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Institute of Estuarine and Coastal Studies

Able Marine Energy Park

Environmental Management and Monitoring Plan: 3. Compensation habitat – Cherry Cobb Sands RTE/managed realignment site and associated wet grassland area

Draft Report (v3)

Report to Able UK Ltd

Institute of Estuarine and Coastal Studies
University of Hull

12th November 2012

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Able UK Ltd

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For and on behalf of the Institute of Estuarine and Coastal Studies	
Approved by:	Nick Cutts
Signed:	[redacted]
Position:	Deputy Director, IECS
Date:	12th November 2012

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1. INTRODUCTION

1.1 Overview

1. Able Humber Ports Ltd (AHPL) has made an application to the Infrastructure Planning Commission (IPC) for consent to develop a marine energy park. If consented, the development will be known as Able Marine Energy Park (AMEP). AMEP will incorporate a new quay together with facilities for the manufacture of marine energy components including offshore wind turbines.
2. The development of AMEP, east of North Killingholme and between C.RO Ports (Killingholme), (the former Humber Sea Terminal) and ABP Immingham Port, will lie partly within the Humber Estuary Special Area of Conservation (SAC), Special Protection Area (SPA) and Ramsar site.
3. In addition to the proposed development at North Killingholme, and in line with the requirements of the Conservation of Habitats and Species Regulations 2010 (the Habitat Regulations), the project includes developing new compensation habitat which will be located on the north bank of the estuary at Cherry Cobb Sands.
4. This document comprises the Environmental Management and Monitoring Plan (EMMP) for the compensatory habitat.

1.2 Proposed compensation habitats - Cherry Cobb Sands and adjacent wet grassland

5. The AMEP development is anticipated to result in the long term loss of a total area of 44 ha of intertidal mudflat arising, both directly and indirectly, from the AMEP development (Annex B of the Statement of Common Ground on the shadow Habitats Regulations Assessment) with an additional 13.5 ha of subtidal habitat being lost due to quay construction.
6. In overview, at least 101.5 ha of new estuarine habitat will be created at the Compensation Site. This will comprise an area of c.72 ha of new intertidal mudflat habitat (four fields, each of c.18 ha in area) to be maintained by a system of regulated tidal exchange (RTE), in addition to c.32 ha of open managed realignment area that will drain the area into the Cherry Cobb Sands Creek. All of this new habitat will be on the landward side of the existing flood defence embankment.
7. Taking into account the particularly large number of birds to be displaced, an additional area of 38.5 ha of habitat will be created to provide roosting and foraging habitat for some of the bird species affected by the development, especially Black-tailed Godwit (*Limosa limosa isclandica*), mimicking the existing provision at North Killingholme. This are will include a 5 ha area of open water (with an average depth of 0.7 m and a maximum depth of 1.4 m)

along with two low-lying islands (totalling 0.25 ha in area). This additional terrestrial compensation will support and augment the intertidal resource habitat and will reduce the uncertainty in the provision of compensation, ensuring that the overall package of measures is robust.

8. Evidence of the value of grassland fields for foraging Black-tailed Godwits comes from a variety of sources including:
    - at Clonakilty Bay in County Cork, where birds spend part of their time inland foraging on grassland fields from November onwards, supplementing the food obtained from the estuary mudflats (Hutchinson & O'Halloran, 1994); and
    - at Poole harbour where terrestrial fields were considered of vital importance for shorebirds such as black-tailed godwit (Durell *et al.*, 2006).
9. The new wet grassland is to be located in an area of current arable field use which is readily accessible to birds from both the estuary and the RTE site.
10. An assessment of the likely available feeding resource provided by the intertidal compensation site and the wet grassland predicts the potential available food resource to be considerably greater than that required to compensate for the direct and indirect loss of intertidal waterbird foraging habitat as a result of the AMEP development.
11. The details of the compensation habitat (including the operational site management) are provided in EX28.3 submitted by the applicat to the Examinaing Authority on 12 October 2012. The total area of intertidal habitat, wet grassland and wet roost is referred to as the *Compensation Site* in this document.

1.3 Scope of Report

12. This document provides an overview of the compensation works associated with the AMEP development (Cherry Cobb Sands intertidal development and associated wet grassland) that are planned to fulfil the requirements of the Habitat Regulations.
13. After reporting available baseline data, and identifying quality objectives for habitats and species, descriptions are provided of environmental management and monitoring arrangements, relevant to the Compensation Site environment, The monitoring is designed to provide evidence that either the site is achieving its objectives or, in the alternative, to inform adaptations to the management of the site in order that it does achieve its objectives.
14. The environmental management and monitoring arrangements for the terrestrial and marine elements of the AMEP development are reported separately.
15. This EMMP (or any approved revisions of it) will be implemented for a minimum period of 10 years.

16. At least three months prior to the works commencement date, the applicant will call a meeting of the EAG to obtain agreement on the start date for the works.

1.4 Report Approval

17. In accordance with the requirements of the development Consent Order for AMEP, this Plan is to be approved by Natural England following consultation with the Environment Agency and the East Riding of Yorkshire Council.

1.5 The Ecological Advisory Group

18. An Ecological Advisory Group (EAG) will be established under the auspices of AHPL, to receive such habitats and species monitoring reports as are produced, to assess the efficacy of ongoing compensation measures, and to make recommendations regarding the need to extend monitoring in either scope or timeframe beyond its initial 10 year timeframe. .
19. The core membership of the EAG shall include representatives from AHPL, Natural England, Environment Agency, Humber INCA, Lincolnshire and Yorkshire Wildlife Trusts and the RSPB. This core group may invite other members of the scientific community to attend meetings.
20. The EAG, meeting on a six-monthly basis, will provide objective analysis of the habitats and species monitoring and provide recommendations on adaptive management to AHPL
21. The EAG will be chaired by a representative from the Humber INCA, or an alternative organisation agreed by the majority of the EAG.
22. The EAG's remit will be advisory, as final approval of the EMMP will rest with Natural England and responsibility for implementation will rest with AHPL.

1.5.1 Reporting to the AEG

23. Monitoring reports will be provided for review by the AEG on an on-going basis as soon as they are finalised.
24. AHPL will produce an annual interpretative report which will include, inter alia, the following information:

- Review of construction activity in the previous year.
- Environmental incidents on the site and corrective actions.
- Monitoring results for the previous year.
- Discussion of population and habitat site impacts.

- Comparison of survey results to objectives within the context of the development phase and also within the context of any national trends or unusual events.
- Statement of Plan Compliance over the previous year.
- Proposals for management actions.
- Programme of construction works for the following year and future monitoring programme.

1.6 Ecological Functioning of Habitats

25. The setting of purely numerical targets in terms of species provision can be open to misinterpretation and/or may ultimately result in targets being met whilst the functional requirements species/group are not fully addressed. Consequently, this approach alone is insufficient to provide adequate information on site development and function and, ultimately, whether or not the compensation is meeting wider management goals. In this context it will be important to consider several aspects of the ecological functioning of the affected aquatic habitats and their associated compensation areas (for example looking at both benthic invertebrate assemblages and wader/wildfowl use of a site, or looking at the wider distribution/re-distribution of particular species within the context of the Humber Estuary site). It is also important to consider that management should have some adaptive element.

1.7 Appointment of Environmental Manager

26. A suitably qualified and experienced Environmental Manager who will be appointed by AHPL and who will, amongst other duties: coordinate all ecological survey work; receive and review all survey work; review Contractor's Construction Environmental Management Plans (CEMPs); liaise with members of the EAG and produce the annual report.
27. The Environmental Manager will be responsible for reviewing environmental monitoring reports on a rolling basis and identifying any trends that are beyond those that have been reasonably anticipated. Where such adverse environmental trends are identified, the Environmental Manager will be responsible for investigating the causes of those adverse trends and issuing instructions to contractors as appropriate. In this way the risks of any permanent adverse effects of the development exceeding what has been assessed, will be as low as reasonably practicable.

2. INTERTIDAL HABITATS

2.1 Baseline

2.1.1 North Killingholme Marsh (NKM) Foreshore

28. The baseline is recorded in Annex 11.2 of the Environmental Statement (ES). No saltmarsh will be directly lost as a result of the proposed works.

2.1.2 Cherry Cobb Sands Saltmarsh Habitat

29. The baseline is recorded in Annex 35.1 of the Environmental Statement (ES). Approximately 2 ha of saltmarsh will be directly lost as a result of the proposed works. A description of the saltmarsh that will be affected by the works is included in Annex 34.1 of the ES, and briefly summarised below.

30. The upper saltmarsh in the vicinity of Cherry Cobb Sands varies in width from five metres seaward from the base of the existing sea defences at Stone Creek in the south of the site, up to 330 m at the Outstray in the north of the site (2010 data). In a similar manner, the width of the mid saltmarsh zone also varies from 60 m in the south to around 300 m in the north of the site.

31. There is dense saltmarsh vegetation cover in the upper and mid saltmarsh zones, with little or no signs of erosion, which indicates that the habitat quality is good. These zones are dominated by sea couch grass *Elytrigia atherica* (*Elymus pycnanthus*) with other species of note including sea plantain *Plantago maritima*, red fescue *Festuca rubra* and *Orache atriplex* sp. A network of saltmarsh creeks runs through these zones, allowing water to drain off following high tide as well as allowing freshwater from the land to discharge into the estuary.

32. The lower saltmarsh zone is extensive, stretching up to 800 m from the edge of the mid saltmarsh zone. It is thought that this zone is gradually accreting. The lower saltmarsh is dominated by 'pioneer' species including annual glasswort *Salicornia europea agg.* and common cord grass *Spartina anglica*.

2.1.3 The Compensation Site

33. The Compensation Site is currently arable farmland lying to the landward side of the flood defence embankment.

2.2 Habitat Quality Objectives

2.2.1 Intertidal

34. The Compensation Site should provide a minimum of 101.5 ha of intertidal habitat.

35. At the commencement of the scheme, the site should provide at least 88 ha of intertidal mudflat. If this target were to be achieved it would provide double the amount of mudflat lost as a result of the AMEP development on the south bank of the Humber.
36. The minimum requirement is for the Compensation Site to provide a minimum of 44 ha of sustainable functioning intertidal mudflat (which must be demonstrably meeting its objectives for bird use and/or its objectives for physical and ecological quality). This area is the same as the amount of mudflat lost both directly and indirectly as a result of the AMEP development.
37. In terms of ecological quality, the mudflat that is created should be suitable to support a range of bird species displaced from their foraging grounds on the foreshore at North Killingholme Marshes (NKM) including, but predominantly, Black-tailed Godwit. In order to achieve this, the compensation package will need to provide the features listed below:
    - The new intertidal habitat will have a suitable mud substrate (i.e. with a high proportion of silt) to a minimum depth of 100 mm.
    - The mud should be capable of supporting principal shorebird prey species such as *Macoma balthica*, *Hediste diversicolor*, *Corophium volutator* and *Hydrobia ulvae*.
    - Prey items should be present in sufficient densities to support displaced shorebird populations (see Section 3.2).
    - The sustainable mudflat should be subject to regular tidal inundation with 500 inundations per year. This will provide a high degree of waterlogging in the sediments to prevent them from drying out between tides and will reduce the ability of saltmarsh species to survive effectively. The site should not dry excessively during neap tide cycles, and should provide a patchwork of shallow standing pools and exposed areas of mud during ebb periods.

