The Sizewell C Project

6.3 Volume 2 Main Development Site

Chapter 14 Terrestrial Ecology and Ornithology

Appendix 14C5 Marsh Harrier Mitigation Area Feasibility Report

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EDF Energy

Sizewell C

Marsh Harrier Mitigation Area
Feasibility Report

Wood Environment & Infrastructure Solutions UK Limited – April 2019

Report for

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Document revisions

No.	Details	Date
1	Report	August 2018
2	Updated following client comment	October 2018
3	Updated following stakeholder feedback	April 2019

Contents

1. Introduction

1.1 Background

Marsh harrier (*Circus aeruginosus*) is an interest feature of the Minsmere - Walberswick Special Protection Area (SPA) during the breeding season. The harriers breed exclusively in reedbed habitat located to the north of the New Cut but they are known to forage widely for food over the Minsmere South Level and also the EDF Energy estate, including Sizewell Marshes Site of Special Scientific Interest (SSSI).

Activities associated with the construction of Sizewell C are not predicted to affect the breeding sites north of the New Cut but have the potential to result in the temporary displacement of marsh harriers from the foraging areas to the south of the New Cut.

The extent to which disturbance-related temporary displacement will occur is the subject of the Habitats Regulations Assessment for the proposed development. However EDF Energy has recognised that there will be a need to mitigate for this during construction of the power station; a period that could extent to 10 years.

The proposed approach to the mitigation is to undertake habitat creation and targeted land management activities on arable farmland, to enhance habitat so that it supports abundant prey species for marsh harriers. However, as measures will be required for a limited duration (10 years) they do not need to be permanent.

1.2 Study objectives

A 47ha area at the northern end of the Sizewell estate has been identified as available for use within a mitigation scheme. The area encompasses the fields extending from the east of Ash Wood to the north as far as and including Sandypytle, Dovehill, Lower Abbey Farm Marsh and the field to the west of this (see Appendix A).

There are two key objectives for the study:

- To develop a proposal that will maximise the number of marsh harrier prey items that the mitigation area will support should marsh harriers be displaced from other areas of habitat in the usual foraging range, with a focus on the breeding season; and
- For the proposal to be developed such that it minimises any implications related to the development planning system and from cultural heritage.

1.3 Previous Project Stages

Design Brief and Specification

A Design Brief and Specification, presented in Hyder, 2015[1], set out an initial vision for the enhanced foraging habitat and detailed the tasks considered necessary to complete a feasibility study of the proposals. The study proposed a scheme comprising '*four distinct core elements, provided as an integrated package of marsh harrier mitigation, as follows:*

[1] Hyder (2015). Marsh Harrier Foraging Habitat Creation. Design Brief and Specification. Report for NNB Genco Sizewell C.

- *Creation of shallow scrapes supporting open water and aquatic and emergent vegetation to provide suitable nesting habitat for water birds such as moorhen and mallard, whilst also providing habitat structure that persists during the winter months.*
- *Creation of lowland heath, scrub and acid grassland, to enhance populations of farmland birds and small mammals and provide habitat structure that persists into the winter months.*
- *Creation of rough tussocky arable grass margins to increase the population of voles and other small mammals, and the sowing of game cover and seed crops to boost populations of farmland birds.*
- *Creation of larger areas of tussock-forming grassland supporting plant species typical of coastal floodplain in Suffolk.*

In addition to the core elements above, it is also proposed to alter the management of Lower Abbey Marsh to allow existing wetland vegetation and rough grassland to increase in extent. Whilst this will only be a modest contribution, it will increase the area of wetland habitat available for foraging harriers.' The report was accompanied by two Figures that identified the area proposed for creation of marsh harrier foraging habitat in relation to the Sizewell C Main Construction Site and also an indicative scheme drawing of the core elements together.

Design Stage

Wood Environment and Infrastructure Solutions UK Ltd ('Wood', then Amec Foster Wheeler Environment and Infrastructure UK Ltd) was commissioned to develop the initial Hyder design, completing the following tasks:

- Review of marsh harrier ecology, and in particular the habitat and feeding requirements of marsh harrier, focussed on the summer period;
- Review available baseline ecological, hydrological, topographical and agricultural management data for the proposed mitigation area; and
- Review and develop the initial vision to provide detailed habitat and management proposals.

The Wood (2015)[2] study is included in Appendix A to this report and concluded that:

> *"Based on a review of the available data on the ground levels, the underlying geology and ground and surface water regimes in and around the mitigation area, it is concluded that it would not be feasible to create wetland across the majority of the mitigation area. Therefore the options for the mitigation area need to focus on alternative non-wetland foraging habitats that published data has demonstrated are also extensively used for foraging by marsh harriers.*
>
> *Recognising the opportunistic nature of marsh harriers, which is likely to mean that the harrier diets' reported may in part reflect the relative abundance of prey items in the foraging areas. Therefore options considered have ranged from maximising small mammal abundance across the mitigation area, to maximising the breeding small farmland bird population at the other end of the scale.*
>
> *The approach to maximising breeding farmland birds has proposed adopting a number of measures proven through the ELS and HLS schemes to benefit both breeding and wintering birds in arable landscapes whilst providing habitat structure that does not prevent marsh harrier foraging activity. It is important to note that the measures would be implemented solely for the purpose of maximising*

[2] Amec Foster Wheeler Environment and Infrastructure UK Ltd (2015). Sizewell C Marsh Harrier Mitigation Area Feasibility Report, Report to EDF Energy.

breeding bird (and small mammal) numbers. There would be no requirement for a financial return from the crops.

