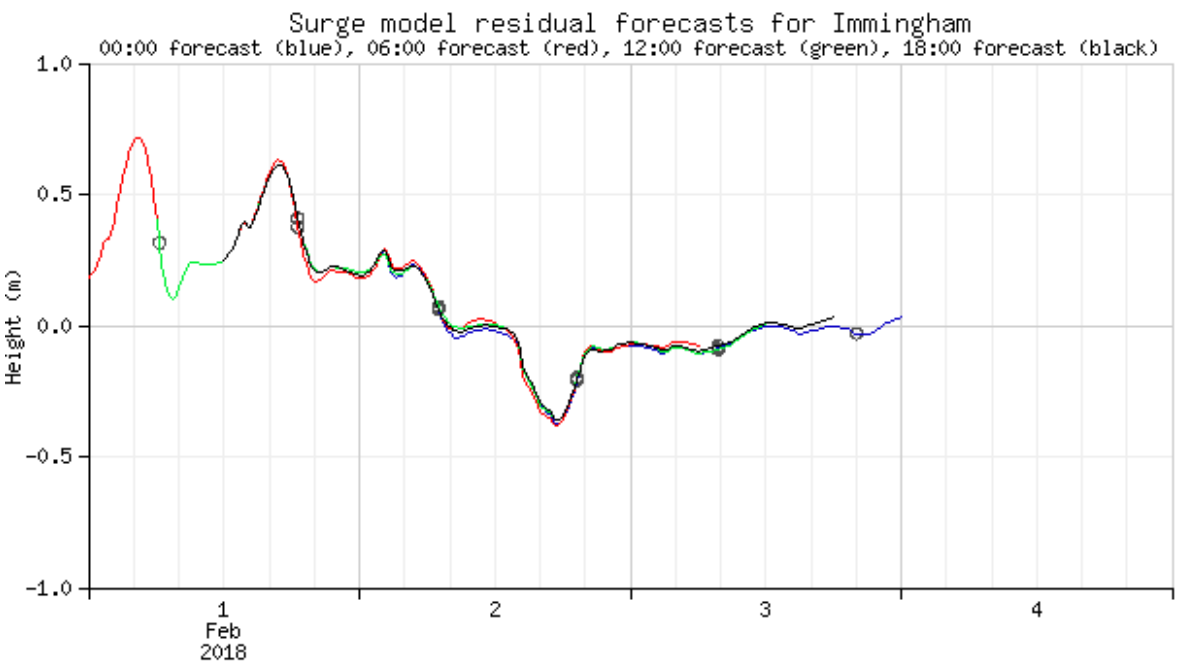

Figure 4. The latest surge forecast for Immingham. Data source: National Tidal Sea Level Facility (2018), last accessed 02/02/2018.

2.2.2 Tidal Flows

The Humber Estuary is a flood dominated system (JBA, 2011). Tidal currents within the area are variable due to differences in seabed type, water depths and distance from land, but typically peak spring flows range from circa 0.1 – 1.1 m s^{-1} with the mean peak spring current magnitude being 0.4 ms^{-1} (see Figure 5 and Table 2). Due to the relatively low tidal current magnitudes within the Humber Estuary, meteorological[3], wind and wave-induced currents will have proportionately more significant effect on current velocities.

[3] In addition to astronomically driven tidal currents, meteorological forcing (which generates phenomena known as 'surges') may also cause additional currents which may be greater in magnitude relative to the astronomical currents (Flather, 1987).

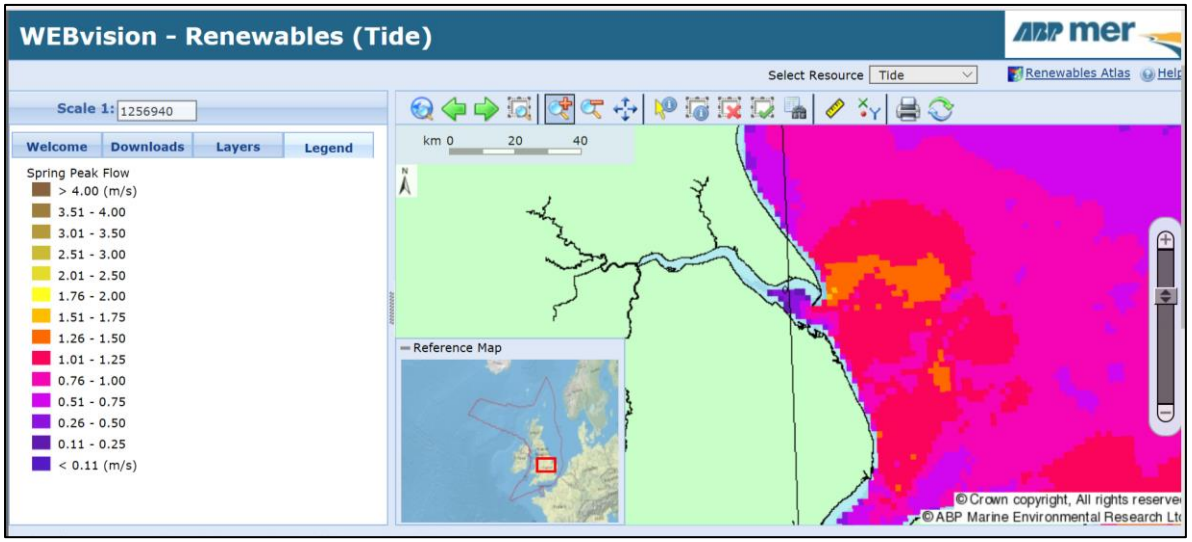

Figure 5. The peak spring tidal flow velocities in the area of the Humber Estuary. Reproduced from [redacted] / © Crown Copyright.

Table 2. The mean Spring peak tidal flows. Data garnered from each model grid node located within the Humber Estuary. Data source: Atlas of UK Marine Renewable Energy Resources (2008).

Grid node id no	Distance from nearest land (m)	Average depth (m)	Mean Spring peak flow (m s^{-1})
122664	1139	6	0.23
121649	758	6	0.34
122154	2234	9	0.67
122661	2553	11	0.81
123169	2467	13	0.84
121652	4042	13	0.31
122157	2486	12	0.37
120648	381	6	0.24
121149	1778	8	0.32
121651	3096	12	0.41
122156	2225	14	0.52
122663	569	11	0.66
120647	0	3	0.14
121148	623	4	0.38
121650	1880	8	0.49
122155	2334	12	0.60
122662	877	13	0.88
123170	612	13	1.06
122660	948	7	0.44

Grid node id no	Distance from nearest land (m)	Average depth (m)	Mean Spring peak flow ($m\ s^{-1}$)
123168	1290	8	0.59
119165	1264	9	0.12
119656	1511	10	0.26
120151	1532	11	0.26
120650	2113	11	0.26
121151	2700	9	0.28
121653	3127	8	0.21
122158	2525	5	0.19
120150	561	8	0.23
120649	1739	10	0.30
121150	2815	12	0.30

2.2.3 Waves

Inspection of the wave data available from the Atlas of UK Marine Renewable Energy Resources (ABPmer, 2008), provide a useful high-level overview of the offshore wave climate in the area of the Humber Estuary. The data shows mean annual significant wave heights (H_{m0}) of ~ 1.0 m (Figure 6).