2.3 Management

2.3.1 Construction Phase

2.3.1.1 Site Inundation

38. Detail of management works associated with the construction phase of the RTE site, together with detail of the physical operational management of the site (e.g. the control of water levels) is provided separately in EX 28.3:Part 3.
39. Once the embankments and profiling have been completed for the RTE site, and the associated engineering hardware (sluice gates, flap valves, spillways, etc.) have been installed, the existing embankment will be breached to allow tidal waters to enter the managed realignment portion of the site and through to the area of RTE. The optimum

location for the single breach (which will be 250 m long) is towards the southern end of the site, although the precise location and level of the breach area will be chosen during detailed design in order to maximise the sustainable creation of intertidal mudflat. The base and southern end of the breached section will not be protected as little erosion is anticipated. The northern end of the breach, which is close to the RTE boundary, will be protected with rock armour.

40. A channel will be cut through the existing saltmarsh at the top of the foreshore fronting the breach to allow water to enter, the material that is removed from the breached section of embankment being placed within the intertidal area of the managed realignment portion of the site. The extent of saltmarsh habitat that will be excavated is approximately 250 m by 70 m which, including the potential for a small additional loss of saltmarsh as a result of scour around the newly created breach, is anticipated to result in the loss of approximately 2 ha of saltmarsh. The area that will be lost is small in comparison to the 627 ha saltmarsh in the Humber Estuary (Environment Agency, 2005) comprising approximately 0.1% of the total. The loss of this saltmarsh will subsequently be compensated for within the Cherry Cobb Sands site once new saltmarsh habitat forms within the site following the breach. Experience from other managed realignment sites on the Humber suggests that the creation of new saltmarsh habitats within such sites is relatively easy, with little or no intervention or site preparation required, propagules enter the site naturally from adjacent areas.

41. Damage of saltmarsh in the immediate area around the excavated channel will be minimal as the channel will be excavated moving backwards from the seaward edge to the landward edge. By restricting movement of construction plant to the area of saltmarsh which is to be removed, damage to the saltmarsh which will remain *in situ* will be avoided with residual impacts considered to be of negligible significance. Where appropriate it is proposed that bog matting will be used by construction plant.

42. It is likely that the breach will be created in the year after the other works at the site have been completed, to allow time for sufficient grass cover to establish on the new embankments; the timing of the breach will be agreed with the Environment Agency. Seeding of the embankments with a suitable seed mix (containing a mix of wildflowers, grasses and sedges suitable for clay soils) is recommended (see below).

2.3.1.2 Embankment Seeding

43. To facilitate seeding, topsoil on the embankments is to be lightly harrowed during the final stages of construction. Seed will be surface sown, for example using a fertiliser spreader, or alternatively mixed to a slurry with mulch and sprayed over the ground in an even layer. This

latter technique ('hydro-seeding') promotes quick germination and helps maintain moisture levels for seeds and developing seedlings.

44. Guidance on sowing rates (volume or weight of seed per unit area) is often provided by the commercial seed suppliers, and will be dependent on the mix of species used. Unless it has been hydro-seeded, the seed should be lightly rolled (but not covered) following sowing to promote soil contact.

2.3.1.3 Noise disturbance

45. In addition to a limited amount of piling work, construction of the Compensation Site will result in noise disturbance arising from the use of plant on the site (e.g. from vehicle movements and earthworks).

46. The main working areas will be transient, as construction of the embankments and sluices progresses across the site. Therefore the distance of waterbirds on the adjacent intertidal zone to some sources of noise (notably delivery lorries travelling along local roads and the construction of the two sluices at the north-western side of the site) is likely to be greater than 200 m. Furthermore, the embankment along the shoreline will be retained throughout construction and the perimeter and internal embankments of the RTE site will be constructed first and during the same phase of works; these will help minimise the transfer of noise from the site to the adjacent foreshore and mudflats. The construction of the sluice structures however, will require some piling.

47. Piling would be undertaken for a maximum of 12 weeks (3 months) during the 18 month construction period. The predicted increase in noise levels from these sources in combination is unlikely to result in significant effects on sensitive receptors due to the proximity of receptors and small numbers of machinery required additional to those assumed in the ES.

2.3.2 Operational Phase

2.3.2.1 RTE Site Management

48. Detail of management works associated with the construction phase of the RTE and managed realignment area, together with detail of the physical operational management of the site (e.g. the control of water levels) are proposed in the design report for the intertidal site (EX28.3).

49. In summary however, automatic recorders will be installed to monitor the water level within each RTE field, and a similar water level monitor placed in the open part of the managed realignment to provide a reference level to assess how water levels inside and outside the RTE fields are related.

50. Sluice operations will be gradually modified as the fields accrete to maintain similar amounts of inundation into the fields. Sediment levels will be monitored by stakes, supported by occasional use of LiDAR remote sensing.
51. Marks on the rising stem of each sluice will allow for simple direct reading of the opening of each sluice; sluice settings used will be recorded and will confirm the relationship between sluice settings and the depth of water in each RTE field for a range of tidal conditions. Other than this, no specific calibration of the sluice structures will be required once the local datum level for each sluice is established during construction.
52. Initial operation will be based on model results but will be reviewed in light of operational experience during the warping up period and, if necessary, modified to ensure the sluice opening provides the required water depth in each RTE field.
53. All the sluices will be regularly used to prevent siltation in the passageways. If it is found to be better to only use one or two of the sluices at a time, those being used should be changed each successive spring tide period.
54. Two full time employees will need to be employed by the Applicant (with provision for holiday and sickness cover) for day-to-day operation, maintenance and management of the RTE fields and their sluices. Their duties will include, routine operation of the sluices to meet the management objectives of the site, maintaining the water level records, the readings of sediment levels and the records of sluice operations.

2.3.2.2 Disturbance

55. Bird hides will be created along the new embankment constructed at the Compensation Site to facilitate views across the mudflats whilst avoiding disturbance to birds. The footpath that currently runs along the flood defence embankment will be re-routed along the landward base of the new flood defence embankments..
56. Given the re-routing of the existing footpath, the associated intertidal mudflats at Cherry Cobb Sands may be able to accommodate more bird-days as disturbance will be reduced. This effectively provides an additional opportunity for birds displaced from Killingholme Marshes foreshore, and particularly those which are more restricted to intertidal mudflat habitats, to forage whilst the Compensation Site matures.
57. Vehicle access along embankment tops will be required for management purposes. Such access will need to be carefully managed so as to reduce disturbance to a minimum, although it is recognised that such access will be an operational requirement of the site as the water management regime will require personnel on-site on a frequent basis.
58. An appropriate site access protocol will need to be developed to ensure that any potential for disturbance is, as far as is practicable, minimised.

2.3.3 Site Maintenance

59. Vegetation cover on the embankments within the site will need to be managed, as will any associated planting that is undertaken.
60. Where the landward slopes of the main perimeter embankments are planted with low scrub it will need to be kept very short so as not to provide a habitat for raptors or other predators. Annual cutting of the perimeter embankments should be planned for, although management will need to be adaptive and pragmatic.
61. An appropriate site management and maintenance plan will be developed to embody these requirements.

2.4 Monitoring

2.4.1 Botanical Monitoring

62. Botanical monitoring will be extremely useful to record the development and maturation of the wet grassland. The information will also help inform grazing and hydrological management (allowing both to be undertaken on an adaptive basis).
63. Standard survey methods will be employed (for example see JNCC, 2004) using a combination of permanent transect and random quadrat approaches. The number of sampling station will need to be commensurate with the size of the site.
64. Annual surveys, recording vegetation structure and composition (i.e. number of species and percentage cover within random 1 m^2 quadrats and at stations along set transects) will be carried out.
65. Results should be reported to the EAG on an annual basis.

2.4.2 Fish Monitoring

66. Although the site is not being developed as compensation for loss of functional fish habitat the RTE/managed realignment site will be monitored to demonstrate its developing ecological value as a nursery and feeding habitat.
67. Six-monthly surveys of both the RTE intertidal mudflat habitat and of the intertidal managed realignment area will be undertaken post site inundation.
68. For each survey a series of fyke nets will be deployed within the intertidal 'fields' and within the main drainage channel/creek system, with each deployment covering two full tidal cycle. Two double-ended fykes are set per field, with a further pair being set in the creek system (i.e. ten double-ended fykes in total).
69. Each double fyke net assembly (consisting of two facing fyke nets joined by a central net wall) will be deployed parallel to the shore, the nets being secured with canes and/or

anchors. It will be important to ensure that the possibility of entrapment of waterbirds and mammals is minimised as far as possible (e.g. by fitting otter guards and by following associated Environment Agency regulations). Deployment is to be at the low tide point and the nets left in place for 24 h (two tidal cycles). Catch will be collected after 12 h and 24 h to stop the catch drying out. Following retrieval of the nets, the catch should be collected and returned (frozen in insulated containers) to the laboratory for identification, enumeration and measurement.

70. 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).

2.4.3 PHYSICAL MONITORING

71. The main focus of this report is the determination of a management and monitoring programme for the site in relation to the key environmental objectives of the Compensation Site and the wider development of the ecological compensation and mitigation package. As such, the main foci of attention are in the provision of suitable habitats and associated functionality to compensate for direct and indirect losses of SPA and SAC features due to the AMEP development. Such compensation primarily relates to the provision of a suitable benthic invertebrate community characteristic of the middle estuary and similar to that lost from the south bank, and the functional attributes associated with this community, for waterfowl (and fish). In particular, the over-riding objective is the provision of a benthos capable of supporting the Black-tailed Godwit population that will be displaced from NKM foreshore.

72. However, it should be noted that in order to achieve such conditions, and in particular, a benthic community characteristic of the middle estuary, it will be necessary to satisfy a series of basic environmental (physico-chemical) conditions which would allow such development to occur. These conditions include a range of physical factors, such as flow, inundation and exchange rates, as well as associated water quality metrics such as dissolved oxygen, suspended sediment levels and turbidity. In turn, these factors will affect both the development of sediment conditions within the RTE and the establishment of the benthic community (and hence the associated foraging potential for waterfowl).

73. In terms of its construction and operation, the proposed development of the RTE site as a sustainable intertidal resource is more complex than previous managed realignment schemes constructed on the Humber Estuary. Its operational management (which at least initially, as the site develops, is likely to be somewhat adaptive) will need to be informed by a detailed RTE monitoring strategy.

74. Such a strategy of monitoring and refining ongoing operational activities will help identify, for example, requirements for modifications to the sluice and water transfer components of the site's operation (against modelled predictions). It will also inform the wider process of RTE field level management and associated needs for dredge maintenance.

75. A series of parameters will therefore need to be monitored, including flow and inundation rates around the site, wider water level data (including fill and discharge data), turbidity levels, salinity, accretion rates and sediment depth, sediment redox, sediment water and organic content.

76. Whilst these data will be of specific value to the management of the RTE fields and wider Compensation Site, they will also provide useful data which can be incorporated into the wider environmental monitoring and management package for the SPA and SAC compensation objectives. Where necessary they can be used to assist in any ongoing modifications to allow management to better meet any objectives and targets.

77. Following the initial breach of the managed realignment site, there will be a temporary increase in suspended sediment as soils from agricultural land enter the estuarine waters in the vicinity of the site. This may lead to increased levels of deposition on mudflat and saltmarsh habitats, resulting in an increased rate of accretion and localised morphological change. The settling out of material may lead to localised accretion to the extent that there is the potential for smothering of benthic invertebrates, and there is the slight potential of smothering of saltmarsh plants leading to die off. However, considering the very high concentration of suspended sediment in the Humber Estuary the magnitude of this effect is considered to be very low and the sensitivity of intertidal habitats is considered to be low, resulting in an impact of negligible significance.