The approach to maximising small mammal numbers would focus on provision of a combination of tussocky grassland and short acid grassland with hedge and scrub foci for the benefit voles and rabbits.

Although it is concluded that the approach to maximising small mammals is likely to provide more prey items than the approach to maximising breeding farmland birds, the latter may more reliably provide increased prey abundance and there are some potentially significant disadvantages with the mammal focussed approach that makes its likelihood of success less certain. Therefore it has been proposed that an approach that combines measures that would maximise small mammal abundance whilst also maximising breeding bird numbers as well would be preferred.

The optimised scheme primarily comprises provision of tussocky and acid grassland, with the acid grassland and the associated scrub foci distribution designed to provide stepping-stone habitat to facilitate more rapid colonisation by rabbits from outside the mitigation area. Areas of wild bird seed cover and nectar rich flower mixes are also provided and distributed widely to provide food sources for birds, mammals and invertebrates across the site.

It is considered that the proposed approach will lead to significant elevated marsh harrier prey items (small mammals and breeding birds) being present in the area when the habitats are established and that this will draw marsh harriers to forage over the mitigation area. The use of measures that benefit both mammals and birds allows a degree of flexibility in the event that small mammal or breeding bird numbers do not increase to the extent expected or that monitoring indicates that one type of prey is favoured by harriers over the other sufficiently to consider alteration to the scheme."

Designs maximising the potential for breeding bird presence and for maximising small mammal presence, were illustrated in Figures 4.1 and 4.2 respectively of the 2015 report, with the optimised scheme illustrated in Figure 5.1 of the 2015 report (see Appendix A).

These designs were presented and discussed at a Habitats Regulations Assessment workshop, held on 24 November 2015 with Natural England, RSPB and Suffolk Wildlife Trust, on the potential for marsh harrier disturbance arising from construction of Sizewell C.

Further Development of Designs

Feedback on the designs referred to above broadly accepted that it was not possible to establish wetland on the chosen site. In light of this, an approach combining the provision of habitat favouring both small mammals (including rabbits) and birds was favoured but it was concluded that the designs could be enhanced.

The workshop identified the following specific principles to be taken into account in the design:

- Create habitats to maximise marsh harrier prey (small mammals including rabbits and breeding birds) abundance and availability (as opposed to just maximising abundance);
- Take account of the way marsh harriers hunt, typically ambush hunters surprising their prey; and
- Design must be practical to deliver and manage.

Additionally it is necessary to develop an approach that quantifies the benefit to marsh harrier to inform selection of the preferred design option.

1.4 This Report

Wood has been asked to develop the mitigation area design further, taking into account both stakeholder feedback and the principles presented above, informed by:

- A site visit undertaken in December 2016;
- Further research and discussions with the project team; and
- Stakeholder feedback received following a workshop held on 20 November 2018.

The structure of this report is as follows:

- Section 2 of the report presents a summary of the habitat components of the enhanced designs and summarises the design considerations that have informed these;
- Section 3 presents the updated design options;
- Section 4 presents an assessment of habitat provision for prey items and relative change in harrier prey item abundance for the design options;
- Section 5 presents the preferred design option; and
- Section 6 presents a summary of the studies undertaken.

2. Habitat components and design considerations

2.1 Habitat components

The principles identified during the November 2015 workshop have driven the amendment of some habitat components in the mitigation area designs presented in the 2015 study report.

The components now included comprise:

- Tussocky grassland that would be managed to provide a mosaic of tall vegetation and short vegetation. The focus on tussocky grassland in updated designs rather than a mosaic with acid grassland included previously allows for greater flexibility in delivering diverse habitat structure through management;
- Existing and re-inforced hedges (replanted where gappy in accordance with Natural England comments); retained (included previously);
- Hedge/scrub belts (new component, gorse, broom and bramble) which, in the medium term, would significantly increase the availability of breeding birds within the prey mix available to marsh harriers;
- Earth banks (new component) provided alongside scrub belts, off-set, or as features in their own right, to provide instantaneous landscape features, similar to beetle banks only taller, to support the habitats of, and provide cover for, small mammals and rabbits in the near term. Would be sown with tussocky grass mix;
- Wildbird seed planting and nectar rich flower mix. Mix to comprise some tall species such as sunflower and maize to give height; and
- Scrub foci – these would be small patches of gorse/broom around wood/brash piles.