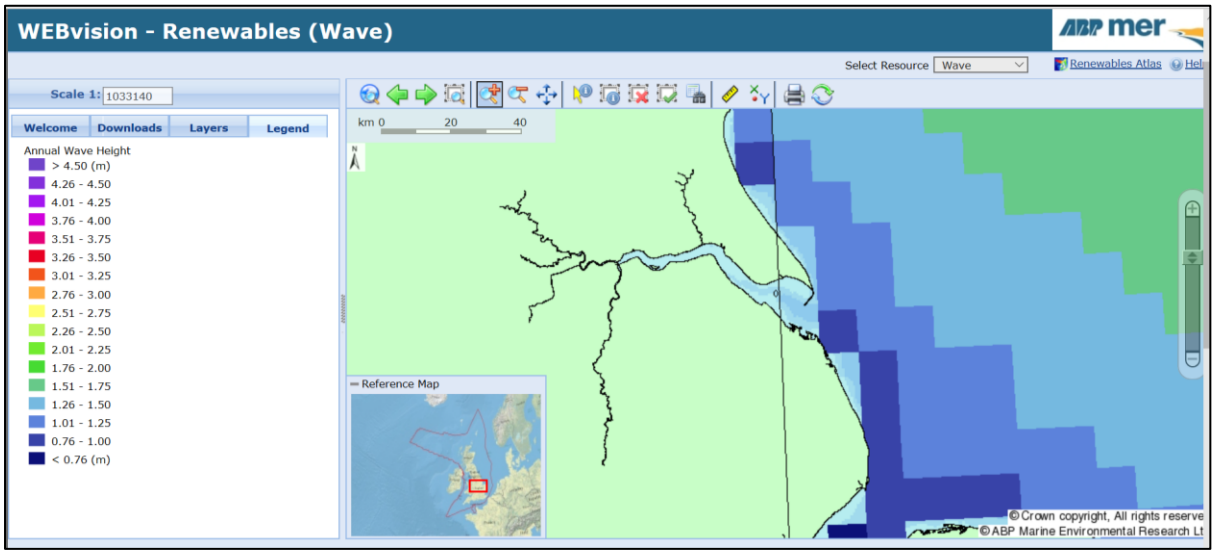

Figure 6. The mean significant annual wave height around the Humber Estuary. Reproduced from [redacted] © Crown Copyright.

Further information is garnered from two historic instrument deployments at the mouth of the estuary. Figure 7 shows the location of the two instruments.

Figure 7. The location of the 'Spurn Head' (north) and 'Donna Nook' (south) deployments. The instrument locations are identifiable by the two green dots. Source: CEFAS (2018).

The historic record of wave heights revealed significant wave heights (H_{m0}~1-2 m) with periods of ~3 – 5 s, and largest waves of the order 2-3 m with associated periods of ~5-7 s (Figure 8). It is likely a strong seasonal divide in wave energy exists with the highest incident energy experienced in the late winter months (i.e. due to a combination of higher, longer period waves occurring during the winter months). It was noted by Winn (no date) that waves of up to 4 m high can occur in the outer estuary but these are reduced to ~ 1m in height as they propagate upstream.

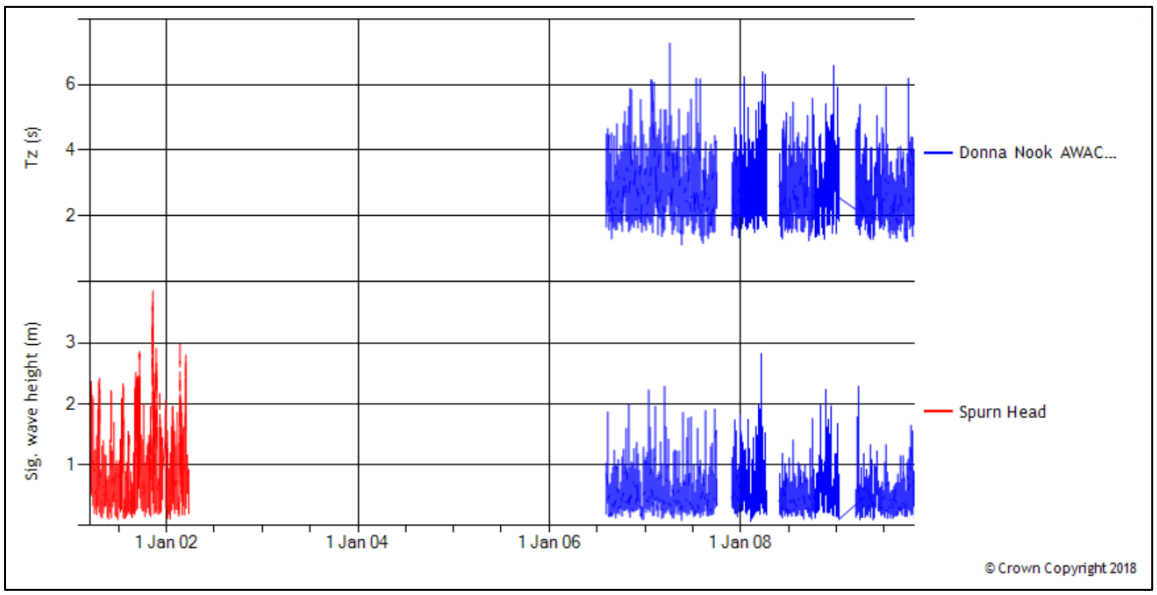

Figure 8. A time-series of average (zero crossing) wave period (*Tz*) (top) and significant wave height (bottom) from the historic deployments at Spurn Head (Wave buoy) and Donna Nook (Automated Wave and Current Meter [AWAC]). Data source: CEFAS (2018).

2.3 Designations

The Humber Estuary supports a rich variety of habitats and species and as such is considered internationally important for wildlife and is designated as a European Marine Site (EMS). The Humber Estuary itself is also designated as a Special Area of Conservation (SAC) and Special Protection Area (SPA) under the European Council (EC) habitats regulations. Further, the estuary is considered an internationally important wetland under the Ramsar Convention and is designated as a Site of Special Scientific Interest (SSSI) under the Wildlife and Countryside Act (1981). Table 3 summarises the designations assigned to the Humber Estuary and Table 4 details some of the key designated features and protected species which inhabit the estuary.

