MORGAN AND MORECAMBE OFFSHORE WIND FARMS: TRANSMISSION ASSETS

Technical note on the energetics of the birds at landfall and the adequacy of the Fairhaven Saltmarsh

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Glossary

Term	Meaning
400 kV grid connection cables	Cables that will connect the proposed onshore substations to the existing National Grid Penwortham substation.
400 kV grid connection cable corridor	The corridor within which the 400 kV grid connection cables will be located.
Onshore Order Limits	Onshore Order Limits See Transmission Assets Order Limits: Onshore (below).
Onshore substations	The onshore substations will include a substation for the Morgan Offshore Wind Project: Transmission Assets and a substation for the Morecambe Offshore Windfarm: Transmission Assets. These will each comprise a compound containing the electrical components for transforming the power supplied from the generation assets to 400 kV and to adjust the power quality and power factor, as required to meet the UK Grid Code for supply to the National Grid.
Special Protection Areas	A site designation specified in the Conservation of Habitats and Species Regulations 2017, classified for rare and vulnerable birds, and for regularly occurring migratory species. Special Protection Areas contribute to the national site network.
Transmission Assets	The area within which all components of the Transmission Assets will be located, including areas required on a temporary basis during construction and/or decommissioning.
Transmission Assets Order Limits	The area within which all components of the Transmission Assets landward of Mean High Water Springs will be located, including areas required on a temporary basis during construction and/or decommissioning (such as construction compounds). Also referred to in this report as the Onshore Order Limits, for ease of reading.

1 Technical note on the energetics of the birds at landfall and the adequacy of the Fairhaven Saltmarsh

1.1 Background and aims

1.1.1.1 Natural England submitted the following comments in their Relevant Representations RR 1601 concerning the mitigation measures at Fairhaven Saltmarsh:

- RR 1601 H.6: *The level of detail presented in the mitigation area summaries is not sufficient to fulfil the expectations of the HRA with regards to certainty of outcome. Intertidal mitigation with the saltmarsh protection in the absence of any other measure the question remains as to the sufficiency of this measure and whether there is any certainty the approach will be successful. Additional questions remain: • how much energy will the birds be saving by being able to utilise this area? • How does that compare with the risk of the energy saving not being correct? • Will this energy saving offset the loss of feeding areas? (no figures have been presented to support this). At present there is not enough information to accept the conclusions. In the absence of evidence, the risk of a net negative energetic outcome is high for the construction period. Additionally, the assessment does not take into account recovery of food resources, which is unlikely to be instant. During the operational phase there is likely to be no loss of feeding from the development for a large proportion of the time, therefore the roost proposal would likely be beneficial. Additionally, there is no information to ascertain how much energy the birds will be saving by being able to utilise this area. We question how that compares with the risks that birds will not get enough food because they are displaced to sub- optimal/already defended/ more disturbed etc feeding areas and that birds may not receive enough energetic saving from the proposed roost site. We consider this approach is likely to be effective during the operational phase as there will be low impacts on the waders, although there seems no particular reason why a seasonal restriction would not be possible given the time required. However, during construction, the likely impacts are much greater and the need for seasonal restrictions much more compelling, therefore in the event of compensatory measures being sought, proposed management needs to be far more detailed to ensure efficacy.*

1.1.1.2 Natural England also raised concerns regarding the mitigation measures at Fairhaven Saltmarsh within their Risk and Issue Log (REP1-093):

- RI_H51: *Fairhaven Saltmarsh is identified as a mitigation area, however questions remain over its suitability. Natural England strongly advise the Applicant to produce some supplemental information clarifying why this proposal is considered likely to be effective, clarifying the management required to support delivery, and justifying its energetic value to the species impacted.*

1.1.1.3 On 14th May 2025, the Applicants proposed an approach to Natural England concerning the energetics of the birds at the landfall and Fairhaven Saltmarsh:

- At the Landfall site, due to the lack of available data to run an Individual-Based Model (IBM) to assess the impact on fitness (as detailed in Section 1.2), the Applicants propose to calculate the percentage increase in baseline mortality resulting from the displacement of individuals due to temporary habitat loss and additional disturbance buffers. This approach is highly precautionary, assuming that all birds will be displaced and that some may die as a result of this displacement. Displaced birds are expected to meet their daily energy requirements by foraging elsewhere in the Ribble Estuary SPA.
- At Fairhaven Saltmarsh, the Applicants propose to estimate the energetic savings resulting from a reduction in recreational disturbance by considering a range of scenarios. This will be accomplished using equations from the literature on flight costs and thermoregulation.

1.1.1.4 On 23rd May 2025, Natural England provided the following comments (via email) in response to the proposed approach:

‘The second bullet NE agree with as the way to articulate the benefit of the roost protection work, if the developer can come up with a plan that works to manage people. This also allows for the factoring in of energetic gain from other birds using the roost area including individuals of the species affected at landing as well as other species. But I’m not sure the first bullet is a precautionary or appropriate comparator for it.