Habitat components and how these influence prey availability (and abundance) in the updated designs are discussed below.

2.2 Design considerations

Habitat components influencing prey availability (and abundance)

Harriers prefer a diversely structures environment, with variation in vegetation height and features, such as ditches which offer them the most chance for surprise as they fly over and suddenly appear at close quarters to prey hidden in them.

For prey to be available to harriers the mitigation scheme needs to provide habitats that harriers can use in the same way (i.e. using the element of surprise to flush or pounce on prey (depending on the prey species involved)).

The habitats/features provided to maximise prey availability, allowing harriers to flush or pounce on prey items present, are summarised below:

- Inclusion of a network of linear habitat features (e.g. banks, new hedge/scrub belts and retained hedges to allow harriers the element of surprise). The design height would be 1-2m reflecting the height of reeds alongside ditches.

- Provision of scrub foci that would allow harriers to approach otherwise open areas of grassland habitat unseen.
- Provision of blocks of wildbird seed planting/nectar-rich flower mix habitat located away from areas of woodland such that harriers can approach from any direction and flush or pounce on prey items.
- Provision of extensive areas of tussocky grassland that would be expected to support high numbers of small mammals. Harriers hunt extensively over the tussocky grassland present in the western South Level adjacent to the mitigation area. The tussocky grassland sward on the mitigation area would be expected to reach between 0.5m and 1m in height in the summer. This is similar to the height of grazing marsh sward. Linear strips will be mown in extensive areas of tussocky grassland to enhance prey availability.

Trees and woodland have been avoided in the design as woodland is not a favoured foraging/hunting habitat for harriers and any prey items within these features would not be considered available to harriers.

Implications for the design

Specific design considerations related to the included components are presented below.

- Hedge/scrub belts: the orientation and distance between these would be optimised – to provide habitat but retain an open aspect to the mitigation area. Due to the time taken to mature these would be supplemented by earth banks (see below).
- Earth banks: would be provided immediately alongside scrub belts, as features in their own right or off-set from scrub belts by 7-10m will provide instantaneous landscape features/cover for colonisation by rabbits and small mammals and, where off-set, provide an additional linear corridor providing cover for animals and birds and also increased chance of surprise for harriers. Where alongside north-south oriented scrub belts, these will be located to the east and off-set to minimise shade effects. Where alongside east-west oriented belts, they would be located on the north side. Some of the earth banks will be constructed around logs that will allow a greater height to be achieved immediately. The balance of log supported versus free standing banks will depend on the amount of wood available.
- Short grassland: Areas of short grassland would be included, managed for rabbits. The patch size takes account of recorded home range size of 1-3ha, with core habitat areas of up to 0.5ha. Whilst these data derive from Spain (Lombardi et al., 2007[3]), it is reported elsewhere (Pennsylvania Wildlife No.9[4]) that 'Rabbits generally do not feed more than 100m from protective woody cover. Therefore where short grassland is included it would not exceed 200m across without provision of scrub (scrub foci), although areas will generally be smaller than this.
- ELS wildbird and nectar rich seed blocks: There are currently 5.16ha of ELS wildbird and nectar rich seed blocks in the mitigation area. To comply with the ELS agreement the same extent must be retained as a minimum however the blocks do not need to be retained in the same locations. Some of the blocks currently present are not ideally placed in respect of the design of the marsh harrier mitigation area and would be moved. Additionally the current extent would be supplemented by the addition of new blocks. New blocks would be approximately 0.4ha in area, which is the minimum size required to qualify for ELS, and would provide additional areas of cover for birds/mammals and features for harriers to hunt around.

[3] Lombardi, L., Fernandez, N. and Moreno, S. (2007). Habitat use and spatial behaviour in the European rabbit in three Mediterranean environments. Basic and Applied Ecology: 8, 453-463.
[4] Pennsylvania Wildlife No.9 (undated). Managing habitat for eastern cottontails.

- ELS wildbird and nectar rich seed blocks would almost exclusively be placed in the tussocky grassland to provide food and cover to the birds and small mammals (mice and voles) present in this habitat type, as opposed to the short grassland for rabbits.
- Scrub foci would comprise wood/brash in loosely placed piles of approximately 10m length, 3m width and 1.5-2m height, supplemented with goose/broom planting to achieve the desired extent. In short grassland areas. Scrub foci would not be established in the pony paddock as this field is let to the tenant of Lower Abbey Farm and is likely to remain so until the tenancy ends.

2.3 Summary of approximate extents and the benefits provided by the components included

The approximate extents, and the benefits provided by the components included in the updated designs, are presented in Table 2.1 below.