78. As well as monitoring the development of the newly created intertidal areas, it will be important to assess whether or not there are adverse changes to adjacent existing habitats within the Humber Estuary. In this context it will be necessary to monitor erosion and deposition on existing intertidal areas, as well as assessing possible changes to Stone Creek (due to increased silt loadings). This monitoring should allow for changes to intertidal profile before, during and after construction works to be assessed. In total, three areas will need to be monitored:

- The new intertidal habitat within the Compensation Site;
- The existing intertidal in the vicinity of the proposed breach in the sea defence embankment; and
- Stone Creek.

79. Whilst LIDAR would be a viable option for the provision of a topographic dataset for both the Stone Creek and Cherry Cobb sand foreshore areas, the vertical accuracy (in the range of +/- 10-15 cm) might not be adequate. In addition, LIDAR can potentially give false 'ground' readings over areas of vegetation (e.g. saltmarsh) as the top of the vegetation can be mapped rather than the substratum.
80. An alternative will be to employ a GPS-based approach. For extensive heterogeneous smooth soft sediment areas a GPS rover unit may be mounted on a hovercraft (or quad bike in some instances) and 'flown' over the mudflat to collect continual positional data. A large area of intertidal habitat can be covered using this technique often in conditions where an 'on foot' survey would be unsafe and/or very time consuming. Again interpolation can be employed between the trackfiles to increase the 'coverage'.
81. However, for high vegetation and other rugged topography, 'on foot' transects or a 'walk about' approach may be used as a hovercraft (or quad bike) cannot access such areas safely. This restricts the amount of coverage somewhat in such habitats (as it is slower on foot) although it is possible to interpolate between the trackplots. In addition, there are constraints to hovercraft operation in terms of creek height, steepness and other terrain issues that may preclude all areas being surveyed. Also, it should be noted that hovercraft deployment may require Habitats Regulations Approval.
82. Given the nature of the area that needs to be surveyed a combination of techniques will be used.
83. Surveys will be repeated annually.
84. In addition to the above, bed levels in the entrance to Stone Creek will be observed prior to, during and after periods of removal of material from the RTE fields by bed levelling and/or dredging (as described in Part 3 of EX 28.3) to demonstrate that there are no adverse impacts on this system. Should bed levels rise in the entrance to Stone Creek during such periods of operational activity, consideration will be given to the need to remove any build up using bed levelling techniques. Where necessary, fixed stakes will be employed to assist in these observations. Findings, and any resultant actions, will be reported to the AEG on an annual basis.

3. INTERTIDAL BENTHIC COMMUNITIES

3.1 Baseline

3.1.1 CHERRY COBB SANDS FORESHORE

85. There is an extensive area of mudflat and sandflat stretching from the edge of the mid saltmarsh zone, this area is referred to as Foul Holme Sands. In some places saltmarsh vegetation has colonised the intertidal zone and it may be classed as lower saltmarsh (comprising saltmarsh vegetation interspersed by mudflat). Vegetation is sparser towards the mean low tide mark where the mudflats/sandflat habitat is dominant.

86. Intertidal benthic invertebrate assemblages were assessed by the Environment Agency based on a sampling programme covering 12 locations across the north bank of the Humber (Allen, 2006). The surveys provided five replicates of samples per station, samples being collected from the mid-foreshore using 10cm diameter hand-held corers (sampling 0.0079m^2 of sediment). One of these sites was located at Cherry Cobb Sands and provides useful baseline data for the benthic invertebrate assemblage at this site. These data (which were collected from the mid-foreshore) can be used to assess impacts due to the breaching of the defence embankment as part of the development of the Compensation Site. These raw data are reproduced in Table 1 below, and a précis follows. These data consist of abundance (density) values only; no biomass data are available to accompany these abundance data.

87. Considering the north bank intertidal dataset as a whole, *Heterochaeta costata* was the most abundant species at the majority of sample sites across the north bank of the Humber, although not at Cherry Cobb Sands. The lowest species richness recorded was one species/sample (which was recorded at several sites). Species abundance across the full dataset ranged between 1 and 760.

88. The most commonly occurring species in the intertidal samples of Cherry Cobb Sands site were a type of pot worm *Enchytraeidae*, sludge worms *Tubificoides benedii*, Baltic tellin *Macoma balthica* and roundworms *Nematoda*. All except the latter were found in every sample (five samples were taken each year from 2000 to 2003), as was a type of sandworm *Hediste diversicolor* (though in much smaller numbers). *Nematoda* sp. were recorded as one of the dominant species in 2001 but were not present in the 2000 or 2002 data. This was also the case for the sample sites at Thorngumbald and Stone Creek, which are upstream (north-west) and downstream (south-east) of Cherry Cobb respectively.

89. Stone Creek had similar dominant species to those recorded at Cherry Cobb Sands but the overall abundance varied considerably, with *Enchytraeidae*, *M. balthica* and *Nematoda* all more abundant at Cherry Cobb Sands whilst *T. benedii* was present in considerably lower

abundance. Thorngumbald also had *Enchytraeidae* and *Nematoda* as dominant species but the abundance was approximately 30% of that recorded at Cherry Cobb Sands.

90. Intertidal communities of the north bank of the Humber were reported as showing trends typical to estuarine communities. Observed variation in species richness and abundance were believed likely to be due to natural variability. Species richness of intertidal samples in the proximity to Cherry Cobb Sands were typical of the middle region of the Humber Estuary. Average abundance from 2000 to 2003 may have been lower than the general trend for this location, as analysis of data from 1989 to 2003 by Allen (2006) suggested higher average abundances. Samples from Thorngumbald, Cherry Cobb and Stone Creek showed particular variability ranging from an average of 500 to 1,757 individuals/ sample from 1989 to 2003, however it was noted that these sites showed marked variability throughout the sampling programme (Allen, 2006).

91. In general, species found were typical for the intertidal area of the middle region of the Humber Estuary; there were no species of particular conservation importance although many of those present are key prey species for birds. Whilst some of the larger invertebrates such as *Hediste diversicolor*, *Nephtys* spp., *Arenicola marina* and *Scrobicularia plana* are often important prey items for some waterbird species, other smaller organisms can also be of importance, either as specific prey such as *Corophium* spp., or due to their shear abundance, such as *Tubificoides* spp. and *Hydrobia ulvae*, where they contribute an important component to the biomass of some non-specific feeders such as Shelduck (*Tadorna tadorna*).

Table 1 Raw abundance data (individuals.sample^{-1}) from Cherry Cobb Sands intertidal monitoring

	2000					2001					2002				
	Rep.A	Rep.B	Rep.C	Rep.D	Rep.E	Rep.A	Rep.B	Rep.C	Rep.D	Rep.E	Rep.A	Rep.B	Rep.C	Rep.D	Rep.E
Abra tenuis	13	8	16	6	11	10	6	9	9	3	0	0	0	0	0
Corophium volutator	0	0	0	0	2	0	1	1	0	0	0	0	0	0	0
Crangon crangon	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Cyathura carinata	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Enchytraeidae	57	342	4	3	26	667	597	760	560	712	94	105	50	60	37
Eteone longa	0	1	5	0	3	0	1	0	0	2	0	1	3	1	1
Hediste diversicolor	2	4	7	3	7	10	9	12	10	13	7	12	10	8	10
Hydrobia ulvae	0	1	3	2	0	0	0	0	0	0	3	4	3	2	1
Macoma balthica	22	25	26	23	29	27	33	47	28	45	50	57	38	60	40
Manayunkia aestuarina	7	131	11	0	2	0	0	1	0	0	0	0	0	0	0
Nematoda	0	0	0	0	0	337	264	360	284	319	0	0	0	0	0
Nephtys	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Nephtys hombergii	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Paranais litoralis	0	0	3	0	1	0	0	0	0	0	0	0	0	0	0
Pygospio elegans	0	0	0	0	0	0	2	0	0	0	19	7	22	17	13
Scrobicularia plana	0	0	0	0	0	0	0	0	0	0	1	1	7	3	6
Streblospio shrubsolii	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
Tubificoides benedii	24	226	205	10	109	51	63	48	54	44	9	10	13	4	12

3.1.2 NORTH KILLINGHOLME MARSHES FORESHORE

92. Comparative baseline data are also available for the south bank of the estuary. An intertidal benthic survey was undertaken at the AMEP site in May 2010, to provide baseline data on marine ecology within the area. A total of 36 intertidal samples were taken along 12 intertidal transects with three samples taken using a 0.01m^2 corer on each transect. These raw data are presented as Tables 2 and 3 below, with the location of sampling stations shown in Figure 1.
93. ANY TEXT FROM NICK TO GO HERE?
94. 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.
95. *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.
96. 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.
97. 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.

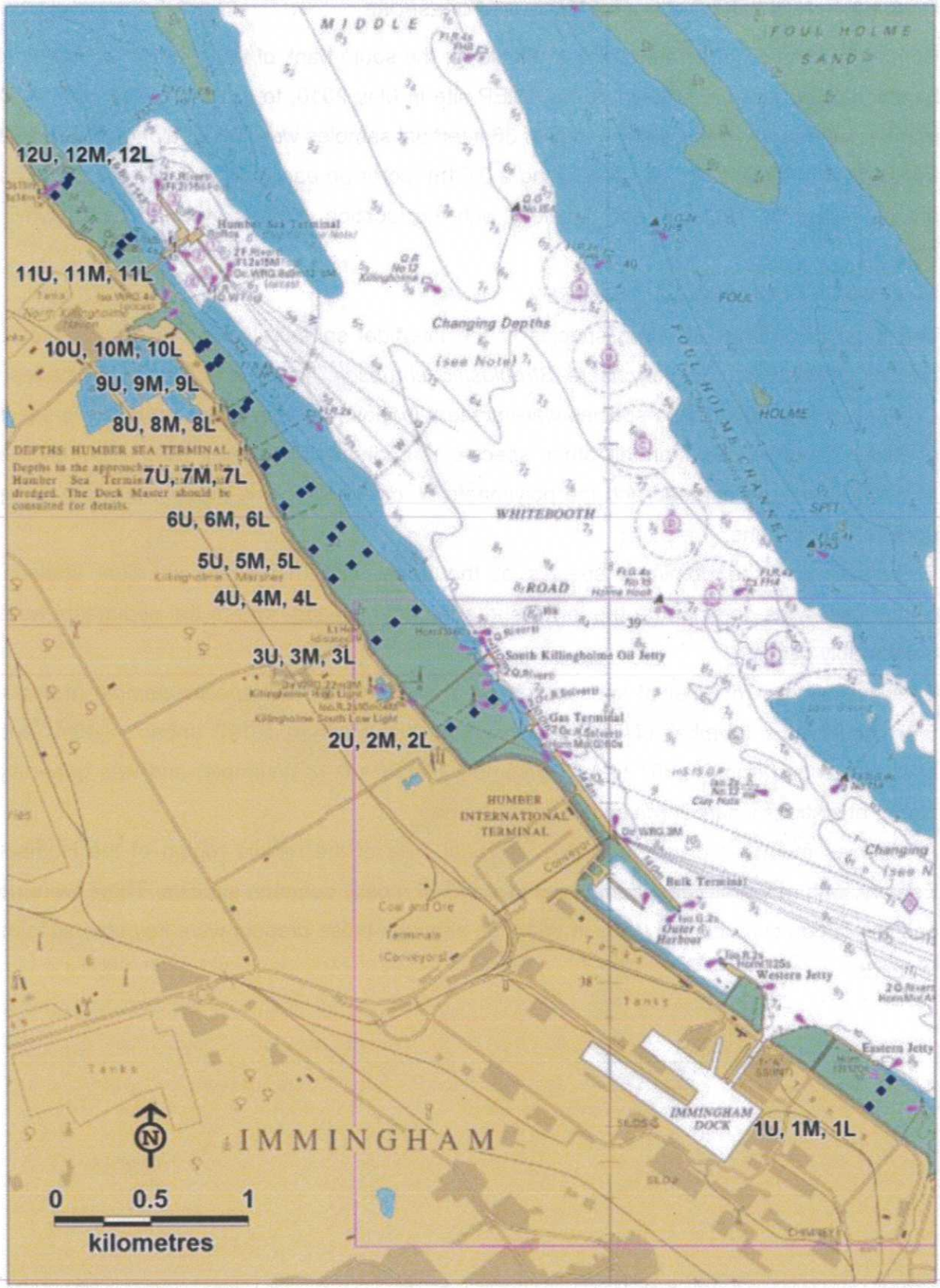

Figure 1: Intertidal benthic invertebrate sampling stations

Table 2: Raw biomass data (g.sample^{-1}) from North Killingholme intertidal monitoring (2010)