Table 3. A summary of the designations assigned to the Humber Estuary. Source: Scott Wilson (2010)

Designation	Spatial extent (hectares)	Key features
SAC	36,657	- Intertidal mud and sand flats - Coastal lagoons - Salt meadows and saltmarsh vegetation colonising mud and sandflats - Several protected species
SPA	37,630	- Supports populations of Annex 1 protected species - Supports populations of Annex 2 protected species
RAMSAR	37,988	- Assemblages of international importance and species/populations occurring at levels of international importance - In addition to several bird species (grey seal, river and sea lamprey)
SSSI	37,000	- Nationally important site

Table 4. Key designated features within the Humber Estuary (Humber Nature Partnership, no date)

Feature	Notes
Humber Estuary	- Second largest coastal plain estuary in the UK
Mud and sand flats	- Extensive intertidal mudflats and sandflats which are submerged at high tide and exposed at low tide - Represents 4.5% of the UK's total mud and sandflat resource
Saline lagoons	- Bodies of saline water separated from the sea by a physical land barrier - Rare habitat supporting specialist species and biotopes - Humber estuary supports 10% of the total UK resource of coastal lagoons
Saltmarsh	- Circa 630 hectares of saltmarsh on the Humber - Rare saltmarsh composition compared to other UK estuaries - Extensive areas of saltmarsh lost due to land reclamation
Sub-tidal sandbanks	- A series of permanently submerged, highly dynamic, sub-tidal sandbanks
Breeding birds	4 species of breeding birds designated as part of the Humber SPA: - Avocet - Bittern - Marsh Harriers - Little terns
Wintering and passage birds	- Humber Estuary plays an international role in bird migration and is considered one of the most important wetland sites in the UK - Provides a safe feeding and roosting area for species moving from breeding sites in the arctic to wintering grounds in southern Europe and Africa - Bird numbers can reach annual peak of ~130,000
Grey seals	- Largest and most abundant of the two-seal species found in British waters - The main 'haul out' spot for the grey seal in the area is the beach at Donna Nook
River and sea lamprey	- Lamprey are a member of the jawless fishes' family (Petromyzonidae) - Estuaries are considered important migratory routes for the species

2.4 Sensitive Receptors

The local sensitive receptors which have the potential to be impacted by these works are described in the Marine Environmental Management and Monitoring Plan (MEMMP) (AMEP, 2016). Table 5 summarises these receptors and the potential impacts of particular concern identified by the regulators (Natural England [NE], Marine Management Organisation [MMO] and Environment Agency [EA]) and noted in the MEMMP).

Table 5. Sensitive receptors in the vicinity of the AMEP development.

Receptor	Activity of principal concern	Potential impacts identified
The seabed and foreshore	Capital and maintenance dredging	- Localised impacts on intertidal and subtidal habitats - Changes in local sediment conditions - Reduction of ecological potential under the Water Framework Directive (WFD) - Deleteriously affecting the operation of the E.ON and Centrica intake and outfall operation
Saltmarsh and mudflats	Capital and maintenance dredging	- Reduction of ecological potential under the Water Framework Directive (WFD)
Benthic communities (intertidal and sub-tidal	Capital and maintenance dredging Impact of development longer term	- Loss of habitat (i.e. transformation of intertidal mudflat to saltmarsh) - Permanent loss of intertidal and subtidal habitat - Dredging activities leading to smothering of intertidal and subtidal benthos - Reduction of ecological potential under the Water Framework Directive (WFD)
Fish communities	Capital and maintenance dredging Impact of development longer term	- Smothering of subtidal benthos - Reduction of ecological potential under the Water Framework Directive (WFD)

3. MONITORING

The AMEP Development Consent Order [DCO] (AMEP, 2014) defined the requirements of this part of the compliance monitoring programme, as being, to monitor the water temperature and dissolved oxygen levels (DCO Schedule 8, part 4, para. 39), and suspended solids (DCO Schedule 11, para 36, 38, 39), during the construction phase of the AMEP development. To assess the potential impact of construction activities a robust understanding of the natural variation in these parameters is required. Thus, Able UK commissioned Partrac to conduct a year-long baseline monitoring campaign to continually measure these parameters at locations near the AMEP development site: Two monitoring systems were installed, one fixed, jetty-mounted, system positioned on South Killingholme Jetty, and a buoy-mounted system deployed in the Humber Estuary between North Killingholme Haven and South Killingholme Jetty (Figure 9).

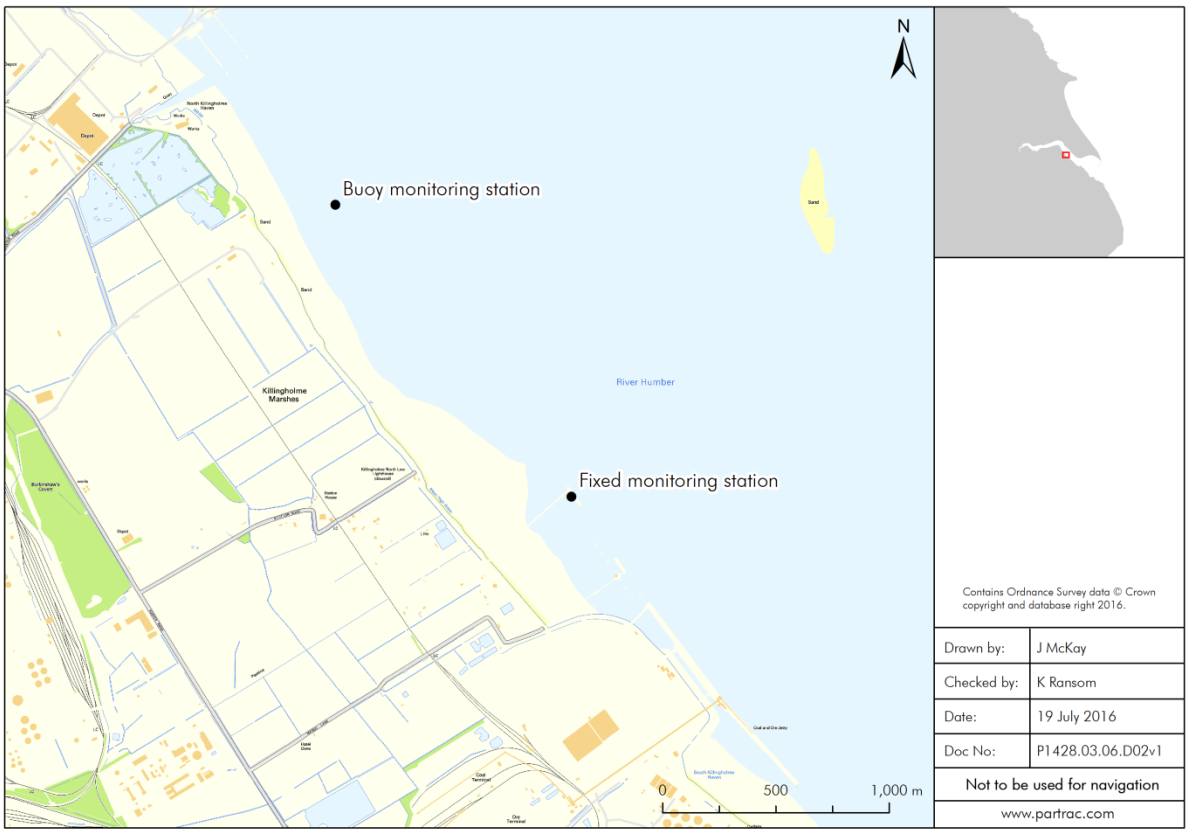

Figure 9. Location of the buoy and fixed (jetty) monitoring stations.