Accepting that you don’t have the data to investigate IBM’s, in this instance NE don’t think direct mortality is helpful. Previous discussion was about resourcing need for species on passage, impacts below mortality affect likelihood of completion of successful migration and fitness to breeding on arrival on the breeding grounds. Displaced birds will be able to forage elsewhere in site, but that is at the cost of both some of their individual fitness and the individual fitness of those birds that would be sequentially displaced on other feeding grounds. NE are looking for an outcome that is energetically neutral or positive for the species directly at risk. If, from the literature, you can understand what the daily energy need of a migrating wader is and the number of passage bird-days likely to impacted that should give us a window on the energetic hit being taken by the displaced birds. Assuming these birds can’t feed in the footprint and can’t compensatory feed in the SPA gives a precautionary worst case, and a figure which can be used to compare to the energetic saving offered by the roost protection.

Following this you can then work back on refining estimation of that impact if there are elements of the landing work that allow (e.g., will only be working at one point in the corridor as opposed to up and down it for a full tidal cycle?). Given the birds foraging habitat is linked to where the moving tideline sits on the shore at any given point in time, it is important we understand the logistics of the works in more detail than is currently included.’

1.1.1.5 The aim of this technical note is to provide supporting information on the energetic implications of temporary habitat loss and disturbance at landfall for birds, as well as on the reduction of recreational disturbance in the mitigation area at Fairhaven Saltmarsh.

1.1.1.6 In response to the comments from Natural England, this note is structured as follows:

- Section 1.2 provides background information on the Individual-Based Model (IBM) and discusses the lack of site-specific data needed to run the model for the project.
- Section 1.3 provides an alternative approach to measuring energetics at the landfall and at Fairhaven Saltmarsh in response to Natural England's comments.
- Section 1.4 provides information on the size and duration of temporary habitat loss and disturbance at the landfall, as well as the predicted number of birds impacted and daily energy requirements.
- Section 1.5 provides information on energetic saving at the proposed mitigation area at Fairhaven Saltmarsh.

1.2 Individual-Based Models (IBMs)

1.2.1.1 Understanding and predicting the effects of temporary habitat loss and disturbance on the fitness of wintering waders (e.g., body condition, survival, and breeding success) is challenging, as is the use of Individual-Based Models (IBMs). IBMs have become an established method for simulating animal behaviour in realistic environments (Grimm & Railsback, 2005). Numerous platforms exist (DeAngelis & Diaz, 2019), notably MORPH, a flexible platform developed over the past 30 years for various species, particularly birds, and environmental issues (Stillman, 2008). The MORPH model simulates how birds forage across patches to meet their daily energy requirements, based on the principle that individuals make fitness-maximizing decisions (Grimm & Railsback, 2005). It predicts feeding time, bird distribution, body condition, and survival—essentially, individual fitness.

1.2.1.2 However, the MORPH platform requires numerous detailed and accurate parameters (e.g., patches, environmental factors, foragers, and resources) to assess the impact of temporary habitat loss or disturbance due to construction activities or reduced recreational disturbance at Fairhaven Saltmarsh. As with any modelling, it is not just the quality of the model that is key, but rather the quality of the data that is inputted which will influence the accuracy and robustness of results.

1.2.1.3 Given that the number of birds affected by construction is very low in the context of the SPA, the Applicants believe that an IBM may not detect the subtle effects of temporary habitat loss or disturbance. Aside from the bird data collected by the Applicants, there are no contemporary data on food resource parameters, critically, from across the Ribble Estuary SPA (e.g., prey energy content at the start and end of the model period) to validate the model.

1.2.1.4 Using data from other locations as a surrogate would leave results open to question/challenge and the Applicants regard this to be poor science, as this is a specific site with unique conditions. Consequently, the model output is likely to be inaccurate, even with proxies introduced.

1.2.1.5 In the absence of sound available parameters (e.g., benthic biomass and low distribution across the Ribble Estuary SPA), numerous assumptions would need to be made, undermining the model's robustness. While the Applicants understand the desire to model energetics, doing so in this case would introduce significant uncertainty into the conclusions.

1.3 New approach and assumptions

1.3.1.1 In response to Natural England's comments on 14 May 2025, the Applicants have proposed a new approach at the landfall and at Fairhaven Saltmarsh:

- Defining the size and duration of impacts at the landfall based on knowledge of disturbance distances and the predicted footprint of the works.
- Interpolating the average number of birds that may be present at any given time within the impact zones during the passage periods.
- Understanding the daily energy needs of the passage wader species based on existing literature. A comprehensive understanding of their daily requirements during the passage period is challenging due to the numerous external variables that may influence bird responses at any given time.
- Assessing the energetic costs of flight in response to disturbance.
- Calculating the average number of birds present at Fairhaven Saltmarsh at any given time during the passage period.
- Calculating the average number of flight-initiating disturbance events at Fairhaven Saltmarsh during the passage periods.
- Identifying alternative roost sites that may be available to birds disturbed at Fairhaven Saltmarsh.
- Presenting a range of potential energy savings that could be achieved depending on the success of the proposed mitigation measures at Fairhaven Saltmarsh.

1.4 Impact at the landfall

1.4.1 Size and duration of the temporary habitat loss

1.4.1.1 Temporary habitat loss is anticipated in the supra, intertidal, and subtidal areas at the landfall site. As detailed in Table 1.76 of the Habitats Regulations Assessment Stage 2 Information to Support an Appropriate Assessment Part Three – Special Protection Areas (SPA) and Ramsar Site assessments (APP-017), the installation of export cables between the Highest Astronomical Tide (HAT) and the Mean Low Water Springs (MLWS) during the construction phase is expected to result in a temporary loss of supporting habitat and/or resource availability amounting to up to 474,640 m². Since the application was submitted, additional information regarding the proposed works, including an indicative layout of work activities, can be found in Annex 5.3 of the Applicant's response to Hearing Action Points: ISH1 13, 14, 16, 17 (REP1-040).