	Site 1			Site 2			Site 3			Site 4			Site 5			Site 6		
Taxon	Upper	Mid	Lower	Upper	Mid	Lower	Upper	Mid	Lower	Upper	Mid	Lower	Upper	Mid	Lower	Upper	Mid	Lower
TURBELLARIA													0.00					
NEMATODA	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			0.00	0.00
Eteone flava/longa																		
Hediste diversicolor	0.28						1.36						0.26					
Nephtys hombergii																		
Scoloplos armiger						0.00												
Pygospio elegans						0.00		0.00					0.00				0.00	
Streblospio shubsolii	0.00	0.00		0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tharyx sp.														0.00			0.00	
Tharyx killariensis																		0.00
Capitella capitata (sp. complex)		0.00																
Arenicola (juvenile)												0.00			0.00			
Manayunkia aestuarina	0.00	0.00					0.00						0.00					
Paranais litoralis					0.00	0.00	0.00			0.00			0.00					
Heterochaeta costata				0.00									0.00					
Tubificoides benedii	0.03	0.12	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.04	0.01	0.00	0.02	0.00	0.00	0.03	0.00	0.00
Tubificoides swirencoides								0.00	0.00		0.00	0.00						
Enchytraeidae																		
Corophium (juvenile)								0.00										
Corophium volutator				0.02			0.00	0.09		0.08	0.03			0.09		0.00	0.01	
Diastylis rathkei																		
Hydrobia ulvae	0.00	0.02		0.00														
Mytilus edulis																	0.00	
Mysella bidentata																		0.06
TELLINACEA (juvenile)	0.00	0.00		0.00		0.00									0.00	0.00		
Macoma balthica	0.09	0.12	0.03		0.10	0.08		0.39	0.03	0.04	0.01						0.01	0.00
Abra tenuis	0.00	0.00	0.00															

Table 2 (continued): Raw biomass data (g.sample^{-1}) from North Killingholme intertidal monitoring (2010)

	Site 7			Site 8			Site 9			Site 10			Site 11			Site 12		
Taxon	Upper	Mid	Lower	Upper	Mid	Lower	Upper	Mid	Lower	Upper	Mid	Lower	Upper	Mid	Lower	Upper	Mid	Lower
TURBELLARIA																		
NEMATODA	0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00		0.00	0.00	0.00	0.00
Eteone flava/longa		0.00																
Hediste diversicolor				0.34			0.03					0.07	0.15			0.43		
Nephtys hombergii															0.00			
Scoloplos armiger																		
Pygospio elegans								0.00										0.00
Streblospio shubsolii	0.00	0.00	0.00		0.00	0.01		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Tharyx sp.		0.00			0.00													
Tharyx killariensis																		
Capitella capitata (sp. complex)																		
Arenicola (juvenile)																		
Manayunkia aestuarina	0.00												0.00			0.00		
Paranais litoralis	0.00																	
Heterochaeta costata				0.00									0.00					
Tubificoides benedii	0.03	0.01	0.00	0.01	0.04	0.00	0.00	0.00			0.00	0.00	0.00	0.00			0.01	0.00
Tubificoides swirencoides								0.00										
Enchytraeidae													0.00			0.00		
Corophium (juvenile)																		
Corophium volutator	0.05	0.00		0.03	0.03		0.19	0.00	0.00		0.01	0.02	0.01	0.15		0.04	0.03	0.11
Diastylis rathkei															0.00			
Hydrobia ulvae																		
Mytilus edulis																		
Mysella bidentata																		
TELLINACEA (juvenile)												0.00					0.00	
Macoma balthica	0.11	0.16		0.01	0.03	0.00	0.00	0.00	0.00	0.01	0.01		0.01	0.51	0.07		0.22	
Abra tenuis																		

Table 3: Raw abundance data (individuals.sample^{-1}) from North Killingholme intertidal monitoring (2010)

	Site 1			Site 2			Site 3			Site 4			Site 5			Site 6		
Taxon	Upper	Mid	Lower	Upper	Mid	Lower	Upper	Mid	Lower	Upper	Mid	Lower	Upper	Mid	Lower	Upper	Mid	Lower
TURBELLARIA													1					
NEMATODA	5	35	1		10	5	6	8	1	3	3	1	2	7			11	3
Eteone flava/longa																		
Hediste diversicolor	12						26						5					
Nephtys hombergii																		
Scoloplos armiger						1												
Pygospio elegans						1		3					1				1	
Streblospio shubsolii	6	9		1	4		6	4	6	2	4	2	3	2	2	4	6	15
Tharyx sp.														4			2	
Tharyx killariensis																		1
Capitella capitata (sp. complex)		1																
Arenicola (juvenile)												1			1			
Manayunkia aestuarina	1	1					32						2					
Paranais litoralis					6	1	5			9			6					
Heterochaeta costata				2									1					
Tubificoides benedii	38	136	1	2	12	1	43	4	2	55	5	1	38	4	1	50	10	1
Tubificoides swirencoides								1	15		1	1						
Enchytraeidae																		
Corophium (juvenile)								1										
Corophium volutator				3			2	34		12	10			32		1	10	
Diastylis rathkei																		
Hydrobia ulvae	4	6		1														
Mytilus edulis																	1	
Mysella bidentata																		1
TELLINACEA (juvenile)	13	1		1		1									1	2		
Macoma balthica	2	5	2		4	4		9	2	1	2						4	1
Abra tenuis	3	3	1															

Table 3 (continued): Raw abundance data (individuals.sample^{-1}) from North Killingholme intertidal monitoring (2010)

	Site 7			Site 8			Site 9			Site 10			Site 11			Site 12		
Taxon	Upper	Mid	Lower	Upper	Mid	Lower	Upper	Mid	Lower	Upper	Mid	Lower	Upper	Mid	Lower	Upper	Mid	Lower
TURBELLARIA																		
NEMATODA	2	2		2	5	1	6	3	1		4	4	20		1	3	5	3
Eteone flava/longa		1																
Hediste diversicolor				24			4					3	13			30		
Nephtys hombergii															1			
Scoloplos armiger																		
Pygospio elegans								1										2
Streblospio shubsolii	12	6	9		1	15		5	4	6	2	6	9	6	5	1	1	27
Tharyx sp.		2			2													
Tharyx killariensis																		
Capitella capitata (sp. complex)																		
Arenicola (juvenile)																		
Manayunkia aestuarina	1												5			1		
Paranais litoralis	5																	
Heterochaeta costata				1									3					
Tubificoides benedii	30	16	1	6	56	1	1	3			4	3	5	2			19	3
Tubificoides swirencoides								1										
Enchytraeidae													2			1		
Corophium (juvenile)																		
Corophium volutator	10	1		13	12		52	4	2		2	15	3	70		13	27	71
Diastylis rathkei															1			
Hydrobia ulvae																		
Mytilus edulis																		
Mysella bidentata																		
TELLINACEA (juvenile)												1					1	
Macoma balthica	3	3		1	3	1	2	2	1	3	1		1	6	3		8	
Abra tenuis																		

3.2 Objectives

98. Following inundation and subsequent operational management of the RTE site, intertidal habitats will become established providing opportunity for benthic invertebrate communities to colonise. With suitable source communities close by in the existing estuarine mudflats, this is likely to happen fairly quickly. For example, experience at Paull Holme Strays has shown that, after five years, species richness is comparable to that outside the managed realignment site (20 species recorded inside the site and 21 species recorded outside the site in 2008) and was at levels that are typical of a middle estuary community (Environment Agency, 2009). Indeed, experience at Paull Holme Strays identified some functional delivery of invertebrate prey (and perhaps vegetative matter) more quickly than this, with foraging by some species occurring within one year of the breach, waterfowl assumed to be taking advantage of animals and other material washed into the site (as well in the case of Paull Holme Strays) of terrestrial plant material and organisms present within the site at the time of breach.

99. Whilst differences were apparent within the observed communities from inside and outside the realignment site, with mean values of species richness, abundance and diversity found to be slightly lower inside the site compared to outside, the overall biomass was found to be more or less equal as larger species were found inside the site compared to outside (Environment Agency, 2009). Initial colonisation by different invertebrate species may be due to difference in sediments within the site (which, as former agricultural soil, will be nutrient rich and will have different physic-chemical properties to sediments outside the site).

100. Although many birds are frequently opportunistic feeders, some do have particular preferences and their distributions may show significant relationships with the densities of their preferred prey. The most abundant invertebrate species dominating the diets of birds in the Humber Estuary have been found to be *H. diversicolor*, the Baltic tellin *M. balthica* and the mud shrimp *C. volutator* in the middle estuary (Stillman *et al.*, 2005). These are likely, therefore, to be key prey items determining site quality for waders on the Humber estuary, although other molluscs and annelid worm species are also important for certain wader species.

101. Most studies suggest that, whilst it is the larger prey items that are the main preferred dietary component of Black-tailed Godwit on estuaries, a wide range of prey are generally taken, with a likely shift to smaller prey items later in the winter or wherever preferred prey are restricted by other factors (e.g. disturbance at preferred feeding stations) making utilisation of the alternative resource beneficial. Observations of Black-tailed Godwit foraging on the middle Humber (when prey swallows can be seen) suggests that they take quite large items

such as *Nephtys*/*Hediste* and (occasionally) larger bivalves (Nick Cutts, pers.obs.). This does not however preclude the possibility that smaller items may also be taken. Notwithstanding, the percentage dominance biomass figures from recent surveys on the North Killingholme Marshes foreshore intertidal foraging area suggests that smaller organisms such as *Tubificoides* represent only around 10% of the biomass represented by *Hediste*/*Macoma*/*Corophium* for the majority of the area, and so this would probably not be the preferred prey item.

102. Monitoring data has demonstrated that the intertidal benthic community at North Killingholme Marshes supports an assemblage typical of the middle reaches of the Humber Estuary and in particular, similar levels of *Hediste* abundance have been seen at Paull Holme Strays and at Cherry Cobb Sands for example. However, given its use as a key foraging ground for SPA/ Ramsar species (especially for Black-tailed Godwit) it would seem appropriate to base benthic invertebrate quality objectives on assemblages seen at North Killingholme Marshes foreshore. As an overall objective therefore, the new intertidal habitat created within the RTE should develop a benthic invertebrate assemblage that is generally commensurate with that observed at North Killingholme Marshes foreshore and the intertidal mudflat habitat at Cherry Cobb Sands. In particular, the contributions that are made by *Hediste*, *Macoma* and *Corophium* should be considered as being useful indicators of the forage value of the assemblage.
103. Whilst there are obviously many factors that will influence this provision, and particular challenges in terms of addressing the provision of large prey items for Black-tailed Godwit within the RTE compared to the open shore of the North Killingholme Marshes frontage, it should be noted that data from monitoring at Paull Holme Strays has shown that the greatest density of Black-tailed Godwit foraging use was associated with areas of high *Hediste* density, the density and size of the *Hediste* being comparable to those seen along the North Killingholme Marshes frontage. Furthermore, similar *Hediste* density values were also seen on the fronting Foul Holme Sands intertidal zone, but without an associated Black-tailed Godwit foraging flock preference.
104. The above would indicate, albeit with a limited data set, that mudflat within at least one managed realignment site in the middle Humber is capable of supporting an invertebrate assemblage and associated environmental conditions that are favoured by Black-tailed Godwit as a foraging habitat.
105. Currently, it is only the site characterisation data from North Killingholme foreshore (as discussed above) that is available to help develop a quality objective for intertidal benthic invertebrates at the Compensation Site. There is the need to complete a more detailed

baseline survey, ideally as close to pre construction phase as possible but, where possible, timed to also meet other criteria (for example on bird use and prey availability). Data from these surveys, which should cover the intertidal foreshore at both North Killingholme Marshes and Cherry Cobb Sands, should be used to develop more detailed and robust targets.