The fixed jetty-mounted monitoring station comprised of a YSI EXO2 multi-parameter sonde[4] installed on the western side of the jetty, a telemetry unit positioned on the jetty approach walkway, and an EXO2 data transmission cable installed in cable routing running from the EXO2 sonde to the telemetry unit. The sonde was deployed within a protective pipe secured to a jetty head ladder at a depth of approximately 1.2 m below Lowest Astronomical Tide (LAT).

[4] The YSI EXO2 sonde (and associated sensors) measure Dissolved Oxygen (DO), water temperature, turbidity and salinity at each station (jetty and buoy). The telemetry unit for both stations logged sonde data and transmitted data over the GPRS network. Throughout the monitoring period real-time data was made accessible via a web portal.

The floating station was installed on a specialised pontoon buoy near Centrica/EON intake/outfall pipes and included a YSI EXO2 multi-parameter sonde and telemetry unit. The sensors of the EXO2 sonde were deployed below the buoy at a depth of approximately 1.2 m below water level. The buoy was anchored to the river bed via a chain. The mooring was specifically designed to minimise the potential drift of the buoy during low water, changing water levels and periods of high wave activity.

For a full description of system servicing, TSS conversion methodologies and monthly data refer to the monthly reports provided as part of this monitoring programme (Partrac, 2017). It is noteworthy that the data collected throughout the period of baseline monitoring, for certain parameters (DO and water temperature), were reported against pre-existing limiting thresholds previously defined in the DCO (AMEP, 2014), and referenced in the MEMMP (AMEP, 2016). Table 6 details these limiting thresholds.

Table 6. The limiting thresholds as defined in the AMEP development DCO (AMEP, 2014).

Parameter	Limiting threshold as defined in the DCO (AMEP, 2014)
Dissolved oxygen	5 mg l^{-1} (to not reduce to)
Water temperature	21.5^{0}C (to not exceed)
Total Suspended Solids	-
Salinity	-

4. RESULTS

Figure 10 - Figure 13 present time series plots showing the variation of water temperature, salinity, TSS and dissolved oxygen (concentration and saturation), measured by the buoy and jetty monitoring system over the entire baseline monitoring period (1 year). Significant points to note from the measured data are:

- As would be expected, considering the close proximity of each system, there is generally a strong correlation between the data collected by the buoy and fixed jetty monitoring systems (see Figure 10 - Figure 13). Though, slightly increased TSS levels are observed at the jetty site (in comparison to the buoy site) with the maximum observed TSS values at the buoy and jetty site being 2887 mg l^{-1} and 3303 mg l^{-1}, respectively. This is likely due to the shallower water depths at the jetty site.
- Clear seasonal trends are observed throughout the datasets (Figure 10 - Figure 13). For example, Figure 10 reveals that the water temperature dropped to ~ 4^0C in the winter months and peaked at ~ 20^0C in the summer months. Further, salinity reduced throughout the winter period likely due to an increased freshwater input to the system (Figure 11). This in turn, acts to increase DO reflecting greater oxygen solubility with decreasing salinity (Figure 13). Finally, TSS is also enhanced in the winter months principally due to the generally increased hydrodynamic and meteorological forcing experienced during this period (Figure 12).
- Inspection of the TSS dataset reveals the impact of the tidal cycle, with increased TSS observed during the spring tidal cycle in comparison to the neap tidal cycle due to increased tidal forcing.
- At no point, were values recorded which exceeded (or dropped below) the limiting thresholds defined in the DCO (AMEP, 2014) and MEMMP (AMEP, 2016), detailed in Table 6.

Table 7 presents the key statistics in regard to the measured parameters from the buoy and jetty monitoring systems. The overall data return and data quality is detailed in appendix 1.

Figure 10. Annual time series of water temperature measured by the buoy and jetty system. The green line indicates the limiting threshold defined in the AMEP Development Consent Order (being water temperature must not reach 21.5 ^{0}C).

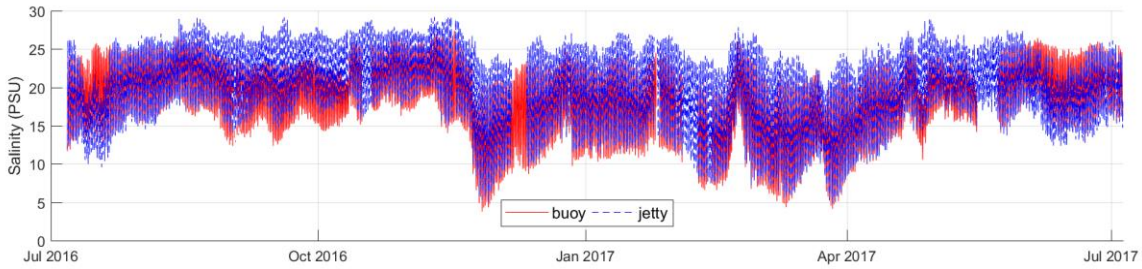

Figure 11. Annual time series of salinity measured by the buoy and jetty system.

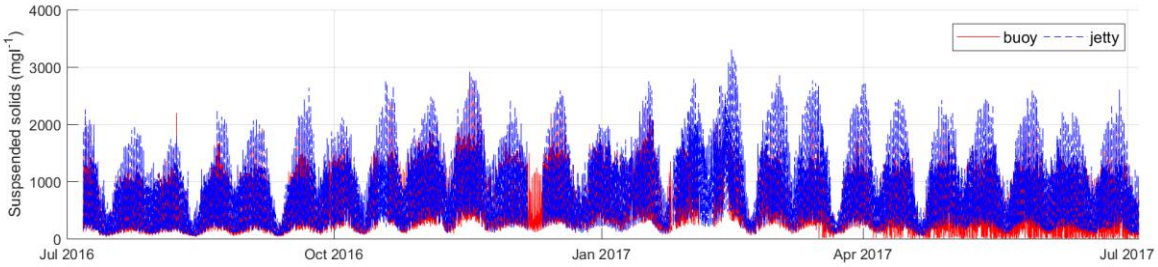

Figure 12. Annual time series of Total Suspended Solids (TSS) measured by the buoy and jetty system.