Table 2.1 Approximate extents and the benefits provided by the habitat components

Habitat component	Approximate extent	Benefit of inclusion
Tussocky grassland - managed to provide a mosaic of tall vegetation and short vegetation.	Mix of a minimum of 3 tussocky to 1 short (could stretch to 2 to 1). Very Approx. 26 : 8ha	Tussocky for small mammals/voles Short for rabbits
Hedge/scrub belts (gorse, broom and bramble).	2m wide max to form linear features to reflect the types of habitat marsh harriers hunt over	Provides habitat for small breeding birds – available to marsh harriers. Also cover for rabbit burrows and other small mammals.
Earth banks (sown with tussocky grass mix).	Approximately 1.5m tall, 2-3m wide where constructed around logs, otherwise around 0.75-1m tall	Instantaneous landscape features/cover for colonisation by rabbits and small mammals.
Earth bank with tussocky grassland on the south side of the public footpath only.	250m along south side of footpath only	Provides additional habitat alongside path whilst maintaining views of the marshes to the north
Wildbird seed planting and nectar rich flower mix. Mix to comprise some tall species such as sunflower to give height. Recommended 50:50 by area mix of wildbird seed planting and nectar rich flower mix to enable appropriate rotation.	Ca 8ha	Seeds to support birds and small mammals (mice and voles) in autumn and winter. Will include sunflower at low density in the mix to provide height to the crop but allow space for harriers to pounce in where prey is located. Less valuable early in breeding season but height increases during spring/summer.
Re-inforced hedges (replanted where gappy).	To be assessed on site	Additional structure for breeding birds.
Scrub foci – these are small patches of gorse/broom around wood/brash piles.	Each one a max of 30m^2 (10m long x 3m wide) and 1.5-2m in height	Cover for rabbits – provide cover in centre of fields away from hedge belts. Will also be used by small nesting birds such as dunnock.

3. Updated design options

A series of 4 new design options (plus variations) have been defined, informed by a review of publications and data on the likely densities of small mammal and birds that could be supported by the different habitats and features of these. The review is presented in Appendix B of this report.

Each is described below, relative to the baseline condition summarised below.

3.1 Design Review

Baseline condition (Option 0)

The baseline condition is assumed to have comprised:

- 39.4 ha of intensively farmed arable land.
- 1ha of short grazed grassland.
- 0.71 ha of tussocky grassland at Lower Abbey Farm.
- 1,650m of hedgerow (assumed to be 3m wide inc margins) (0.5ha).
- 5.35 ha of wildbird seed/ELS planting.
- Total: approx. 47ha.

The 2015 favoured proposal - optimised for small mammals and birds

The components and approximate extents of the optimised scheme for small mammals and birds, as detailed in the 2015 report (Amec Foster Wheeler, 2015), are presented in Table 3.1 below.

Table 3.1 Extent of each habitat represented on Figure 5.1 (in Appendix A)

Habitat	Approximate Habitat Area (ha)
Tussocky grassland/Grassy buffer strips	29.1
Beetle bank (tussocky grassland)	0.2
Short acid grassland	9*
Wild bird seed cover	6
Existing wetland	0.7
Nectar rich flower mix	2
Total	47

* Short acid grassland would include scrub foci. Extents of scrub foci were not defined for the previous design iteration, however based on the dimensions stated in Table 2.1 above, the scrub foci would have covered a maximum area of 0.1ha (1,110m^2), based on inclusion of a maximum of 37 scrub foci.

The optimised scheme comprised measures of benefit to both small mammals and also breeding birds, through provision of breeding habitats and also food sources throughout the year.

The mitigation area was proposed to be primarily tussocky and acid grassland, with the acid grassland and the associated scrub foci distribution designed to provide stepping-stone habitat to facilitate more rapid colonisation by rabbits from outside the mitigation area. The wild bird seed cover and nectar rich flower mixes are distributed widely to provide food sources for birds, mammals and invertebrates across the site.

It was considered that the proposed approach will lead to significant elevated marsh harrier prey items (small mammals and breeding birds) being present in the area when the habitats are established and that this will draw marsh harriers to forage over the mitigation area.

However the degree of elevation in number of prey items relative to the baseline condition was not quantified in 2015, which is a requirement for this design process. This is now addressed in Section 4.

Natural England's key comments on this design that have guided further development of the mitigation area designs were:

> *The area of Nectar Flower Mix is reduced from that contained within the Maximised for Breeding Birds (Figure 4.1 –* in Appendix A*) approach, when this prescription is incorporated within the Optimised for Small Mammals and Breeding Birds approach (Figure 5.1 –* in Appendix A*). We advise increasing this area, rather than decreasing it, by reducing the much larger area of tussocky grassland.*
>
> *We are unaware whether the location and number of scrub foci is just illustrative in Figure 5.1. and assume this will be updated in line with guidance and reflect best practice.*
>
> *The proposed area of habitat patches and their location require further thought. What is currently presented might be entirely correct but it is worth exploring further. For example, the optimum patch size for increasing rabbit availability and whether these patches are best located at field boundaries or within field centres.*

Option 1:

The components of option 1 are summarised in Table 3.2 and illustrated on Figure 3.1.