106. In the interim the following section provides some initial targets for the site based on its ecological potential.

3.2.1 BENTHIC COMMUNITY ANALYSIS & COMPARISON - BROAD TARGET SETTING

107. Target setting has included calculations on broad community metrics that will be lost from the North Killingholme foreshore intertidal area (both in terms of species abundance and biomass, standardised to m^2) (see Table 4) and, associated with these, targets that are necessary to offset these losses. In addition, estimations of likely composition, abundance and biomass, based on data from the estuarine mudflat fronting the proposed Compensation Site (Cherry Cobb Sands 2000-2002) and the Paull Holme Strays managed realignment site (2010) have been provided (Table 5). Based on these data (see Table 5), together with area provision calculations, it has been possible to identify the 'potential' for necessary carrying capacity to be achieved.

Table 4: North Killingholme grouped elevation benthic comparison summary

Taxon abundance Average number/m^2	Upper, middle & lower shore	%	Taxon abundance Average number/m^2	Upper & middle shore	%
Tubificoides benedii	554	33	*Tubificoides benedii*	539	38
Corophium volutator	399	24	*Corophium volutator*	311	22
Streblospio shubsolii	191	11	*NEMATODA*	142	10
NEMATODA	163	10	*Hediste diversicolor*	114	8
Hediste diversicolor	117	7	*Streblospio shubsolii*	100	7
Species > 5% of assemblage		85	Species > 5% of assemblage		86
Taxon biomass (g)	**UpMiLo**	**%**	**Taxon biomass (g)**	**UpMI**	**%**
Hediste diversicolor	2.92	45	*Hediste diversicolor*	2.86	48
Macoma balthica	2.03	31	*Macoma balthica*	1.82	31
Corophium volutator	0.99	15	*Corophium volutator*	0.86	14
Tubificoides benedii	0.38	6	*Tubificoides benedii*	0.38	6
Mysella bidentata	0.06	1			
Streblospio shubsolii	0.05	1			
Biomass > 1% as of assemblage		99	Biomass > 1% as of assemblage		99

Table 5: Comparative summary data from Paull Holme Strays managed realignment (2010) and Cherry Cobb Sands intertidal (2000-2002)

Paull Holme Strays managed realignment			**Cherry Cobb Sands foreshore intertidal**		
Average abundance	**No/ m^2**	**%**	**Average abundance**	**No/ m^2**	**%**
Enchytraeidae	6675	43	*Enchytraeidae*	34380	54
Manayunkia aestuarina	4607	30	*Nematoda*	13198	21
Nematoda	3442	22	*Tubificoides benedii*	7443	12
Species > 5% of assemblage		95	*Macoma balthica*	4641	7
Additional spp			Species > 5% of assemblage		94
Hediste diversicolor	467	3	**Additional spp**		
Hydrobia ulvae	293	2	*Manayunkia aestuarina*	1283	2
			Hediste diversicolor	1046	2
Average biomass (g/m^2)		%			
Hediste diversicolor	13.28	92.4			
Hydrobia ulvae	0.56	3.89			
Enchytraeidae	0.33	2.3			
Manayunkia aestuarina	0.16	1.12			
Biomass > 1% as of assemblage		99			
Abundance data for additional species provided above to allow comparison to the North Killingholme dataset			No biomass data and no sample processing data are available for Cherry Cobb Sands *Additional spp abundance data provided above for comparison to the North Killingholme dataset*		

108. The potential for the Compensation Site to provide surety of foraging provision has also been addressed, and associated with this, a series of targets for the Compensation Site to be assessed against have been developed. These are based on the assemblage that will be lost and those that are likely to develop within the site based on surrogate data from adjacent areas.

109. To be completed

3.3 Management

110. Operational management of the RTE is described within EX 28.3 Part 3. Following detailed design, a comprehensive Operation and Maintenance Manual will be developed.

3.4 Monitoring

3.4.1 MONITORING PROTOCOLS

111. In relation to the compensation works, intertidal benthic invertebrate assemblages will be monitored at a number of sites:

- Cherry Cobb foreshore intertidal (pre- and post-construction) – three stations on each of four transects across the foreshore covering the upper- mid- and lower-intertidal (12 sampling stations in total);

- Newly created intertidal habitat (post-construction) – three stations on each of two transects across each of the four RTE fields (24 stations in total) plus five further stations within the managed realignment area of the site; and
- Non-impacted north bank control site (e.g. within 1 km of breach) – three stations on each of three transects (nine stations in total).

112. Four replicate samples will be taken at each station, three of which will be analysed for macrofaunal species composition, enumeration and biomass (tissue dried wet weight) with the fourth being used for an assessment of sediment particle size and organic content.
113. Sampling should be carried out using hand-held corers (e.g. 0.01 m^2 sampling area) to a depth of c.10 cm. Sample locations along transects should be recorded using GPS to allow for greater site fidelity between years.
114. 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.);
    - Character and composition of surface sediments; and
    - Providing a photographic record of the sampling station.
115. All sites will be monitored on a biannual basis; monitoring in the spring will be used to compare against the original site characterisation data whilst monitoring in the autumn, when productivity and biomass is highest, will show the amount of food that is available to overwintering/passage birds.
116. Where possible a full (spring and autumn) pre-impact baseline survey of the Cherry Cobb intertidal and the proposed north bank control site should be carried out.
117. Monitoring should continue for a period of at least ten years following completion of the works. Consideration will be given to undertaking additional interim surveys of the RTE site following intrusive operational management works, such monitoring being at the discretion of the EAG.

4. TERRESTRIAL HABITATS

4.1 Baseline

4.1.1 WET GRASSLAND INVERTS

118. There are no baseline data for grassland in the area and consequently information from the literature will be used to develop initial quality objectives for this habitat.
119. Site-specific pre-development baseline data on terrestrial invertebrate populations (both soil and surface) across those areas that are intended to become wet grassland will be obtained before works on the grassland creation commence.

4.2 Objectives

4.2.1 WET GRASSLAND HABITAT

120. The compensation package includes the creation of approximately 26 ha of wet grassland from existing arable land at Cherry Cobb Sands within an overall site of approximately 38 ha. The focus of the site is on the development of earthworm populations, to provide foraging habitat predominantly for black-tailed godwits and curlew, rather than the provision of botanically rich grassland.
121. The design and the management regime (hydrological and botanical) will develop and maintain moist but un-flooded grassland.
122. An important part of the compensation package is the provision of a roost site which lies close to feeding areas for the shorebirds, mirroring the current functional relationship between North Killingholme Marshes foreshore and North Killingholme Haven Pits. It is expected to be of particular importance for adult black-tailed godwits which are present during their post breeding moult.
123. The main roost area will be provided in the southern section of the proposed wet grassland site in the form of an area of open water (approximately 5 ha and maximum depth of 1.4 m) with two islands (0.4 ha in total and with a height of 0.5 m above predicted maximum water level). The open water area will be created by lowering the field level and removing approximately 35,000 m^3 of soil. Additional roosting opportunities are also expected in the water filled scrape (1.3 ha and 0.15 m deep, with an island of 0.1 ha) further north in the wet grassland site. See Figure 2.

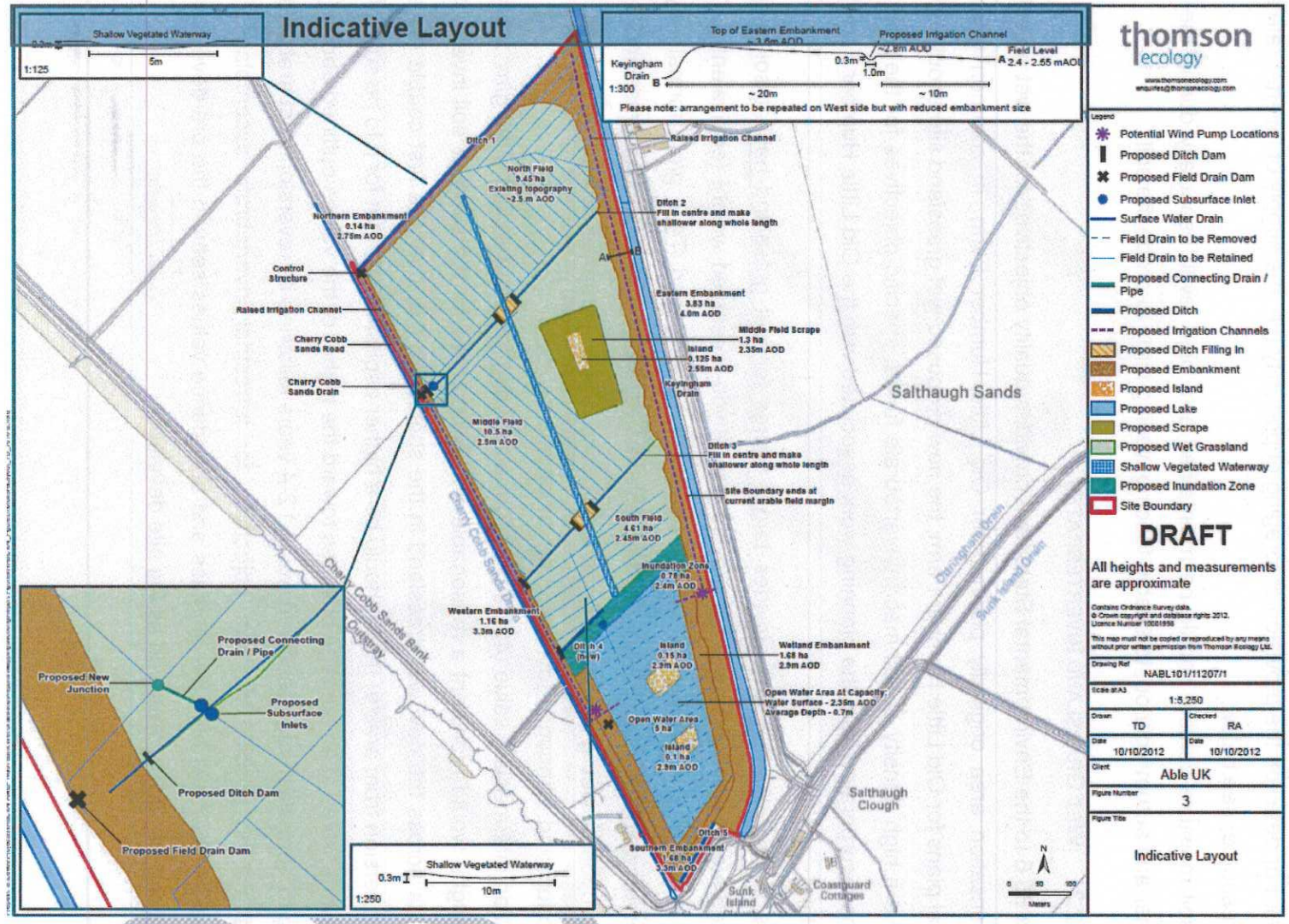

Figure 2: Indicative layout of wet grassland area

124. The primary habitat quality objective for this element of the compensation package is for it to provide functioning wet grassland habitat for foraging birds, to augment that provided by the RTE and managed realignment site, within three years of commissioning.
125. To ensure that invertebrates are concentrated near to the soil surface, and that the soil remains soft enough to be probed by waders, the water table should remain high – ideally around 10 cm below the surface. The site should be wet throughout the period from August to April. For detail on the provision of foraging opportunity (i.e. the supply of invertebrate as a food resource) see below.
126. The soil moisture content should be maintained at a high level, especially during the late summer and autumn period, to enable feeding wading birds to probe the soil.