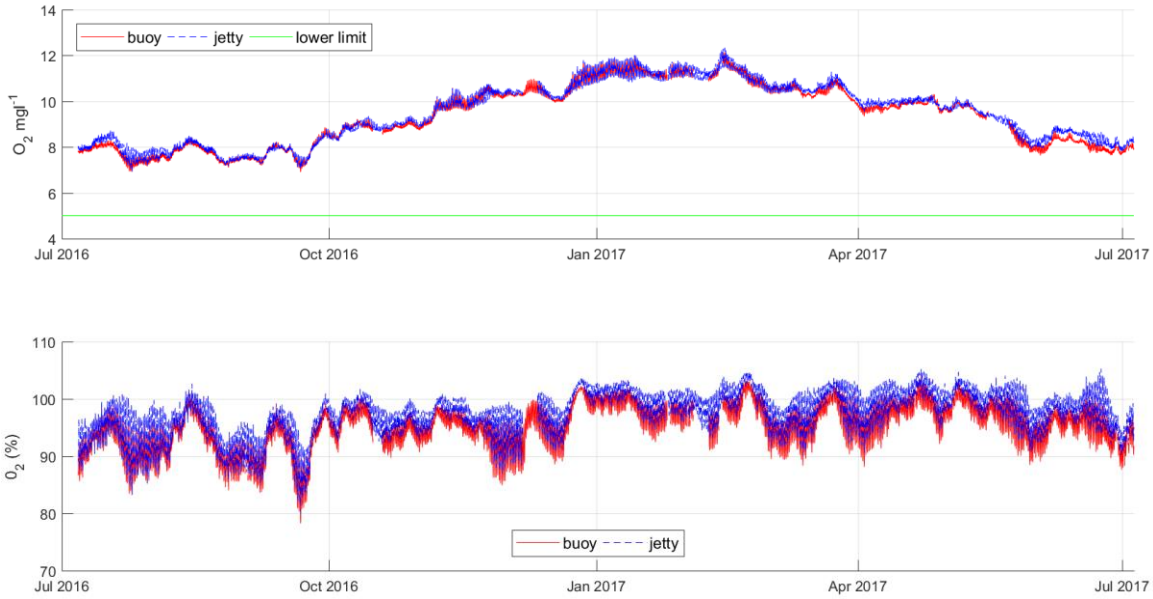

Figure 13. Annual time series of Dissolved Oxygen (concentration [top], percentage saturation [bottom]) measured by the buoy and jetty system. The green line on the top plot indicates the limiting threshold defined in the AMEP Development Consent Order (being dissolved oxygen must not drop to below 5 mg l^{-1}).

Table 7. Key annual statistics related to measured parameters (TSS, DO, temperature and salinity) derived from the buoy and jetty monitoring systems.

Parameter	Buoy Sensor Statistics								
	Min	Mean	Max	StDev	5th percentile	10th percentile	90th percentile	95th percentile	99th percentile
Sea Temperature (°C)	4	12	20	5	4	5	18	19	19
Salinity (PSU)	3	18	27	4	10	12	24	25	26
Dissolved Oxygen (%)	7	9	12	1	7	8	11	11	12
Dissolved Oxygen (mg l^{-1})	78	95	104	4	88	90	100	101	102
Total Suspended Solids (mg l^{-1})	0	502	2888	403	87	121	1139	1338	1676
Parameter	Jetty Sensor Statistics								
	Min	Mean	Max	StDev	5th percentile	10th percentile	90th percentile	95th percentile	99th percentile
Sea Temperature (°C)	4	12	20	5	4	5	18	19	19
Salinity (PSU)	5	20	29	5	11	13	26	26	28
Dissolved Oxygen (%)	7	9	12	1	7	7	11	11	12
Dissolved Oxygen (mg l^{-1})	80	97	105	4	90	92	102	103	104
Total Suspended Solids (mg l^{-1})	38	812	3303	539	144	200	1556	1846	2368

4.1 Is The Data Representative?

As the baseline data was only collected over a single year, there is a requirement to contextualise[5] the data to assess how representative, the data collected are. This assessment is crucial to postulate upon reasonable limiting thresholds. To do this, the baseline descriptions and data reported in the water and sediment quality chapter of the EIA (ERM, 2013) were inspected and compared with the measured data. Broadly, the measured and historic data correlate (see Table 8).

[5] Though efforts have been made to contextualise the measured data, correlating periods of likely 'high' or 'extreme' meteorological forcing (e.g. surges or significant rainfall events) or hydrodynamic forcing (i.e. equinoctial tides or high wave events) to variation in the measured parameters (i.e. DO, temperature and TSS) was considered beyond the scope of this assessment.

Table 8. Comparison between the measured data and the historic data/information.

Parameter	Measured data (range)	Historic data/information	Data source	Is there agreement?
Dissolved oxygen ($mg\ l^{-1}$)	78 - 105	- Dissolved oxygen levels in the nearest WFD surface water body (North Killingholme main drain), were recorded as good*. - Dissolved oxygen for the Humber Estuary Lower unit is defined as "high" under the WFD. - Historically, occasional failures in the upper estuary have been recorded.	ERM (2013)	✓
Water temperature (^0C)	3.7 – 20.3	- 3.3 - 20.8	EA (2007)	✓
Total Suspended Solids ($mg\ l^{-1}$)	0 – 3303	- 5000 – 14000 (@ the turbidity maximum zone) - 100 – 500 (@ neap tides) - 600 – 800 (@ spring tides) - 1 – 4000 (@ various sites within the estuary. Note, it is likely that the maximum range of the instrument used within this analysis was reached and thus maximum values may have exceeded the reported value.)	Boyes and Elliott (2006) IECS (2010) EA (2007)	✓
Salinity[6] (PSU)	3.7 – 27.4	-	-	n/a

* Within UKTAG (2008), a minimum standard of 4 mg l^{-1} dissolved oxygen (95 percentile) is identified at the good-moderate status boundary in fully marine waters, rising to 5 mg l^{-1} in low salinity waters.

In addition, the Humber Estuary has been extensively studied through the years and thus to contextualise the data record further data/information has been garnered from various academic studies and government reports (i.e. National Rivers Authority [1986,1992]; Morris & Mitchell [2005]; Uncles *et al* [2001]; Wass and Leeks [1999]; Pontee *et al* [2004]; and, Mitchell [2005]).