Table 3.2 Components of Option 1

	Short grassland (ha)	Tussocky grassland (ha)	Arable (ha)	Wildbird seed mix /nectar rich mix (ha)	Existing hedgerows (m)	New hedge/ scrub belts (m)	Extent of bank (m)*	No. of hedge intersections	Scrub foci (no./area (ha))
Baseline	1	0.71	39.4	5.35	1650	-	-	2	-/0
Option 1	8	26	0	8	1650	2230	250	7	19/0.057

* Bank on south side of footpath 250m

It is considered that this option addresses the Natural England comments on the 2015 favoured proposal.

Of note are that the hedge belts run east-west, spaced about 75m apart and scrub belts stretch full distance across the fields. This layout would result in the harriers surprising prey when they fly over a hedge.

Option: 2

The components of option 2, and two variations (a and b) are summarised in Table 3.3 and illustrated on Figure 3.2 (Option 2) and Figure 3.3 (Option 2a). Option 2b is not drawn.

Table 3.3 Components of Options 2, 2a and 2b

	Short grassland (ha)	Tussocky grassland (ha)	Arable (ha)	Wildbird seed mix /nectar rich mix (ha)	Existing hedgerows (m)	New hedge /scrub belts (m)	Extent of bank (m)*	No. of hedge intersections	Scrub foci (no./area(ha))
Baseline	1	0.71	39.4	5.35	1650	-		2	-
Option 2	8	26	0	8	1650	2540	250	18	21/0.063
Option 2a	8	25	0	8	1650	2540	1310	18	21/0.063
Option 2b	8	24	0	8	1650	2540	2130	18	21/0.063

* Bank on south side of footpath 250m. Also, banks assumed to be adjacent to scrub belts unless stated otherwise in the description.

It is considered that, as for Option 1, this option addresses the Natural England comments on the 2015 favoured proposal.

Of note are that the scrub belts are oriented north-south, which may be more in keeping with the likely flight direction of the harriers and gives diversity in hedge alignments as there are already some established east-west oriented hedges. Additionally north-south oriented hedges create less shade and hence the grass is likely to grow well on both sides of a hedge – rather than just the south for east-west oriented hedges. The north-south orientation also means the hedges/scrub belts are further apart (100m separation).

Option 2a is the same as Option 2 but with 450m of bank off-set from scrub belts by 7-10m on the western edge to provide an additional linear corridor giving cover for animals and birds and also increased chance of surprise for harriers.

Option 2b (not drawn) has approximately 50% of the earth bank off-set from scrub belts by 7-10m.

Option 3:

The components of option 3, and two variations (a and b) are summarised in Table 3.4 and illustrated on Figure 3.4 (Option 3) and Figure 3.5 (Option 3a). Option 3b is not drawn.

Table 3.4 Components of Options 3, 3a and 3b

	Short grassland (ha)	Tussocky grassland (ha)	Arable (ha)	Wildbird seed mix /nectar rich mix (ha)	Existing hedgerows (m)	New hedge /scrub belts (m)	Extent of bank (m)*	No. of hedge intersections	Scrub foci (no./area(ha))
Baseline	1	0.71	39.4	5.35	1650	-		2	-
Option 3	9	26	0	8	1650	1620	250	13	19/0.057
Option 3a	9	25	0	8	1650	1620	1310	13	19/0.057
Option 3b	9	25	0	8	1650	1620	1670	13	19/0.057

* Bank on south side of footpath 250m. Also, banks assumed to be adjacent to scrub belts unless stated otherwise in the description.

It is considered that, as for Option 1, this option addresses the Natural England comments on the 2015 favoured proposal.

In this option, fields in the southern half of the site are now approximately 150m square. East-west oriented scrub belts have been added relative to Option 2 but this has reduced the extent of north-south oriented belts and give a generally more open landscape.

Option 3a is essentially the same as Option 2 but with 450m of the bank off-set from scrub belts by 7-10m on the western edge to provide an additional linear corridor giving cover for animals and birds and also increased chance of surprise for harriers.

Option 3b (not drawn) has approximately 50% of the earth bank off-set from scrub belts by 7-10m.

Option 4

The components of option 4 are summarised in Table 3.5 and illustrated on Figure 3.6.

Table 3.5 Components of Option 4

	Short grassland (ha)	Tussocky grassland (ha)	Arable (ha)	Wildbird seed mix /nectar rich mix (ha)	Existing hedgerows (m)	New hedge /scrub belts (m)	Extent of bank (m)*	No. of hedge intersections	Scrub foci (no./area(ha))
Baseline	1	0.71	39.4	5.35	1650	-		2	-/0
Option 4	9	28	0	8	1650	-	250	2	19/0.057

* Bank on south side of footpath 250m. Also, banks assumed to be adjacent to scrub belts unless stated otherwise in the description.

Option 4 is similar to option 3 but without the addition of scrub belts/earth banks.

Overall it provides less habitat for breeding birds and the lack of scrub belts leaves this design very open with little to break up sight lines in the tussock grassland areas.

Options 5 and 6

Options 5 and 6 have been included as sensitivity tests for the purposes of the metric discussed in Section 4. The components of options 5 and 6 are summarised in Table 3.6.