4.2.2 WET GRASSLAND INVERTEBRATES

127. Annex 35.6 to the Environmental Statement provides quality objectives for the wet grassland compensation area originally planned for Old Little Humber Farm. In common with the original plans for Old Little Humber Farm, the new proposed wet grassland site should aim to achieve a high density of soil macro-invertebrate fauna; specific objectives for the new site may be incorporated from the planning work associated with the Old Little Humber Farm wet grassland.
128. In this context, Annex 35.6 provides target figures for wet grassland habitat soil macro-invertebrate faunal biomass: c.6.5 g/m^2 formaldehyde-preserved weight (equivalent to 1.28 g/m^2 ash-free dry weight) for winter flooded grassland and 74.2 g/m^2 formaldehyde-preserved weight (equivalent to 14.6 g/m^2 ash-free dry weight) for unflooded grassland.
129. The proposed wet grassland compensation site would comprise a mix of flooded and unflooded land, although most would be unflooded.
130. Whilst an intermediate value (40.35 g/m^2 formaldehyde preserved weight; 7.94 g/m^2 ash free dry weight) would represent a reasonable quality objective for the average soil invertebrate biomass across the new wet grassland in the short term (i.e. over the first couple of years after reversion from arable) there should be a higher aspirational target for it to be supporting soil invertebrates at an average biomass toward the higher of the values outlined above (e.g. c.70 g/m^2 formaldehyde-preserved weight) 2-4 years following its reversion from arable land.
131. There are no specific biomass objectives for terrestrial invertebrate assemblages but significant increases over the biomass and abundance values seen in the pre-development monitoring should be observed as the site develops.

4.3 Management

4.3.1 Wet Grassland Management

132. Detail of management works associated with the construction phase of the wet grassland area, together with detail of the physical operational management of the site (e.g. the control of water levels), is provided separately in EX28.3 part 4. In addition, the development of any final management plan for wet grassland will have regards to the pertinent guidance documents relating to wet grassland creation for wintering waders and wildfowl and for breeding waders that are available from Natural England.
133. For the first two to three years the aim should be for high spring water levels in soil, ditches and other water features (but not extensive surface flooding), with natural drying from June to allow ideal sward management.
134. Arable soils may be depleted of organic matter and nitrogen. Low organic matter may contribute to low earthworm populations. Farmyard manure can have positive effects on insects and earthworms, which in turn support a range of bird species including waders (RSPB, 2008b). Adding organic fertiliser may be necessary to boost invertebrate numbers in order to support a greater number of birds. An RSPB supervised PhD study (Horton-Watkins, 2007) looked at the benefits of farmyard manure on soil invertebrates and the effects on breeding waders on wet grassland reserves. The study experimentally tested various application levels on four RSPB reserves and found that there was a significant increase in earthworm abundance across all four study sites following applications of 10 and 15 t/ha farmyard manure. Preliminary recommendations are that biodiversity benefits will be gained from adding 10 t/ha/annum of farmyard manure. Although this study did not measure nitrate leaching, the RSPB was not of the opinion that the low levels of farmyard manure applied would cause significant diffuse pollution problems. If appropriate, well-rotted farmyard manure can be applied at low rates (e.g. around 10 t/ha) in late winter or early spring (this timing helps to reduce the loss of nutrients).
135. In addition to organic enrichment consideration will be given to using earthworm inoculation (a well researched technique with commercial operators available in the UK) as a means of providing greater certainty for biomass development.
136. Grazing with livestock, usually cattle, at a moderate intensity is an ideal management tool as it creates a mosaic of tussocks and short turf and also augments the invertebrate population through dunging. The grassland should ONLY be grazed following a minimum establishment period of three or six months, depending on whether sown in spring or autumn. Introduction of livestock should follow a careful assessment of the readiness of the grassland for grazing.

137. To avoid trampling of nests, only light grazing should be implemented between mid-March and June. Heavy grazing from late summer onwards will restore the required sward heights for the following year. Although stocking rates can be prescribed (for example, in the first year of grazing, the stock density should be 0.2 livestock units per hectare per year and occur in the months of April to June, inclusive, whilst in subsequent years stock density should be increased to 0.3 livestock units per hectare per year, or to the level required to produce the desired sward structure, and again occur in the months of April to June, inclusive) it is important to recognise the value of adopting an adaptive management practice rather than to set prescriptions in an attempt to create the correct habitat for target species (RSPB, 2008a).
138. The wet grassland site will need to be stock fenced because the drainage ditches do not provide a sufficient barrier to stock.
139. If grazing is not possible then cutting will be essential and should be timed for suitable dry periods after the end of the breeding season, usually between August and October. As a guide, cutting would generally be required at least twice a year.
140. Any weed infestation issues that arise will need to be addressed, e.g. with frequent topping to stop weed species from seeding. Significant weed problems after the first year may need to be controlled (e.g. with a suitable herbicide applied ideally using a weed-wiper, with early grazing being used to introduce a height differential before the herbicide application). A long-term 'operational' management regime can be implemented once the sward has become established.
141. The sward height by August 1st should be less than 10 cm.

4.4 Monitoring

142. As noted in Section 4.1.1 a baseline survey of terrestrial invertebrates (both soil and surface) will be undertaken before works on the grassland creation commence.
143. Once the grassland area has been created, a routine monitoring programme should be established to record the development of the terrestrial invertebrate assemblages.

4.4.1 Wet Grassland Habitat Terrestrial Invertebrates

144. Sampling will follow established protocols (for example see JNCC, 2008) although, for soil dwelling invertebrates, the following approach should be employed by way of guidance:
145. Four 200 m transects will be set out across the site. Soil samples (25 cm x 25 cm in area, and to a depth of 10 cm) should be taken at 20 m intervals along each transect (providing a total of 44 samples). Samples should be taken with a spade using a quick, levering, action to

intercept retreating large earthworms and should be stored in sealed bags or containers (with an adequate volume of air to keep the invertebrates alive until sorting) and kept cool.

146. Laboratory analysis (which should be within ten days of collection) should involve a timed sort (e.g. 20 minutes); all macro-invertebrates encountered in this period should be collected, but no further sorting should be done after the 20 minute period has elapsed.

147. Numbers of macro-invertebrates per sample will be recorded, with specimens being preserved by immersion in boiling water. Wet weights will be recorded to two decimal places. Subsequently, after drying in a laboratory oven for four hours, ash-free dry weights will be taken.

148. Sampling will be annual and should, for consistency with sampling at other sites within the project, be undertaken in April or May. The sampling programme will be established for a period of at least five years following completion of the works. Any longer-term monitoring requirements will be determined at the end of the monitoring period. Results will be reported on an annual basis.

149. For surface dwelling terrestrial invertebrates a 'barriered pitfall trap' design is recommended to assess the existing soil surface invertebrate assemblages. Common ground dwelling invertebrates such as beetles and spiders have a tendency to follow the edge of obstacles they meet. The barrier design exploits this behaviour to guide invertebrates into the traps thus significantly increasing the potential trapping area. The pitfall arrays are simple to deploy. Radiating from the central trap, four 0.5 m channels are cut into the soil using a semi-circular lawn edger. The barriers (plastic lawn edging or similar) are then dropped into the channels so half remains above the soil. The channel is then closed around the barriers and a pitfall trap is placed at the end of each barrier. Each array will take approximately 5-10 minutes to put in place.

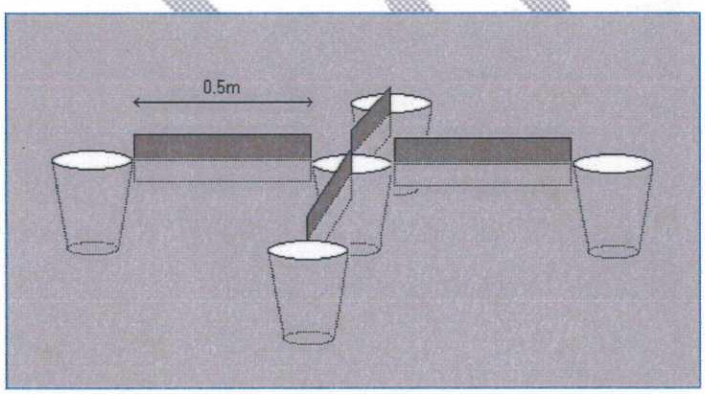

Figure 3: A barriered pitfall trap array

150. As the survey area is relatively large consideration will be given to dividing the field into smaller units, focussing sampling on the central and peripheral areas (with pitfall arrays

being distributed randomly within these defined areas). Sampling should also take place at a minimum distance of 10 metres from field boundaries to minimise edge effects.

151. A total of 20 arrays should be set and monitored, representing a compromise between the use of the high efficiency trapping method proposed and the need to distribute traps in such a way that all areas of the field receive the same sampling effort. Using a randomised method of distributing the arrays over the whole field may be unrepresentative if the replication is not adequate to sample the whole field area.
152. Traps will be left open for 72 hours. Whilst previous studies have shown that 48 hours is a sufficiently long sampling duration, without prior knowledge of invertebrate densities three days should provide an adequate sampling period should densities prove to be especially low. Three days will also allow for timely completion of concurrent soil invertebrate sampling.
153. As results for pitfall sampling cannot be expressed as a density, results will be expressed as the average number of invertebrates caught for the arrays for a particular field. The design should also give an indication of how numbers of invertebrates change in different areas of the fields.
154. The sampling programme for terrestrial invertebrates should be initiated on the basis of it lasting for at least 10 years, although a reduction in this timescale may subsequently be advised by the AEG.

5. BIRDS

5.1 Baseline

5.1.1 CHERRY COBB SANDS INTERTIDAL

155. Annex G to the Habitats Regulations Assessment Report makes reference to a recent report produced for Able UK Ltd. (Institute of Estuarine and Coastal Studies, 2011: Cherry Cobb Sands Compensation Site Bird Survey Results – August 2010 to April 2011) that provides pertinent baseline data in order to describe waterbird usage of the intertidal foreshore areas adjacent to Cherry Cobb Sands. These data were obtained by from weekly surveys undertaken around low tide and high tide between August 2010 and April 2011.

156. The intertidal habitat on the upper shore, including the saltmarsh habitat at Cherry Cobb Sands, were found to provide a key high tide roost for a range of waterfowl including Dunlin (*Calidris alpina*), Curlew, Redshank (*Tringa totanus*), Bar-tailed Godwit (*L. limanda*), Grey Plover (*Pluvialis squatarola*) and occasionally Knot (*C. canutus*). In addition, the intertidal area was well used by Golden Plover (*P. apricaria*), largely for roosting (as they forage on inland fields). At times Golden Plover were observed in numbers that exceeded the thresholds for both national (4,000 birds) and international importance (9,300 birds) with a count as high as 11,735 birds being recorded for the area (September 2010). Golden Plover are an Annex 1 species and are often found in large flocks on the Humber Estuary, both on inland fields and on intertidal mudflats, with flocks habitually using the same areas. The Humber is the single most important site for wintering Golden Plover in the UK, and, although numbers have been in decline in recent years, the estuary can support around a third of the UK population. However it is emphasised that Golden Plover predominantly use the intertidal habitat and terrestrial habitat immediately adjacent to the estuary for loafing and roosting, with foraging undertaken in inland areas, often at night.