Historic monitoring data is presented by the National Rivers Authority (1986, 1992). The authority undertook regular monitoring to inform the assessment of the overall water quality of the Humber Estuary. Figure 14 and Figure 15 present water temperature and DO data from these assessments. The data presented from the Killingholme monitoring station show the temperature was ~ 17 – 18 ^0C (Figure 14), with saturated dissolved oxygen ranging from ~ 60 – 85 % across the tidal cycle (Figure 14 and Figure 15). Again, these data correlate reasonably well with measured data (see Table 7 and Table 8), though the historic DO (saturation) data is slightly reduced in

[6] The Humber is generally a well-mixed estuary with salinity varying by less than 5 per cent with depth (ABP, 2018), though in some areas wide salinity fluctuations are observed (National Rivers Authority, 1986). The salinity data collected is considered a representative record of seasonal salinity fluctuation at two nearshore locations, towards the mouth of the Humber estuary. Salinity data recorded throughout the study has been presented as it provides useful information to contextualise other measured data (i.e. DO data). It is the authors' understanding that variation in the salinity of the water body is not of direct regulatory or stakeholder concern and as such no limiting threshold is presented and salinity is not discussed further in this assessment.

comparison to the baseline record. It is postulated that this may be an indicator of the improved status of the waterbody following the inception of the WFD (DO levels are described as 'high' and the surface water body of North Killingholme main drain described as 'good', in an ecological sense (ERM, 2013)).

STATION	TEMPERATURE C			DISSOLVED OXYGEN (% SATURATION)		
	MAXIMUM			5 PERCENTILE		
	LOW TIDE	HIGH TIDE	ALL TIDES	LOW TIDE	HIGH TIDE	ALL TIDES
TIDAL RIVERS						
OUSE						
Cawood	20	19.5	20	87	21	21
Selby	18.9	19	19	53	11	11
Drax	18.5	19	19	29	24	24
Boothferry	18	18	18	16	31	16
Blacktoft	17.5	17.6	17.6	52	68	52
AIRE						
Snaith	18	19.5	19.5	58	22	22
DON						
Kirk Bramwith	18.9	18.9	18.9	70	68	68
Rawcliffe	18	18	18	44	58	44
TRENT						
Dunham	20	-	20	90	-	90
Gainsborough	19	20	20	84	66	66
Keadby	19	18	19	65	63	63
WHARFE						
Ryther	18.4	19.8	19.8	69	75	69
EQS			25			40
ESTUARY						
Brough	-	17	17	-	62	62
New Holland	17.9	17.5	17.9	80	80	80
Albert Dock	17.8	17	17.8	71	72	71
Saltend	18	17	18	83	74	74
Killingholme	18.2	17.5	18.2	64	82	64
Spurn	18	17	18	91	83	83
EQS			25			55

T = TOTAL D = DISSOLVED

Figure 14. Historic water temperature and dissolved oxygen data from various monitoring stations located within the Humber Estuary. The red box highlights the data collected from within the Humber Estuary and the green box highlights the monitoring station closest to the AMEP development (Killingholme). Data source: National Rivers Authority (1992)

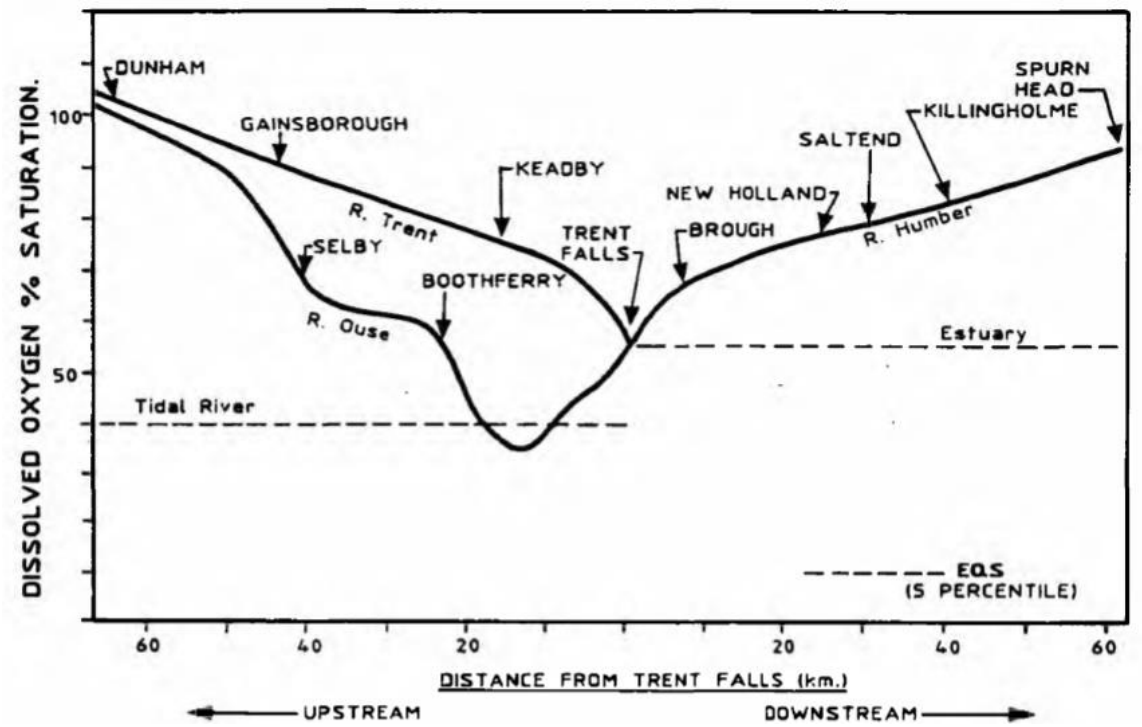

Figure 15. Dissolved Oxygen profile from the 16th June 1986 @ low water. Data source: National Rivers Authority (1986).

Suspended Sediment Concentrations (SSCs) (i.e. TSS) in the Humber Estuary are amongst the highest in the UK and are also noteworthy in a global context (Morris & Mitchell, 2013). Uncles et al (2001) analysed turbidity phenomenon in 48 estuary systems and report the Humber Estuary to have the third highest depth-mean SSC. During the baseline monitoring period TSS ranged from 0 – 3303 mg l^{-1}, with a mean concentration of 502 and 812 mg l^{-1} recorded by the buoy and jetty monitoring systems, respectively. Within the dataset clear tidal and seasonal trends are observed, with increased TSS values recorded during periods of higher tidal and meteorological forcing (i.e. during the spring tidal cycle and during the winter months). The measured data correlated strongly with the data presented in the EIA (ERM, 2013), though higher TSS levels were reported both from fixed point monitoring stations [> 4000 mg l^{-1}] and from within the turbidity maximum[7] [> 5000 mg l^{-1}] (see Table 8). These data indicate that the potential exists for TSS values to exceed the maximum value measured during the baseline monitoring period. Such variation in TSS values is a function of water depth, hydraulic and biological characteristics of the surficial sediments, tidal and meteorological forcing and fluvial discharge. Indeed, Wass & Leeks (1999) highlighted the large temporal and spatial variations in the flux of fluvial sediment in the Humber catchment (a likely causal factor of increased TSS values at the development site) in response to factors such as climate, land use, catchment scale, deposition and reservoir trapment.