1.4.1.2 The duration of active construction works is expected to be up to two weeks direct pipe installation and up to six weeks per cable pull in. This is a maximum timeframe of 48 weeks; however, the direct pipe installation is a discrete activity and will take place prior to the cable trenching and pull in.

Therefore, the greatest habitat loss is predicted to occur during the 36 weeks when cable trenching and pull in activities take place.

1.4.1.3 Due to the commitment to refrain from work between November and March (CoT 129, S_D2,15), the absolute minimum period for the works would need to include at least one complete spring passage period and one complete autumn passage period, with some overlap into an additional spring or autumn passage period.

1.4.1.4 Benthic communities are expected to take time to fully recover and regain their pre-construction foraging quality, although the exact duration is uncertain. As the works proceed one cable at a time, some recovery may occur in the trenches of the first cable while others are still being constructed. Limited evidence exists regarding the response of intertidal communities; however, surveys by Kraus & Carter (2018) indicate that subtidal benthic communities can recover quickly after disturbance, with recovery rates improving at shallower depths. Furthermore, the disturbance from cable burial appears to have minimal impact on the benthos. Habitats will also recover rapidly for roosting and non-foraging birds, which do not depend on benthic communities for these activities.

1.4.1.5 **Table 1** shows the area of habitats expected to be temporarily lost, with most of these losses predicted to occur over 36 weeks during the passage periods.

Table 1: The area and proportion of the survey area that will be impacted by temporary habitat loss

Species	Size of intertidal survey area (m^2)	Size of temporary habitat loss (m^2)	Proportion of temporary habitat loss in comparison to the intertidal survey area (%)	Proportion of temporary habitat loss in comparison to SPA intertidal habitats (%)[1]
Ringed plover	5,060,148	474,640	9.38	0.38
Dunlin	5,060,148	474,640	9.38	0.38
Sanderling	5,060,148	474,640	9.38	0.38
Redshank	5,060,148	474,640	9.38	0.38

[1] The area of the Ribble and Alt Estuaries SPA as taken from the citation

1.4.2 Size and duration of the disturbance effect

1.4.2.1 During the construction phase, the installation of direct pipe exit pits on the beach will take two weeks per cable and the cable trenching and burial within the intertidal will take six weeks per cable, with only one cable installed at a time, resulting in a working area of 80,000 m².

1.4.2.2 Each species has varying sensitivity to disturbance, leading to different areas affected (and consequently lost to displacement). This is quantified in **Table 2**, where buffer areas are calculated in GIS based on a maximum disturbance area of 80,000 m² and the maximum disturbance initiation distance from Goodship & Furness (2022).

1.4.2.3 The main impacts of disturbance will arise from cable trenching and pull-in, with the direct pipe occupying only 3,375 m² (4.2%) at any one time. Since one cable will be laid at a time during a period of up to six weeks, it is assumed that this disturbance will affect birds for up to 36 weeks during the passage period (**Table 2**).

Table 2: The area and proportion of the survey area that will be impacted by disturbance

Species	Size of intertidal survey area (m^2)	Disturbance buffer	Size of disturbance zone (m^2)	Proportion of disturbed area in comparison to the intertidal survey area (%)	Proportion of disturbed area in comparison to SPA intertidal habitats (%)[1]
Ringed plover	5,060,148	Up to 300m	1,352,160	26.72	1.09
Dunlin	5,060,148	Up to 300m	1,352,160	26.72	1.09
Sanderling	5,060,148	Up to 50m	256,493	5.07	0.21
Redshank	5,060,148	Up to 300m	1,352,160	26.72	1.09

[1] The area of the Ribble and Alt Estuaries SPA as taken from the citation

1.4.3 Number of birds present at the landfall

1.4.3.1 To calculate the number of birds that may be present, both the frequency of sightings and the number of individual birds is considered. The total number of sightings of individual birds (not the peak count) from the Applicants' site-specific-surveys were summed according to the behaviours recorded. These totals were then divided by the number of counts conducted during the passage period. A total of 168 hourly counts were conducted during the site-specific surveys (6 counts per survey × 2 surveys per month × 7 passage months × 2 years).

1.4.3.2 This calculation provides the average number of birds that may be present at any given moment between April and October (**Table 3**).

Table 3: The average number of birds present within the survey area and their associated behaviours

Species	Average number of birds present per hourly count (out of 168 passage counts)			
	Foraging	Non-foraging	Roosting	Total
Ringed plover	0.5	0.5	1.2	2.2
Dunlin	0.8	1.3	11.5	13.6
Sanderling	26.6	6.9	26.3	59.8
Redshank	0.3	0.1	0.2	0.6

1.4.4 Number of birds at risk of impact from temporary habitat loss

1.4.4.1 While **Table 3** reports the average number of birds present in the intertidal survey area, the actual number of birds potentially impacted by temporary habitat loss is however 9.38% of this figure (see **Table 1**) assuming equal distribution of birds. This is because the intertidal survey area includes a 500-meter buffer to account for potential disturbances to birds beyond the construction footprint, making it larger than the construction footprint itself.