157. In terms of feeding, the intertidal foreshore of the Cherry Cobb area can at times support large and important numbers of Curlew (with up to 1,703 birds recorded at low tide in August 2010). The pattern of use is however variable with high tide counts sometimes exceeding low tide counts (implying that Curlew may move into the Cherry Cobb Sands foreshore area from elsewhere on the Humber Estuary, or indeed from inland feeding areas).

158. Lapwing (*Vanellus vanellus*) were also recorded on the foreshore. Again, numbers were variable (e.g. four birds in September 2010 and up to 2,073 birds in November 2010), with greater numbers being observed around low tide. Lapwing tend to use the area in a similar way to Golden Plover, primarily foraging in inland areas, and using the intertidal mudflats and terrestrial fields immediately adjacent to the estuary as a roost and loafing resource.

159. Grey Plover, a species that favours the intertidal mudflats of the middle to outer estuary, was predominantly present on the foreshore around low tide (with a peak of 623 observed in February 2011, in excess of the national importance threshold).
160. Bar-tailed Godwit (an Annex 1 species) were recorded largely on the intertidal habitats, with a peak of 358 at high tide in December 2010. This usage is typical for this species which favours mudflats and occurs in peak numbers on the Humber Estuary typically in the early to mid winter period.
161. Survey findings showed that Dunlin predominantly used the intertidal mudflat habitat where they occurred in large numbers (a peak of 2,940 in early October 2010).

5.1.2 NORTH KILLINGHOME INTERTIDAL

162. Through the tide counts for birds using the intertidal areas at North Killingholme are presented in the Marine EMMP and Chapter 6 of the Habitats Regulations Assessment, 'Shadow Appropriate Assessment'; a summary of these data is provided below within Section 5.2.4.

5.1.3 CHERRY COBB SANDS - ADJACENT FIELDS

163. A range of bird species were observed using the adjacent arable fields as roost sites during high tide periods (when alternative roost sites on the intertidal zone were unavailable). The provision of high water roost sites around the estuary is important for a number of species, and in particular, those present in large flocks, such as Golden Plover and Lapwing. On neap to mid tides, roost use by many waterbirds may be possible on the intertidal zone, although some species such as Golden Plover and Lapwing tend to move onto adjacent inland fields rather than be compressed onto the upper shore zone where flight and sight lines may be compromised. On larger tides, saltmarsh and grassland habitat may be available for use on the upper shore, but on spring tides this resource also tends to be covered and flocks may then either congregate on a small number of supralittoral areas, flood protection banks and walls and adjacent terrestrial fields.
164. As such, there is the potential for most arable fields adjacent to the flood banks to be utilised as a high spring tide roost, depending on crop type and status, although some fields tend to be habitually used on other tides (e.g. neap tides or intermediary tides) by some species.

5.2 Objectives

5.2.1 GENERAL OBJECTIVES

165. The overall objective is for population of bird species within the Humber SAC/SPA site to be maintained after taking into account the bird numbers using the compensation site.

166. In the context of habitat, the EC Habitats Directive as applied to this project requires the production of habitat compensation for the loss of Annex 1 habitat types from the Humber SAC. Additionally, the qualifying features of the Humber SPA (i.e. those species of bird listed under Annex 1 of the EC Birds Directive, migratory species present in Internationally Important Numbers and Internationally Important Assemblage of Waterfowl - for which the site has been designated) should be preserved.

167. In the context of bird use this may be accomplished by a redistribution of birds within the SPA (i.e. movement from their current preferred foraging areas, given no concomitant reduction in overall numbers). At its simplest, new (additional) bird use of new intertidal habitat at the Compensation Site (i.e. within the RTE) should be commensurate with that recorded for (and being lost at) the area of foreshore at North Killingholme Marshes that is being compensated for. However, whilst this should be a management aim (in terms of compensatory provision), there needs to be an acknowledgement of uncertainty, in that whilst the Compensatory Site may be able to provide necessary compensatory carrying capacity for waterfowl affected by the development, birds may actually decide to relocate elsewhere in the estuary, rather than to the Compensation Site itself. Given the possibility that, rather than exploit the new habit that is being created, certain species may elect instead to make use of alternative habitats in the locality, it is therefore also important to consider monitoring outwith the immediate impact and compensation areas. Whilst this can be effected through the inception of a dedicated monitoring programme, it will be important also to integrate information from a wider geographic source (e.g. the monthly high water WeBS counts from across the Humber area) to demonstrate that those qualifying bird species within the Humber SPA designation are not, in the wider context, being adversely affected by the AMEP project (i.e. that the integrity of the SPA is being maintained).

5.2.2 NEW INTERTIDAL HABITAT (RTE)

168. As discussed above, it is not considered appropriate to identify a fixed target for bird use of the new RTE habitat in terms of specific species and abundance levels, given the potential influence of numerous exogenic factors. However, for the habitat to be seen as ecologically functional, its ability to support a bird assemblage commensurate with that previously seen at North Killingholme Marshes foreshore after a five year period of operation should be taken as a nominal quality objective. As such, it would be expected that the site should provide sufficient carrying capacity for an assemblage characteristic of a middle Humber Estuary mudflat. Management objectives should be set around the site fulfilling the requirements of groups of species with similar habits (i.e. species guilds) rather being set for than specific individual species per se; relative abundance levels at the site should be set against the

wider perspective of middle estuary usage. The species composition diagrams for the middle and outer estuary (based on WeBS data) provide a useful indication of assemblage composition (Environment Agency & Halcrow, 2011: Humber Flood Risk Management Strategy Habitat Regulations Assessment Volume 1 & 2). It will be important however to view this alongside any assessments of the invertebrate assemblages present in the newly created intertidal.

169. Monitoring of bird usage within the Paull Holme Strays site has recorded both roosting/loafing and foraging usage by Black-tailed Godwit and the provision of some key prey items for the species at density and biomass that are similar to that recorded at the North Killingholme Marshes frontage.

170. In addition, monitoring at Paull Holme Strays has identified that the site provides roost function for Bar-tailed Godwit which forage on the mudflats fronting the site, with roost flocks regularly in excess of 100 using the site.

171. As such it is considered that, based on the analysis of usage from Paull Holme Strays, there is a strong likelihood that environmental conditions (including a benthic assemblage) would develop within the RTE site which would be suitable to support both foraging Black-tailed Godwit and loafing Bar-tailed Godwit.

5.2.3 WET GRASSLAND

172. Similarly, the roosting and foraging habitat provided by the wet grassland (and its associated area of open water, wet scrape and series of islands) is intended to provide a resource for a number of SPA qualifying species potentially impacted by the development at AMEP (in particular, Black-tailed Godwit). It will provide robustness to the compensation scheme by replicating the functional link seen between the North Killingholme Haven Pits and the North Killingholme Marshes foreshore seen on the south bank.

173. It is not a simple matter to ascribe a quality objective to the functionality of this new habitat, although it would be reasonable to expect it to be supporting the foraging activities of a number of wader species including Black-tailed godwit, Redshank, Curlew and perhaps Lapwing and Golden Plover as well as several wildfowl species. The main foraging use would be expected during the autumn, winter and early spring, but with the potential for the site to be used as a breeding resource e.g. by Snipe (*Gallinago gallinago*) and other waterfowl, depending on habitat development.

5.2.4 BIRD USE TARGETS

174. It is proposed that a series of metrics are developed that will allow both broad compensatory targets and wider Natura 2000 integrity checking to be carried out effectively and transparently.

175. There is a requirement to provide 'aspirational' targets for the Compensation Site and waterfowl foraging provision, e.g. that the Compensation Site is able to support in principle, all of the waterbirds likely to be displaced by the development of the AMEP site.

176. As such, the objectives of the target setting are to firstly ensure that there is headroom within the compensation package to provide, with a high degree of confidence, the necessary additional carrying capacity to compensate for lost functionality due to the AMEP development.

177. Table 6 identifies individual species maxima recorded from the through the tide count programme at the AMEP site, this maxima being for all sectors within the study area (including areas which would not be directly lost from the AMEP site, but which might be indirectly affected to some extent). This is therefore the extreme worst case in terms of compensatory provision, but should act as the underlying aspiration of the compensation package in terms of a 'target'. However, in addition to this, a metric has been identified translating the survey programme maxima to maxima based on a habitat loss basis. This has necessitated the assumption that species distribution was uniform across the site (which it was not for some species), but with a similar assumption necessary for the RTE area.

178. Whilst it is acknowledged that there might be issues associated with this approach in terms of key species distribution identified from the survey, it is also considered of note that key species, in particular Black-tailed Godwit are a dynamic feeder, which, due to their often dense foraging strategy can therefore rapidly deplete a 'patch' and move to another area, and as such, distribution may only be a 'snapshot' of activity over a season.

179. However, in order to more accurately capture provisioning throughout the year, metrics have also been derived (again on a species basis) using monthly mean maxima from the through the tide counts, and again, these have been identified both in terms of the total survey area, and in relation to the actual loss of habitat assuming an average distribution (Table 7). Such an approach allows for more sustained use to be captured, perhaps by a sub-set of a larger flock, and thus whilst target maxima might not be achieved, provisioning across the season might be delivered at a level comparable to that seen from the AMEP area. These metrics have been split into the 'winter' and 'passage' periods using the standard WeBS criteria in order to better address specific functional needs. For instance Black-tailed Godwit may

require the site to deliver greater potential during the passage (e.g. moult) period than over winter, a factor which might be masked by a blanket annual mean.

180. Based on these metrics, delivery of adequate compensatory habitat in terms of carrying capacity can be readily checked, and integrated into other standard datasets for wider comparison e.g. survey work along the wider north and south bank frontages, and from the Humber WeBS scheme.

181. However, it is also expected that the functional provision of the Compensation Site requires assessing in relation to the likely invertebrate community that will become established, and the foraging potential that this community will deliver. These benthic metrics are discussed in Section 3.2. Together with the invertebrate targets these bird use metrics provide quantified objectives for the ecological characteristics for the Compensation Site.

182. However, in addition to setting targets for the Compensation Site in terms of carrying capacity potential and its ability to address losses from the AMEP development, it is also necessary to develop a series of metrics to address wider Humber SPA integrity, both in terms of actual integrity issues, but also to provide information for scenarios where other intertidal areas within the Humber may be preferentially used by waterbirds rather than the Compensation Site itself. In this instance a species may move to another foraging area within the estuary either within a few kilometres, or more distant. Such a displacement has the potential to have an effect on the carrying capacity of the estuary, with increased competition either directly displacing another species or group, or through a gradual depletion of a foraging resource. However, there may be sufficient carrying capacity within the Humber to support such a movement, and this also needs to be addressed, as whilst the Compensation Site therefore might not be meeting prescribed targets for a species, through the redistribution, wider Humber site integrity may not be being detrimentally affected.

183. As such, a series of metrics have been provided based around species annual maxima over 5 year periods, using standard WeBS data. These allow the variability of a population to be identified within the Humber, and based on an assumption that the lowest 'natural' maxima is acceptable, then trigger values set for Limits of Acceptable Change (LAC). Such limits will require wider national and even international trends to be taken into account, as well as the setting of an LAC trigger point, for instance it may be necessary to set this trigger at a point above the lowest maxima in order to allow time lags in data availability to be taken into account and a precautionary approach applied. For example the European Bird Census Council provides the following:

184. The 'multiplicative trend' reflects the changes in terms of average percentage change per year. If this trend is equal to 1, then there is no change. For example, if the trend is 1.08,

then there is an increase of 8% per year; if the trend is e.g. 0.93, then there is a decrease of 7% per year.