[7] The turbidity maximum is the zone of highest turbidity. This zone results from turbulent resuspension and flocculation of particulate matter in an estuary due to tidal forcing and the intrusion of saline waters during the flooding tide moving upstream beneath the outflowing river water. The concentration and distance travelled by the turbidity maximum is a function of the sedimentological characteristics of the particulate material, tidal forcing and fluvial discharge. Within the Humber, the location of the turbidity maximum, is frequently quoted as being upstream from the AMEP development around Trent Falls (Pontee et al, 2004), or even further upstream (Mitchell, 2005) and as such the TSS data from within the turbidity maximum is not considered relevant to this assessment.

5. CONCLUSIONS AND RECOMMENDATIONS

The data collected during the year-long baseline monitoring period provides an excellent quality record of intra-annual variability of the measured parameters at the two sites with seasonal and tidal variability clear within the data set. Whilst the data record is for a single year only and for specific locations, a sense check and comparative analysis with other work (see Table 8) suggests that on a broad level the conditions during this year were not atypical in any way. From the assessment, the following conclusions have been drawn:

- The data record and the foregoing analysis provides a strong basis for proposing a reasonable limiting threshold which falls in the bounds of natural variation.
- Uptake of the proposed limiting thresholds would enable a compliance monitoring programme to be implemented during the construction phase of the AMEP development which would demonstrate that capital and maintenance dredging activities, were not:
    1. detrimentally impacting the wider system (i.e. near and far field receptors) in line with EMS and WFD conservation objectives, and;
    2. detrimentally impacting upon nearby infrastructure (i.e. E.ON and Centrica cooling water intakes and outfalls).
- The limiting thresholds defined in the DCO (AMEP, 2014) and MEMMP (AMEP, 2016) for DO and water temperature (being not to drop below 5 mg l^{-1} and not to reach 21.5^{0}C, respectively) are considered 'absolutes' against which proposed works are controlled.
- The sediment regimes at the two sites (jetty; buoy) are different and therefore limiting thresholds must be defined for each, separately[8]. At each of the sites, the difference between the 99th percentile concentration[9] and the maximum recorded concentration is quite large in terms of the overall concentration range (e.g. for the jetty site this is 3303 mg l^{-1} – 2367 mg l^{-1}= 936 mg l^{-1}); this observation provides some justification for prescribing limiting thresholds at, or close to, the maximum recorded concentration values, whilst at the same time providing some 'headspace' to accommodate anthropogenically generated turbidity (which at this point is not known). The obvious advantage of this approach is that concentration remains within the natural range and consequently arguments about excessive environmental impacts due to dredging operations become effectively null and void. Some additional headspace, of the order several 100 mg l^{-1}, can in addition be applied to the maximum concentration, on the basis that we see temporal variations of this order between successive Spring tides (Figure 12). Based on these arguments we would recommend limiting threshold TSS values of 3500 mg l^{-1}, at the jetty and 3000 mg l^{-1} at the buoy location is proposed.
- Note there is no timeframe (duration) attached to the foregoing thresholds; commonly threshold exceedances are associated with a persistence/temporal frame e.g. 'management of dredging will occur when three successive concentration values exceed the threshold', which contrasts with a momentary (one off) exceedance.

Table 9 presents the proposed limiting thresholds to be adopted during the construction phase of the AMEP development for the purposes of regulatory/stakeholder review.

[8] It is noteworthy that, to best ensure a continuous data record, the jetty system was initially installed as a back-up system to the buoy-based system, rather than as a separate monitoring station.

[9] The concentration at which 99% of observations are less than.

Table 9. The proposed limiting thresholds for the measured parameters.

Parameter	Proposed limiting threshold
Dissolved Oxygen	To not reduce below 5 mg l^{-1}
Water Temperature	To not exceed 21.5 ^{0}C
Total Suspended Solids (Jetty)	To not exceed 3500 mg l^{-1}
Total Suspended Solids (Buoy)	To not exceed 3000 mg l^{-1}

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APPENDIX 1 – DATA AVAILABILITY

The baseline monitoring campaign was highly successful in data return and overall data quality. The table below shows the data reception over the yearlong monitoring period (i.e. by statistically comparing the 'expected' and 'received' data return).

Monitoring Station	Data reception		Percentage received (%)
	Expected	Received	
Buoy Monitoring Station	34890	34004	97%
Fixed Jetty Monitoring Station	34889	34225	98%

The following table shows the number of data returns which 'passed' the quality control (QC) protocol[10] developed for the baseline monitoring programme.

Monitoring Station	Measured parameters (no of records passed QC)				
	Temperature (^{0}C)	Salinity (PSU)	Dissolved O_2 (%)	Dissolved O_2 (mg l^{-1})	TSS
Buoy Monitoring Station	33576	32890	33578	32888	33507
QC rate (% of expected records)	96%	94%	96%	94%	96%
Monitoring Station	**Temperature (^{0}C)**	**Salinity (PSU)**	**Dissolved O_2 (%)**	**Dissolved O_2 (mg l^{-1})**	**TSS**
Fixed Jetty Monitoring Station	34215	34115	34209	34107	34213
QC rate (% of expected records)	98%	98%	98%	98%	98%

[10] In this project this was a manual process specifically designed to identify, and remove, anomalous data from the record.

Jo Salisbury

From: Laura Hill
Sent: 24 April 2019 10:36
To: Pennington, Abbey
Cc: Jamie Hoy; Kirk, Paul; Errington, Sarah; Richard Cram
Subject: RE: AMEP conditions 36+38

Hello Abbey,

Many thanks for your below email.

AUK accept such requirements under Schedule 11 of the DCO and will ensure monitoring reports are circulated to all consultees, including C.gen.

Can you now advise if the only aspect preventing conditions 36&38 from being discharged, is incorporating "Uniper and C.gen (formerly Centrica) will need to be informed of the dredging schedule in order for them to plan their operations/avoid operating unnecessarily when dredging is in progress" into the MEMMP?

Kind regards

LAURA HILL
Graduate Environmental Advisor

Able UK Ltd
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Tel: 01642 806080 Fax: 01642 655655 Email: lhill@ableuk.com Web: www.ableuk.com

From: Pennington, Abbey [mailto[redacted]@marinemanagement.org.uk]
Sent: Tuesday, March 26, 2019 11:25 AM
To: Laura Hill
Cc: Jamie Hoy ; Kirk, Paul ; Errington, Sarah ; Richard Cram
Subject: FW: AMEP conditions 36+38

Dear Laura,

Following internal discussion regarding the matter outlined in your emails below, the MMO can provide the following response:

Schedule 11, Requirement 36 of the Able Marine Energy Park Development Consent Order states:

> *'Cooling water intakes and outfalls*

36.—(1) No development is to commence until a scheme for the monitoring of sedimentation along the lines of and in front of the Centrica and E.ON cooling intakes and outfalls has been submitted to and approved by the MMO, in consultation with the Environment Agency, Centrica plc and E.ON.
(2) The scheme must include—
(a) details of monitoring proposals, including location and frequency; and
(b) details of trigger levels and resultant actions or mitigation required if trigger levels are exceeded.
(3) Development must proceed in accordance with the approved scheme and any timetable contained in the scheme.'