1.4.4.2 This adjustment is reflected in **Table 4**. It is assumed that these birds will be affected for 36 weeks during the passage period.

Table 4: The average number of birds that may be present within the area of temporary habitat loss

Species	Average number of birds present per hourly count (out of 168 passage counts)			
	Foraging	Non-foraging	Roosting	Total
Ringed Plover	0.04	0.04	0.12	0.2
Dunlin	0.07	0.12	1.08	1.27
Sanderling	2.49	0.65	2.47	5.61
Redshank	0.03	0.01	0.02	0.06

1.4.5 Number of birds at risk of impact from disturbance

1.4.5.1 Similarly to habitat loss, the average number of birds predicted to be impacted at any given time during the passage period was calculated by applying the percentage of area expected to be disturbed (as shown in **Table 2**) to the average number of birds present in the intertidal survey area (**Table 5**). It is assumed that these birds will be affected for 36 weeks during the passage period. Disturbance is clearly the greater impact for all species except for sanderling, which are relatively tolerant of disturbance.

Table 5: The average number of birds that may be present within the area of disturbance

Species	Average number of birds present per hourly count (out of 168 passage counts)			
	Foraging	Non-foraging	Roosting	Total
Ringed Plover	0.12	0.12	0.33	0.57
Dunlin	0.21	0.35	3.07	3.63
Sanderling	1.35	0.35	1.33	3.03
Redshank	0.07	0.02	0.04	0.13

1.4.6 Impact on bird energetics at the landfall

1.4.6.1 To determine whether the proposed mitigation offers net benefits to passage birds compared to losses from construction, it is essential to estimate their daily energy requirements. The thermoneutral daily energy requirements for waders is shown in **Table 6** and can be calculated using Nagy *et al*. (1999) equation:

Energy requirement (kJ) = 10.5 × M^0.681,

where M is body mass in grams.

1.4.6.2 This energy requirement may vary based on environmental conditions, site differences, and individual needs. For instance, waders wintering in tropical areas exhibit a lower Basal Metabolic Rate (BMR) than those in colder climates (Kersten *et al*., 1998). However, Kvist & Lindström (2001) found that returning juvenile waders in southern Sweden had a BMR that was, on average, 16% lower than expected compared to Arctic breeding grounds, and only 8% higher than in tropical Africa. Additionally, some birds may undergo moulting during their journeys (from non-breeding to breeding and vice versa), which can increase energy requirements (Remisiewicz, 2011).

1.4.6.3 There is currently a lack of understanding regarding the seasonal energy requirements of waders at different stages of their journeys. The daily energy requirements of birds passing through the Ribble and Alt Estuaries SPA are likely influenced by their journey stage (in relation to wintering and breeding grounds and the distance to their next stopover) as well as environmental conditions at the time of their visit. Therefore, the information in **Table 6** should be interpreted with caution. Migrating and breeding birds are likely to have higher energy demands, which may also fluctuate interannually based on environmental conditions. Furthermore, long-distance migration is energetically demanding, and waders typically increase fat reserves at stopover sites. Martins *et al*. (2013) documented a 65% increase in energy uptake for dunlin during spring migration compared to their wintering intake.

Table 6: The mass and thermoneutral daily energy requirements for the passage features at risk of impacts at the landfall. As taken from Collop *et al.* (2016)

Species	Mass (g)	Thermoneutral daily energy requirement (kJ)[b]
Ringed Plover	64	178.32
Dunlin	48	146.59
Sanderling	54	158.84
Redshank	143	308.3

[b] Using Nagy *et al*. (1999) allometric equation and taken from Collop *et al.* (2016)

1.4.6.4 Construction at the landfall may displace birds due to temporary habitat loss and disturbance. Displaced birds may be forced to forage in areas with increased inter- and intraspecific competition or in suboptimal habitats, leading to reduced daily energy intake and loss of individual fitness. This, in turn, may increase mortality or decrease productivity on the breeding grounds.

1.4.6.5 Without knowing which patches the birds are switching to or the resources and competition present in these alternative areas, it is impossible to calculate the energy lost by individuals. Additionally, it is unclear how much energy may be lost by birds recorded as loafing or roosting at the landfall, as these activities can occur throughout the SPA with varying disturbance levels.

1.4.6.6 In response to Natural England's comments on 23rd May 2025, the Applicants have provided the area and duration of impact, the estimated number of affected individuals, and the daily energy requirements of the impacted birds.

1.4.6.7 However, a lack of data prevents modelling the energetic loss (e.g., using an IBM). The Applicants have proposed calculating additional mortality from construction activities based on a worst-case scenario (i.e., using the assumption that displaced birds may die). However, Natural England has deemed this unnecessary.

1.5 Measuring energetic saving at Fairhaven saltmarsh

1.5.1 Approach

1.5.1.1 While the Applicants cannot provide a robust estimate of the energetic costs associated with disturbance and habitat loss resulting from construction activities at the landfall, they can outline an approach to energy savings that may be achieved through reduced flight responses as a result of the proposed mitigation measures at Fairhaven.