Table 3.6 Components of Options 5 and6

	Short grassland (ha)	Tussocky grassland (ha)	Arable (ha)	Wildbird seed mix /nectar rich mix (ha)	Existing hedgerows (m)	New hedge /scrub belts (m)	Extent of bank (m)*	No. of hedge intersections	Scrub foci (no./area(ha))
Baseline	1	0.71	39.4	5.35	1650	-		2	-
Option 5	28	9	0	8	1650	-	-	13	19/0.057
Option 6	1	36	0	8	1650	-	-	13	19/0.057

* Bank on south side of footpath 250m. Also, banks assumed to be adjacent to scrub belts unless stated otherwise in the description.

3.2 Creation of the habitats

Creation of the habitats is predominantly a straightforward planting process. However the ability to create the proposed earth banks which are included to provide 'instant' landscape features will be dependent on the availability of material to create them; either created by mounding earth, or constructed by mounding earth around logs. Where constructed around logs the proposal is that they will be approximately 1.5m tall and 2-3m wide but where logs are not available the banks would be around 0.75-1m tall.

It is recognised that the banks and scrub belts shown on Figures 3.1-3.6 are currently straight. Stakeholder feedback has suggested that these be made sinuous where possible to increase site heterogeneity. The extent to which this is possible will be determined on site.

3.3 Management of Habitats

All the options will require on-going management to ensure they provide the intended habitats for the period that mitigation is required.

EDF's land management consultant confirms that all of the designs could be managed once created to maximise the habitat benefit. The management actions required will be similar for each design as the types of habitat provided by each are the same, albeit with different areas of each habitat. However the more complex the design the more effort will be required to ensure all areas are managed appropriately. This is likely to apply particularly where earth banks are off-set from scrub belts (e.g. Options 2a, 2b, 3a and 3b).

It is also noted that all of the options defined above may be enhanced by management adopting a similar approach to that used by Schlaich et al (2015)[5]. Schlaich designed a novel agri-environment scheme, now referred to as Birdfields, that aims to increase both prey abundance and availability, as does the marsh harrier mitigation scheme defined in this report. Birdfields consist of alternating strips of set-aside and alfalfa. Set-aside strips are sown with a mixture of cereals, grasses and herbs, and their most important function is to enhance local densities of voles. Alfalfa strips are harvested three times per year, and their main function is to enhance prey availability. It is suggested that prey availability could be increased in the tussocky grassland areas by periodically mowing strips within it, thus increasing potential for harriers to catch prey items.

In addition to management of habitats, management of rabbits may also be required to ensure that they do not create significantly expanded areas of short grazed habitats, which would likely be detrimental to the number of harrier prey items that the mitigation area as a whole would support.

[5]Schlaich, A.E., Klaassen, R.H.G., Bouten, W., Both, C. and Koks, B.J. (2015). Testing a novel agri-environment scheme based on the ecology of the target species, Montagu's Harrier *Circus pygargus*. IBIS, 157 (4): 713-721.

4. Assessment of habitat provision for prey items and relative change in harrier prey item abundance

The assessment of habitat provision for prey items and relative change in harrier prey item abundance resulting from each of the design options has been determined based on development of 2 simple metrics. The metrics have been informed by the discussion and criteria presented in Appendix B on the likely numbers of small mammals and nesting birds supported by particular habitats (e.g. tussocky grassland, short grassland etc.) and habitat features (e.g. hedge intersections, scrub foci etc.).

However, the metric results also need to be considered in the context of professional judgement in respect of marsh harrier habitat requirements and also ability to manage the adopted design.

4.1 Assessment of relative change in harrier prey item abundance

The metric used to assess the relative change in harrier prey item abundance derives a simple ratio of potential numbers of prey items (small mammals (including rabbits) and birds separately) relative to the baseline condition (see Appendix C). The numbers of prey items per extent of habitat derived by the metric must be treated as indicative only and provide a measure of the scale of provision, not absolute values.

The extent of grassland habitats and wildbird seed/nectar rich mix is not specifically included in this metric in respect of numbers of birds as, for the key options, these would be approximately the same and would therefore not significantly influence the scoring.

The metric results are presented in Table 4.1 below.

Table 4.1 Metric Scores for Relative change in harrier prey item abundance

	Mammals				**Birds**			
Option	**Max number**	**Min number**	**Relative to baseline high**	**Relative to baseline high**	**Hedge/ bank per hectare**	**Hedge/ belt (ratio to baseline)**	**Inter-sections**	**Scrub foci**
Option 0	2119	603			35		**2**	**0**
Option 1	13601	5457	**6.4**	**9.1**	83	**2.17**	**7**	**19**
Option 2	13942	5627	**6.6**	**9.3**	89	**2.35**	**18**	**21**
Option 2a	14803	6108	**7.0**	**10.1**	89	**2.35**	**18**	**21**
Option 2b	15400	6456	**7.3**	**10.7**	89	**2.35**	**18**	**21**
Option 3	12970	5136	**6.1**	**8.5**	70	**1.83**	**13**	**19**
Option 3a	13831	5617	**6.5**	**9.3**	70	**1.83**	**13**	**19**
Option 3b	14227	5815	**6.7**	**9.6**	70	**1.83**	**13**	**19**
Option 4	11523	4313	**5.4**	**7.2**	35	**0.92**	2	19