The interpretation section of the DCO states:

'"Centrica" means Centrica Plc and all of its subsidiaries, and Group companies, transferees, assignees, etc., including but not limited to Centrica KPS Ltd, Centrica Storage Limited and Centrica Energy. '

The MMO consider that C.gen is a transferee of Centrica, therefore, under Schedule 11, Requirement 36 C.gen must be consulted and their comments taken into consideration before the MMO can approve the Scheme for the Monitoring of Sedimentation and discharge the aforementioned condition.

In C.gen's consultation response they state they require to be consulted throughout the works in order to ensure that they can protect their assets:

'C.GEN is dependent on … the MMO fully ensuring that the monitoring schemes take account of the matters we have raised, and enable the effect on our assets to be monitored, and appropriate remedial action being taken where there are adverse effects. This includes identifying where the assets are becoming buried as a result of AMEP's activities and taking the remedial action. Please can you confirm that you will consult with us in relation to these elements, or otherwise how we are able to monitor satisfactory performance as construction progresses.'

Therefore, the MMO are able to receive the monitoring reports and consult on these, however, this would be a chargeable activity. Alternatively, you can provide the monitoring reports direct to all consultees listed to keep them informed of progress and allow them to know if trigger points have been reached and what mitigation measures haven enacted.

If you have any further queries please do not hesitate to ask.

Kind regards,
Abbey

From: Laura Hill [redacted]]
Sent: 11 February 2019 14:52
To: Errington, Sarah [redacted]@marinemanagement.org.uk>
Cc: Pennington, Abbey <[redacted]@marinemanagement.org.uk>; Richard Cram [redacted]@ableuk.com>; Jamie Hoy [redacted]@ableuk.com>
Subject: RE: AMEP conditions 36+38

Hello Sarah,

Please see AUK's response to points raised below:

1. How and when will Uniper be informed if the TSS concentration exceeds the threshold level of 3000 mg/l at the monitoring buoy? Automatic notification to be provided via monitoring equipment. Uniper to provide contact details of delegated person(s). If equipment does not allow such notification, then notification will be made via email as soon as reasonably practical to the provided delegated person(s).
2. How and when will Uniper be informed if the limits of acceptable change in bed level have been triggered? As per the above.

3. How and when will Uniper be informed if dredging is to be undertaken to return the bed profile around the intake and/or outfall to an acceptable level? Uniper to be informed via email 28 days prior to such dredging activities. Uniper to provide contact details of delegated person(s)

In addition to the clarifications above the following matters listed below will require updating in the MMEP in order to discharge conditions 36 and 38:

- Uniper and C.gen (formerly Centrica) will need to be informed of the dredging schedule in order for them to plan their operations/avoid operating unnecessarily when dredging is in progress. Please add this notification requirement to the MMEP.
- The Sediment Monitoring Commitments Report specifically states some of the results will be emailed to a specific EA email address within two weeks of completion of each survey. This same information must also be disseminated to Uniper and C.gen within the same timescale via an agreed notification route. Point**(s)** noted ***for Uniper only***. It is our understanding that Centrica power station has been demolished and as such, the land sold to C.gen. Para 36 of the DCO, makes no mention of any successors in title, if indeed the power stations were closed and the land sold. We therefore question on what grounds you consider C.gen to be entitled to this information. C.gen would have to seek their own planning permission(s) if indeed they did require access/use of such cooling intakes and outfalls. This however, is not the same for Uniper, as it was in fact formally E.ON.
- The report stated that if the power stations are closed, and the outfalls and intakes are no longer required, then some aspects of the monitoring to the north of the reclamation may be removed, and re-consideration of monitoring needs would include consultations with the owners of the CW infrastructure. For Uniper, it is important that the CW infrastructure remains usable to allow for future development of the site by Uniper, therefore, monitoring must not stop if the power station ceases operation. Point noted, consultation to occur if indeed this situation arises.

Please can you provide our response to Uniper, and consult with Abbey on the above and get back to me.

Kind regards

LAURA HILL
Graduate Environmental Advisor

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From: Errington, Sarah [redacted]@marinemanagement.org.uk]
Sent: Friday, January 25, 2019 12:42 PM
To: Laura Hill [redacted]@ableuk.com>
Cc: Pennington, Abbey [redacted]@marinemanagement.org.uk>
Subject: AMEP conditions 36+38

Good Afternoon Laura,
DCO/2013/00020 - Schedule 11: Conditions 36 and 38

Apologies, it has come to our attention that Uniper (formerly EON) are content with the document provided, however, they have submitted some minor comments that require clarification before the conditions can be discharged. Please review and provide clarifications to the three points below:

1. How and when will Uniper be informed if the TSS concentration exceeds the threshold level of 3000 mg/l at the monitoring buoy?
2. How and when will Uniper be informed if the limits of acceptable change in bed level have been triggered?
3. How and when will Uniper be informed if dredging is to be undertaken to return the bed profile around the intake and/or outfall to an acceptable level?

In addition to the clarifications above the following matters listed below will require updating in the MMEP in order to discharge conditions 36 and 38:

- Uniper and C.gen (formerly Centrica) will need to be informed of the dredging schedule in order for them to plan their operations/avoid operating unnecessarily when dredging is in progress. Please add this notification requirement to the MMEP.

- The Sediment Monitoring Commitments Report specifically states some of the results will be emailed to a specific EA email address within two weeks of completion of each survey. This same information must also be disseminated to Uniper and C.gen within the same timescale via an agreed notification route.

- The report stated that if the power stations are closed, and the outfalls and intakes are no longer required, then some aspects of the monitoring to the north of the reclamation may be removed, and re-consideration of monitoring needs would include consultations with the owners of the CW infrastructure. For Uniper, it is important that the CW infrastructure remains usable to allow for future development of the site by Uniper, therefore, monitoring must not stop if the power station ceases operation.

Please do not hesitate to contact case manager, Abbey Pennington or I if you have any question.

Kind Regards,

Sarah Errington | Marine Licensing Case Officer | Marine Management Organisation (MMO)
Direct Line: 02082257401 | Email: [redacted]@marinemanagement.org.uk |
Address: Lancaster House, Hampshire Court, Newcastle Business Park, Newcastle upon Tyne, NE4 7YH

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*** Want to tell us what you think of the East and South Marine Plans? Then we'd appreciate your views through our voluntary East and South surveys (closing date: 25/01/19). Your data will be anonymised and the surveys are GDPR compliant. For further information, or a copy of our Privacy Statement, please contact – East: [redacted]@marinemanagement.org.uk; South: [redacted]@marinemanagement.org.uk ***

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