1.5.1.2 This approach excludes the unquantifiable energetic costs such as increased vigilance, movement to alternative roosts and the need for increased foraging time caused by the disturbance.

1.5.1.3 This approach involves a number of steps:

1. Calculating the energetic cost of an average disturbance event;
2. Calculating the average number of birds present at the roost site;
3. Calculating the average number of disturbance events; and
4. Producing a range of outcomes to highlight the energy savings made by reductions in disturbance

1.5.1.4 While this approach is simplistic, as it only considers the flight costs associated with disturbance and does not account for increased vigilance, the costs associated with commuting between alternative roosting sites and their preferred foraging grounds, or the additional flight time between foraging and roosting, it does provide a measure in kilojoules (kJ).

1.5.2 Energetics of flight

1.5.2.1 To calculate the energy cost of flight, the following equation was used (Kvist *et al*., 2001)

$$Cost\ (kJ) = \frac{10^{0.39} \times M^{0.35} - 0.95}{1000} \times S$$

S = time spent in flight in seconds, and M = body mass in grams.

1.5.2.2 Assumptions made included that birds were flushed from the minimum disturbance distances reported by Goodship & Furness (2022), while the assessment of impacts in the Application document and **Table 4** used the maximum disturbance distances. This discrepancy arises because the flight initiation distance is typically lower than the alert distance.

1.5.2.3 It was also assumed that birds would not return until the danger had passed. To quantify this, it was assumed that the average pedestrian walks at a speed of 2.5 km per hour and that the birds would wait until the disturbance was the same distance from the roost as when flight was initiated (i.e., disturbance distance multiplied by 2). Consequently, flight time is a product of disturbance distance and walking speed.

1.5.2.4 The thermoneutral daily energy requirement was also used to calculate the energy cost of a disturbance event as a percentage of the daily energy requirement; however, it should be noted that this may not provide an accurate comparison to the needs of birds during the passage period. These calculations are displayed in **Table 7**.

Table 7: Average flight time per disturbance event

Species	Flight initiation distance (m)[c]	Metres walked per second (at 2.5km per hr)	Flight time (s)	Cost per second of flight	Cost per flight response (kJ)[a]	Thermoneutral daily energy requirement (kJ)[b]	Cost per flight as % of daily intake requirement
Ringed Plover	100	0.6944	138.8889	0.0096	1.3270	178.32	0.7442
Dunlin	150	0.6944	208.3333	0.0086	1.7910	146.59	1.2217
Sanderling	50	0.6944	69.4444	0.0089	0.6200	158.84	0.3904
Redshank	200	0.6944	277.7778	0.0130	3.6156	308.30	1.1728

[a] Using cost per second of flight from Kvist et al. (2001). [b] Using Nagy *et al*. (1999) allometric equation and taken from Collop *et al*. (2016). [c] Minimum recommended buffer as taken from Goodship & Furness (2022).

1.5.3 Average numbers of birds present

1.5.3.1 The Applicants site-specific surveys are ongoing and the findings to date are presented in **Table 9**. The WeBS five-year data for this sector are also presented although this is not directly comparable to the site-specific surveys because the survey used for the site-specific survey is smaller (**Table 8**).

1.5.3.2 The data indicate that on average the Fairhaven Saltmarsh is used by high numbers of dunlin during the passage period.

Table 8: Five-year average monthly counts between 2017 and 2022 at Fairhaven Lake and Lytham Beach WeBS sector.

Species	April	May	June	July	August	September	October	Passage average
Ringed plover	666	**1,553**	40	53	785	51	9	**451**
Dunlin	2,562	**5,896**	17	2,310	3,752	173	1,217	**2,275**
Sanderling	713	410	0	0	**1,021**	23	145	**330**
Redshank	314	14	13	167	**779**	588	518	**342**

Table 9: Monthly peaks from the site-specific survey data

Species	2023		2024						Passage average
	Sep	Oct	May	Jun	Jul	Aug	Sep	Oct	
Ringed plover	41	22	**309**	0	0	65	0	0	**55**
Dunlin	295	1,538	1,190	12	1,050	125	**1,585**	1,240	**879**
Sanderling	582	**2,000**	1,100	0	0	0	57	78	**477**
Redshank	59	**131**	0	1	0	23	23	52	**36**

1.5.4 Current levels of recreational disturbance

1.5.4.1 Daytime disturbance events have not been fully recorded throughout the passage period, but snapshot counts of disturbance events at Fairhaven saltmarsh indicated one disturbance event in May 2024, 17 in June 2024, and seven in September 2024. This results in an average of 8 disturbance events per high tide period during the passage seasons; however, this figure is likely inaccurate due to the small sample size (n = 3).

1.5.4.2 Most daylight disturbance events involve pedestrians and dogs walking along the tide line, which disrupts most, if not all, of the birds present. Therefore, to calculate energy losses, it was assumed that all birds take flight and then return to the area once a pedestrian has passed through.

1.5.5 Nearest known roost sites

1.5.5.1 In addition to the energetic costs associated with individual disturbance events at Fairhaven, the cost of relocating to alternative roost sites must also be considered. However, due to uncertainty regarding the number of birds involved and the frequency of such relocations, this cost is unquantifiable.