	Mammals				Birds			
Option	**Max number**	**Min number**	**Relative to baseline high**	**Relative to baseline high**	**Hedge/ bank per hectare**	**Hedge/ belt (ratio to baseline)**	**Inter-sections**	**Scrub foci**
Option 5	6488	2650	**3.1**	**4.4**	35	**0.92**	13	19
Option 6	13378	4925	**6.3**	**8.2**	35	**0.92**	13	19

The supporting metric results are presented in Appendix C.

Based on the assumptions made, the proposed mitigation options will all result in a significant increase in the numbers of marsh harrier prey items present, with Option 2 maximising the number of mammals and providing the greatest increase in extent of habitat for breeding birds over the longer term during the mitigation (power station construction) period.

Options 5 and 6 are sensitivity test options. Options 5 has grassland area approximately 3:1 short relative to tussocky (28ha short to 9ha tussocky) and has reduced numbers of mammals as short managed grassland supports few rabbits relative to the number of small mammals in tussocky grassland. Option 6 has grassland comprising almost entirely tussocky grassland (36ha to 1ha short managed) and has very high numbers of small mammals but very few rabbits. Both of these would support a relatively low number of birds relative to most of the other design options.

4.2 Habitat Provision for Prey Items

A simple single metric has been developed, that scores the extent of different habitat types and number of habitat features provided, to determine which of the options provides the greatest extent of suitable habitats for harriers to hunt over – maximising the potential for prey capture (see Appendix C).

The selected criteria comprise:

- Tussocky grassland (ha).
- Short grassland (ha).
- Number of scrub foci (no.).
- Length of linear feature (m/ha).
- Number of hedge/belt intersections (no.).

The extent of wildbird seed/nectar rich mix is not specifically included as it would be the same for all options and would therefore not influence the scoring. Scores are applied as detailed in Table 4.2 below.

Table 4.2 Metric scoring of habitat provision for prey items

Tussocky grassland (ha)	**Metric score**	**Short grass (ha)**	**Metric score**	**Scrub foci**	**Metric score**	**Linear features (hedge and earth bank / ha**	**Metric score**	**Hedge intersections**	**Metric score**
0-4.9	1	0-4.9	1	0	0	0-19.9	1	0 to 5	1
5-9.9	2	5-9.9	2	1 to 5	1	20-39.9	2	6 to 10	2
10-14.9	3	10-14.9	3	6 to 10	2	40-59.9	3	11 to 15	3

Tussocky grassland (ha)	Metric score	Short grass (ha)	Metric score	Scrub foci	Metric score	Linear features (hedge and earth bank / ha	Metric score	Hedge intersections	Metric score
15-19.9	4	15-19.9	4	11 to 15	3	60-79.9	4	16 to 20	4
20-24.9	5	20-24.9	5	16 to 20	4	80-99.9	5	20 to 25	5
25-29.9	6	25-29.9	6	20 to 25	5	100-119.9	6	26 to 30	6
30-34.9	7	30-34.9	7	26 to 30	6	120-139.9	7		
35-39.9	8	35-39.9	8						

The metric score is derived by the summation of the individual scores. There is no weighting to the sub-metric scores so they are all deemed to have the same importance in allowing harriers to hunt over the habitat. The metric results are presented in Table 4.3 below.

Table 4.3 Metric scores for habitat provision for prey items

Option	Short grassland	Tussocky grassland	Linear feature/ha	Hedge intersections	Scrub foci	Total metric score	Rank
Option 0	1	1	2	1	0	**7**	
Option 1	2	6	5	1	4	**18**	**7**
Option 2	2	6	5	4	5	**22**	**3**
Option 2a	2	6	6	4	5	**23**	**2**
Option 2b	2	6	7	4	5	**24**	**1**
Option 3	2	6	4	3	4	**19**	**5**
Option 3a	2	6	4	3	4	**19**	**5**
Option 3b	2	6	5	3	4	**20**	**4**
Option 4	2	6	2	1	4	**15**	**8**
Option 5	2	6	5	3	4	**20**	
Option 6	0	0	5	3	4	**12**	

The supporting metric results are presented in Appendix C.

Based on the metric scores, Option 2 ranks top overall. Option 2b scores the highest based on the provision of more linear habitat, thus providing the greatest opportunities for harriers hunting over the area, followed by 2a and then 2. Option 3 (3b) ranks 4th.

5. Preferred design option

Options 2 and 3 rank highest in the metrics as these provide the greatest extents of habitat considered likely to support the highest numbers of prey items (small mammals including rabbits, and birds).