185. This trend estimate can be converted into one of the following categories to facilitate its further interpretation. Note: the category is not only determined by the value of the trend itself, but also by its uncertainty in the form of its 95% confidence interval (i.e. the trend estimate +/- 1.96 times the standard error of the trend).

- **Strong increase** - increase significantly more than 5% per year (5% would mean a doubling in abundance within 15 years). Criterion: lower limit of confidence interval > 1.05.
- **Moderate increase** - significant increase, but not significantly more than 5% per year. Criterion: 1.00 < lower limit of confidence interval < 1.05.
- **Stable** - no significant increase or decline, and most probable trends are less than 5% per year. Criterion: confidence interval encloses 1.00 but lower limit > 0.95 and upper limit < 1.05.
- **Uncertain** - no significant increase or decline, and unlikely trends are less than 5% per year. Criterion: confidence interval encloses 1.00 but lower limit < 0.95 or upper limit > 1.05.
- **Moderate decline** - significant decline, but not significantly more than 5% per year. Criterion: 0.95 < upper limit of confidence interval < 1.00.
- **Steep decline** - decline significantly more than 5% per year (5% would mean a halving in abundance within 15 years). Criterion: upper limit of confidence interval < 0.95.

186. In any case, it is considered that these LAC triggers should act only as a trigger for the EAG to undertake additional investigation. For instance, a species may have a clustered distribution within the Humber to the extent that whilst in the absence of any external downward trend, a decline has occurred of substantial proportion in another WeBS sector, but with numbers maintained in the AMEP area.

187. As such, the EAG will need to draw on a wide range of metrics to ascertain causal factors related to the AMEP and or Compensation Site delivery, including waterbird data from dedicated surveys in the vicinity of the development and Compensation areas, wider WeBS data, as well as other 'in site' metrics relating to habitat quality and associated function.

Table 6: Potential bird losses from North Killingholme foreshore

Species	Counts summed across 77.5ha (total number of birds)			Equivalent densities (number of birds/ha)		
	Baseline programme (annual) maxima	Winter mean maxima	Passage mean maxima	Density / ha (NK Max)	Density / ha (NK Winter Mean Max	Density / ha (NK Passage Mean Max)
AV	4	0	1	0.1	0.0	0.0
BA	123	49	14	1.6	0.6	0.2
BW	2366	273	644	30.5	3.5	8.3
CU	215	126	97	2.8	1.6	1.3
DN	1029	607	172	13.3	7.8	2.2
L	325	135	3	4.2	1.7	0.0
RP	210	1	67	2.7	0.0	0.9
SU	109	60	46	1.4	0.8	0.6

Table 7: Compensation targets

Species	RTE (based on density values from NK & a 31.5ha direct loss)		
	Annual maxima across full site	Winter mean maxima	Passage mean maxima
AV	2	0	0
BA	50	20	6
BW	962	111	262
CU	87	51	39
DN	418	247	70
L	132	55	1
RP	85	0	27
SU	44	24	19

188.

5.2.5 CHERRY COBB SANDS FORESHORE

189. The situation for management targets is perhaps clearer for the foreshore adjacent to Cherry Cobb Sands where, as an ideal, there should be no significant adverse effects on bird use of the foreshore linked to the construction or operation of the RTE/managed realignment area.
190. The habitat quality objective for Cherry Cobb Sands foreshore is therefore that, overall, the use of this area by birds should remain commensurate with that identified in the available baseline data, subject to natural variation.

5.2.6 ADJACENT FIELDS

191. Annex G to the Habitats Regulations Assessment report highlights that fields currently lying inland of the defence embankment at Cherry Cobb Sands are used by a number of species as high tide roost habitat. Survey findings from 2010/2011 (reported by Institute of Estuarine and Coastal Studies, 2011, and summarised in Annex G to the Habitats Regulations Assessment report) showed that birds tended to prefer to roost on the upper intertidal areas and that they used the adjacent fields outside the designated site predominantly on the highest spring tides, when there was little or no intertidal habitat remaining for them to use.
192. Whilst roosting waterfowl will occasionally be displaced from the existing foreshore (and from the RTE/managed realignment site) they can be expected to use extant adjacent arable fields in the same way that they currently use adjacent fields behind the existing flood defences. The general landscape in the local area is dominated by similar arable farmland made up of large fields. Fields immediately north of the area to be developed for RTE/managed realignment are also arable fields of a similar size to those that will be lost to the development. Although localised disturbance may prevent birds from using one or more of these adjacent fields from time to time, such disturbance is not likely to be any greater than at present. Taking this into consideration and assuming the continuation of current agricultural practice in the area, it has already been concluded that there is not likely to be an adverse effect on the integrity of the Humber Estuary SPA/Ramsar site due to the loss of farmland associated with the development of the planned RTE and managed realignment site at this location.
193. The management of the adjacent grassland is intended to support wader and wildfowl foraging and roosting (especially for Black-tailed Godwit). Whilst the available evidence suggests that the birds are likely to roost on arable fields close to the estuary / farmland interface, the creation of a wet grassland area is expected to draw foraging birds from the estuary intertidal area (there is little of this habitat type present in the local area, and several species will favour the grassland over arable fields as a foraging habitat).

194. It is expected therefore that habitat (field) loss due to the RTE development will not significantly impact on the provision of roost habitat in the area, and consequently no quality objectives have been applied.

5.3 Management

195. Management for birds *per se* is generally inherent in the design and management of the Compensation Site (RTE) and the adjacent wet grassland area.
196. A prime threat to the successful adoption of the sites by displaced wildfowl and waders centres around disturbance, and the proposed re-routing of the public footpath and the installation of bird observation hides will help mitigate for this.

5.4 Monitoring

5.4.1 MONITORING PROTOCOLS

197. In relation to the compensation works, bird use will be monitored at a number of sites:
198. Disturbance impacts will be monitored at Cherry Cobb Sands adjacent to the compensation site on the north bank and in the fields adjacent to the works (which are currently used as high tide roost areas);
199. Following its initial development, bird use of the wet grassland area should be monitored; and
200. Immediately following inundation, monitoring should also be extended to the newly created intertidal habitat at the RTE compensation site adjacent to Cherry Cobb Sands.
201. Given the importance of the existing Cherry Cobb Sands intertidal area for waterbirds, the use by birds of the existing intertidal mudflats adjacent to the works will be monitored before and after the construction of the RTE/managed realignment. Ideally a reasonable baseline of data can be collected ahead of construction in order to gauge the level of disturbance that construction has but, irrespective, should continue for a period of at least five years post construction.
202. It is considered extremely important that in addition to baseline data collected for the ES phase of the works (see Annex 35.4 to the Environmental Statement), targeted and detailed waterbird usage data is collected for the existing mudflat fronting the Compensation site (and extending at least 500m either side of the site's boundary) for at least one winter prior to works commencement. This monitoring should continue once the Compensation Site is operational, in order to both provide comparison data on functional value between the areas, but also act as a partial control against which take-up within the RTE as well as wider patterns of usage in the middle estuary can be assessed. Such data would be used to both assist in any detailed construction mitigation advice; provide information on general intertidal

habitat use by waterbirds which might be of value in assisting the development of management targets within the RTE; and a broad baseline of waterfowl use in this area against which future use can be assessed once the Compensation Site is operational (e.g. whether the site is being used by birds from adjacent existing areas or from a wider catchment). Note that the monitoring reported in Annex 35.4 to the Environmental Statement was based on high tide and low tide counts and not through the tide counts (TTTC).

203. Monitoring of the newly created intertidal habitat at the Compensation Site adjacent to Cherry Cobb Sands should be carried out for a period of at least five years post inundation, to tie in with invertebrate monitoring data and to provide evidence for the adequate ecological functioning of the habitat in terms of its provision for birds. These data should be considered in the context of data from the adjacent Cherry Cobb frontage in order to assess general population trends as well as inter area take-up and any linked population/function changes.

204. Indeed, given the importance of the south bank of the Humber (within and around the AMEP development) for the provision of habitat function for Black-tailed Godwit, it will also be necessary to monitor the usage of North Killingholme Marshes frontage and pits through a detailed ornithological survey programme. These aspects are covered in the other EMMPs.

205. In all instances, monthly through the tide counts (TTTC) of waterbirds (which allow peak and mean numbers to be characterised) should be conducted, in addition to high water counts in arable fields and the wet grassland located on the landward side of the flood defences. Individual counts should be undertaken at low, mid and high tide as a minimum and survey dates should be timed to be complimentary to the WeBS core count programme (i.e. timed so as to be offset relative to the WeBS counts in the area). Note: WeBS data is collected through counts performed at high tide, and the overall spatial coverage of WeBS counts is not, in its own right, detailed enough to provide adequate monitoring for the Cherry Cobb Sands intertidal mudflat habitats. It is, however, useful in providing context for more spatially detailed monitoring work.

206. This suggested approach of using WeBS data to help contextualise the specific TTTC monitoring will serve to maximise the value of the data that is gathered. It is recommended that monitoring of bird use of the intertidal and follows the same methodology as employed in the baseline studies for North Killingholme Marshes foreshore (e.g. Mander *et al.*, 2011 – also presented as Annex 11.9 to the Environmental Statement). During each count, bird numbers (for each species) should be recorded along with activities taking place, e.g. whether or not they are foraging.

207. Survey areas should be divided into manageable sectors (using naturally occurring stable reference points such as creeks where possible). Usage levels and function should be mapped within these sectors. In addition, other environmental factors should also be recorded, including weather etc., as well as any notable third party disturbance (source and effect). Rather than transiting along the entire survey area, it is considered good practice to undertake a series of point counts, with transiting between points carried out where possible below the bank crest in order to reduce counter disturbance to birds using the site. In all instances, monitoring should be on a monthly basis, from October through to March (both months inclusive) with annual reporting.
208. Any longer-term monitoring requirements (subsequent to the initial five-year period) will be determined by the Environmental Steering Committee towards the end of the initial monitoring period.

6. REVIEW AND ADAPTATION

209. All monitoring reports will be presented to the EAG for review. Through receipt of these reports the Group will be consider where the site is not operating as intended, or where significant additional environmental issues have become apparent.

210. In such instances, adaptive measures may be required, and these may be recommended by the Group (with additional input from other external parties as appropriate).

211. The range of circumstances that could give rise to the development of operational problems are wide-ranging and it would be difficult to attempt to identify them in advance and develop adaptive measures for all eventualities.

6.1 Environmental Management Measures

212. There are a number of generic management measures that will be applied in order to ensure that environmental impact is minimised:

- All Contractors will be required to appoint an 'Ecological Clerk of Works' to oversee their operations.
- During works, construction staff will receive regular site briefings and appropriate communication arrangements will be established. In particular, adherence to relevant Codes of Practice and the adoption of sensitive working practices (such as those identified as mitigation measures, for example the restriction of heavy plant movement across existing intertidal areas and management of personnel onto the intertidal zone and bank crest) will be promoted;
- Contingency plans, for example for oil spillage, will be developed.

213. Landscaping outside of the main site embankment will include linear features (i.e. hedges, ditches and scrub) that will provide habitat for breeding birds and offer cover to mammals such as badgers. In addition to berry-bearing species, new planting will include some native fruiting trees and shrubs (such as blackberry, damson, crab apple and wild pear) to provide additional seasonal foraging opportunities for badgers.

214. Other than the foregoing, and mitigation measures outlined previously and within earlier submissions, there are no additional management measures specific to the habitats and species that will be implemented during the construction phase.

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