1.5.5.2 **Figure 1** to **Figure 4**, which use data last confirmed in 2012/13, illustrate the known locations of roost sites within the Ribble and Alt Estuaries SPA. It is assumed that birds roost at Fairhaven Saltmarsh because it is the closest suitable site to their food resources, and the same applies to other roost sites. High levels of disturbance at the Fairhaven Saltmarsh that force birds to relocate may significantly impact the fitness of this particular cohort, likely due to the additional energy costs of flying to and from further foraging grounds or switching foraging sites, which can also lead to increased competition or reduced resource quality, both negatives.

1.5.5.3 **Figure 3** shows that sanderling have the longest distance between roost sites, approximately 20 km from Fairhaven Saltmarsh (both northern roosts are at Fairhaven saltmarsh) to Formby. In contrast, ringed plover travel the shortest distance, about 2 km to the east (**Figure 1**). The nearest redshank roost is approximately 4 km to the east (**Figure 4**), while dunlin must travel about 5.5 km to the saltmarshes on the southern bank of the Ribble Estuary (**Figure 2**)

- The red dots indicate roosts of international importance
- The orange dots represent roosts of national importance

- The green dots denote all other roosts

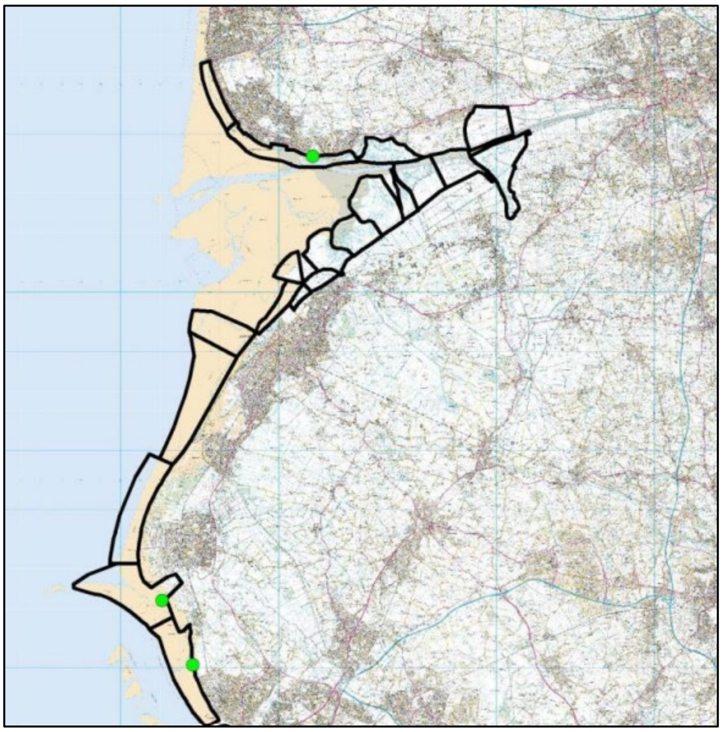

Figure 1: Known roost sites for ringed plover (Still *et al*., 2015)

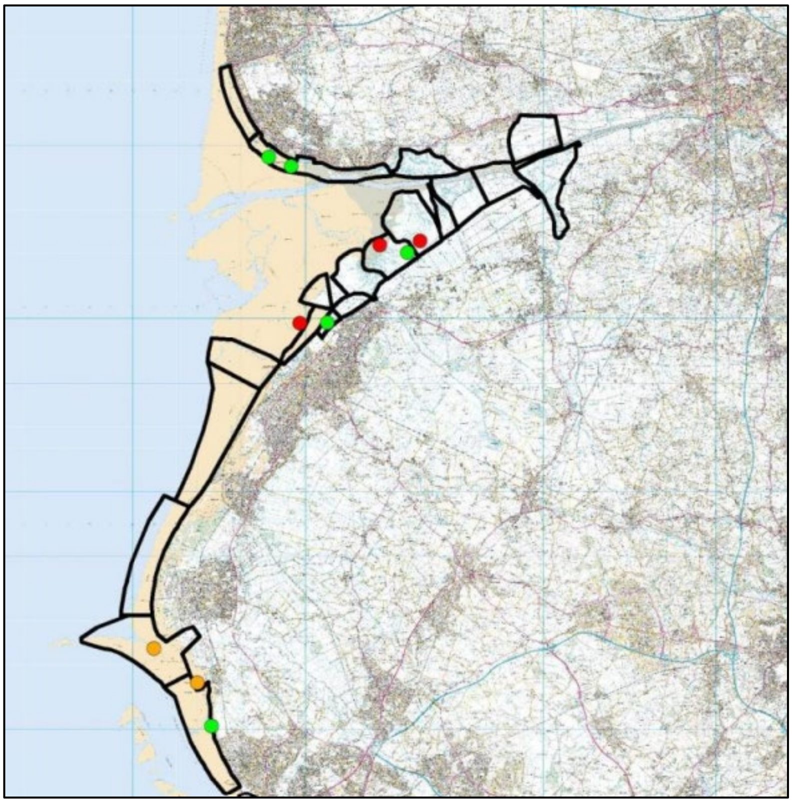

Figure 2: Known roost sites for dunlin (Still *et al*., 2015)

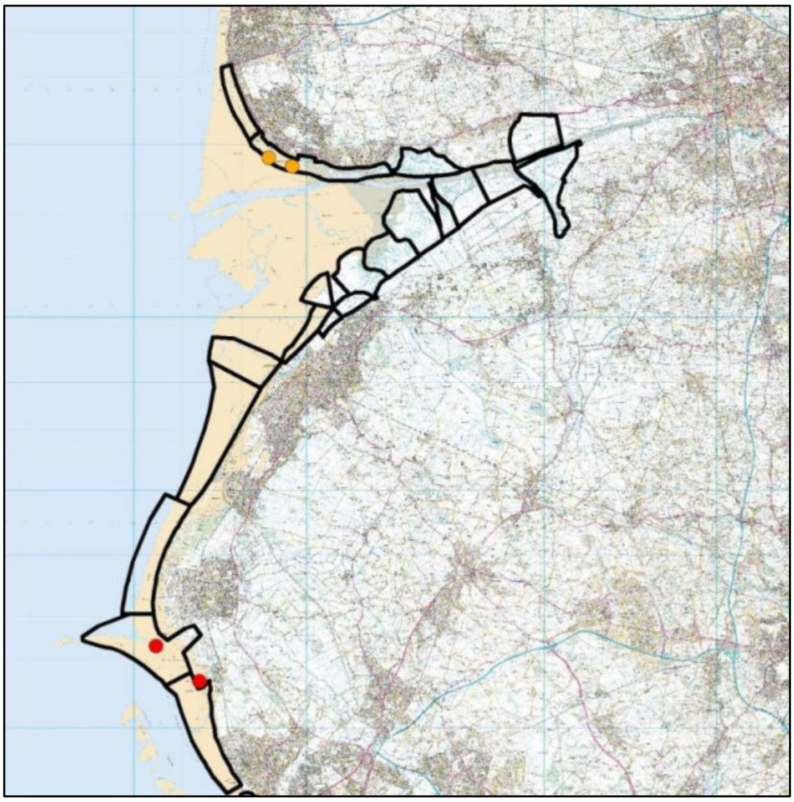

Figure 3: Known roost sites for sanderling (Still *et al.*, 2015)

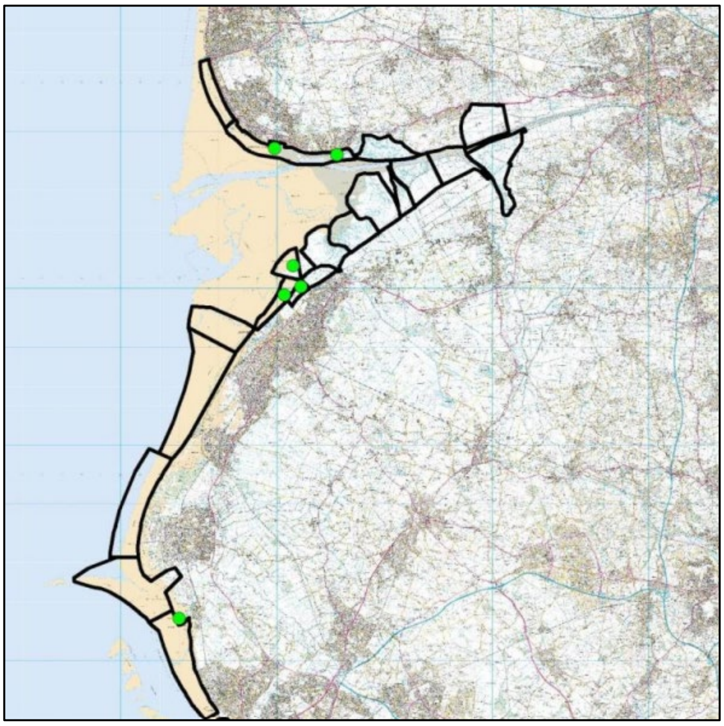

Figure 4: Known roost sites for redshank (Still *et al.*, 2015)

1.5.6 Energy saved from reductions in disturbance

1.5.6.1 To calculate, in a simplified manner, how disturbance may impact birds at a roost site, the following equation is used:

Energy Lost = Cost per Disturbance x Number of Disturbances x Number of Birds

1.5.6.2 The results of this equation are presented in **Table 10**. The Applicants would like to emphasize that these costs are part of the existing baseline and that any mitigation measures to reduce disturbance will be implemented for a longer duration than just the construction period at the landfall. Consequently, the benefits may extend beyond the impacts experienced during construction. However, for comparison purposes, the same construction period has been utilised.

Table 10: The predicted current daily increases in energy to passage birds using the Fairhaven saltmarsh

Species	Cost per flight (%) as taken from Table 7	Average daily disturbances events	Daily cost of disturbance per bird (%)	Average number of birds
Ringed Plover	0.7442	8	5.9535	55
Dunlin	1.2217	8	9.7740	879
Sanderling	0.3904	8	3.1228	477
Redshank	1.1728	8	9.3820	36

1.5.6.3 Since the extent to which mitigation measures may reduce disturbance is unknown, a range of outcomes has been provided. The literature indicates that, when properly implemented, measures such as wardening can achieve high success rates, with some reports indicating effectiveness above 90% (Weston *et al.*, 2012). Additionally, wardening was rated as a highly effective measure in a poll of experts (**Figure 5**) (Liley & Tyldesley., 2013).

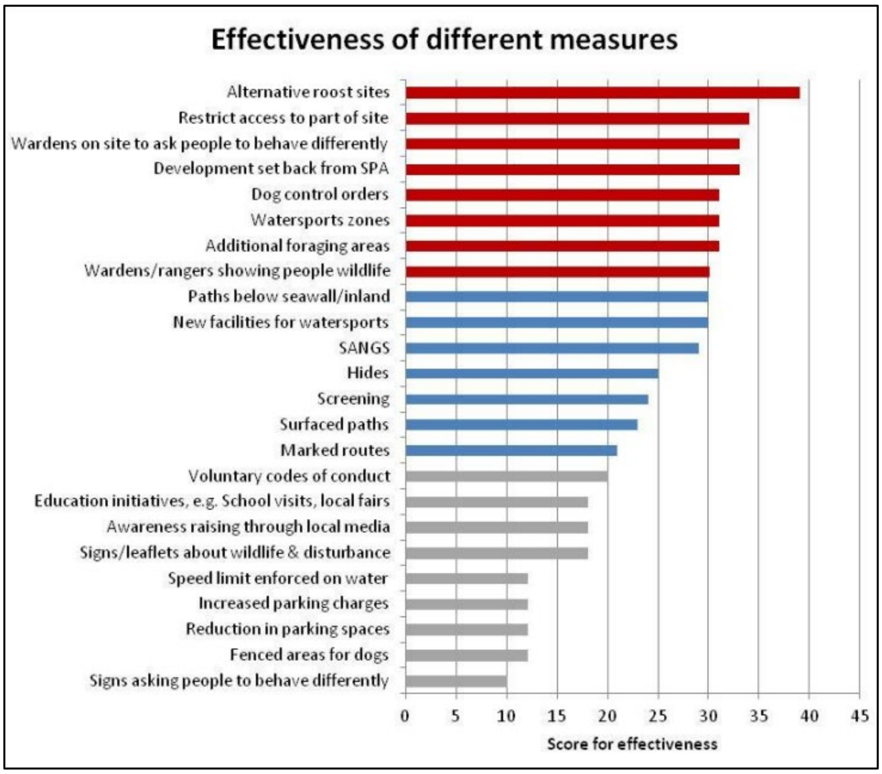

Figure 5: Overall scores for different measures. Colours reflect scores, such that measures coloured in red are those were scored reasonably high (30 or above) and those in grey ones with a relatively low score (20 or below) (Liley & Tyldesley., 2013).

1.5.6.4 It is important to note that while the results presented in **Table 11** indicate the potential energy savings from reductions in disturbance flights at Fairhaven saltmarsh, several less quantifiable factors, such as increased vigilance and movement to alternative sites, should be considered. Therefore, these figures should be interpreted with caution. Additionally, the Applicants would like to highlight that, beyond these factors, many other bird species which form part of the SPA assemblage, including knot, curlew, grey plover, and bar-tailed godwit, will also benefit from reduced disturbance at Fairhaven saltmarsh.

Table 11: Ranges of energy savings per bird that may be made through reductions in disturbance events from the current baseline

Species	Energy saved as % of daily energy requirement per individual through a range of % reductions in disturbance										
	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Ringed plover	0.0000	0.0022	0.0216	0.1080	0.3601	0.9002	1.8003	3.0006	4.2865	5.3582	5.9535
Dunlin	0.0000	0.0035	0.0355	0.1773	0.5911	1.4778	2.9557	4.9261	7.0373	8.7966	9.7740
Sanderling	0.0000	0.0011	0.0113	0.0567	0.1889	0.4722	0.9443	1.5739	2.2484	2.8106	3.1228
Redshank	0.0000	0.0034	0.0340	0.1702	0.5674	1.4186	2.8371	4.7285	6.7550	8.4438	9.3820

1.6 Conclusion

This technical note outlines the potential energetic impacts of temporary habitat loss and disturbance of birds at the landfall and at the proposed mitigation area.

The Applicants do not have sufficient data to run an Individual-Based Model (IBM). There is a lot of uncertainty about the fate of displaced birds (i.e. movement within or outside the estuary). Insufficient information exists about alternative foraging, loafing, or roosting areas to draw definitive conclusions about the energy lost by individuals, although it is evident that alternative areas are available to birds.

Relatively few birds are expected to be affected by the construction activities at the landfall; however, disturbance at the landfall poses a greater impact for all species except sanderling, for which temporary habitat loss is more significant.

While thermoneutral energy requirements are provided, there is considerable uncertainty regarding the daily energy needs of passage waders, which may vary based on individual, seasonal, and environmental factors, leading to high variability both inter- and intra-specifically.

Construction at the landfall may displace birds, forcing increased competition in some areas and displacement to sub-optimal habitats, which could reduce their daily energy intake and individual fitness, potentially affecting mortality and productivity on breeding grounds; however, due to insufficient data, it is impossible to robustly model the energetic losses associated with this displacement. Whilst the Applicants have proposed a very precautionary approach for calculating additional mortality, Natural England has deemed this approach unnecessary.

Although the calculations suggest potential energy savings from reduced disturbance flights at Fairhaven Saltmarsh, factors such as increased vigilance and movement to alternative sites were not included due to lack of data.

The literature supports the effectiveness of wardening and similar measures, with success rates reported to exceed 90% in some cases.

1.7 References

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