In terms of the most appropriate habitat design to provide opportunities for marsh harrier it is considered that Options 1, 2 and 3 all address Natural England's key comments on the 2015 favoured proposal:

Option 1: comprises hedges/scrub belts and banks that run east-west, spaced about 75m apart and scrub belts that stretch the full distance across fields. Whilst this layout would result in the harriers surprising prey when they fly over a hedge, marsh harriers would be expected typically to fly along the linear feature when hunting rather than across it so this main orientation of features is less desirable than a predominantly north-south orientation. At an approximate 75m separation the site begins to appear relatively enclosed, which is not desirable in the context of the more open character typical of marsh harrier foraging areas.

Option 2: comprises hedges/scrub belts and banks predominantly oriented north-south, which will suit the likely flight direction of the harriers and give diversity as there are already some established east-west oriented hedges. Additionally it is recognised in agriculture that north-south oriented hedges create less shade and hence the grass is likely to grow well on both sides of a hedge – rather than just the south for east-west oriented hedges. The north-south orientation also means the hedges/scrub belts are further apart (100m separation), making the fields less enclosed than in Option 1. Options 2b ranks the highest against the metrics as the provision of banks off-set from scrub belts introduces additional corridors for harriers to hunt along. Whilst this layout also requires additional consideration in respect of habitat management, as detailed in Section 3, all the options will require on-going management to ensure they provide the intended habitats for the period that mitigation is required.

Option 3: In this option, east-west oriented scrub belts and banks have been added relative to Option 2 but the extent of north-south oriented scrub belts is reduced, giving a generally more open landscape. The overall result is that there is a reduced extent of linear habitat which also provides fewer hedge intersections which provides for a more open landscape than Option 2 but the orientation is less favourable and this design is considered likely to support fewer prey items.

Option 4: This option provides much less habitat for breeding birds and the lack of scrub belts and banks leaves a very open landscape with little to break up sight lines in the tussock grassland areas.

Options 5 and 6: The sensitivity test options demonstrate that if the extent of short grassland is increased significantly, then the number of small mammals is likely to drop significantly. Conversely, if the extent of tussocky grassland is increased the number of small mammals increases dramatically at the expense of rabbits. This is probably undesirable as the aim is to provide a mix. To maximise small mammal densities Natural England, in feedback on the November 2015 workshop, suggested a 3:1 ratio of tussocky to short grassland, or perhaps lower (which it is assumed meant nearer to 2:1), provided it was as a mosaic rather than large blocks, would be appropriate. This is the approximate ratio provided by the majority of the design options.

Overall, Options 2 and 3 comprise combinations of habitat areas that would lead to the greatest increases in the numbers of small mammals, rabbits and birds present, whilst delivering significant opportunities for harriers to ambush prey by breaking up the sight lines through the provision of scrub belts, earth banks and scrub foci. Taking into account the optimised orientation of the scrub belts and banks, Options 2a and 2b are preferred, with 2b delivering additional foraging corridors relative to 2a.

The practicality of creating the extent of banks included in the design options is being investigated with the final heights dependent on the availability of logs around which to build them.

6. Summary of the studies undertaken

Marsh harrier is an interest feature of the Minsmere - Walberswick Special Protection Area (SPA) during the breeding season. The harriers breed exclusively in reedbed habitat located to the north of the New Cut but they are known to forage widely for food over the Minsmere South Level and also the EDF Energy estate, including Sizewell Marshes Site of Special Scientific Interest (SSSI).

Activities associated with the construction of Sizewell C are not predicted to affect the breeding sites north of the New Cut but disturbance, particularly associated with construction noise, has the potential to result in the temporary displacement of marsh harriers from the foraging areas to the south of the New Cut.

The extent to which this displacement will occur is the subject of the Habitats Regulations Assessment for the proposed development. However EDF Energy has recognised that there will be a need to mitigate for this during construction of the power station; a period that could extent to 10 years.

The proposed approach to the mitigation is to undertake habitat creation and targeted land management activities on 47ha of arable farmland, to enhance habitat so that it supports abundant prey species for marsh harriers.

Though no specific study has been undertaken into the prey species of marsh harrier taken at Minsmere, the adults and/or young of the following species are likely to form an important part (this list is not exhaustive):

- Wetland habitats: wildfowl (e.g. mallard) and passerines (e.g. reed bunting).
- Lowland grassland: scrub, tussocky neutral and acid grassland: meadow pipit, linnet, field vole and rabbit.
- Arable: pheasant, red-legged partridge, lapwing, skylark, linnet, rabbit and brown rat.

The mitigation area was, until recently, under intensive arable production (the baseline condition) and is considered to be of low value to marsh harriers. The key to a successful scheme will be to provide habitats and management prescriptions that maximise the populations of marsh harrier prey species during the marsh harrier breeding period (April to July). To achieve this requires consideration of:

- Habitat composition and structure;
- Speed of habitat establishment;
- Population dynamics of the potential prey items; and
- Support to species during the non-breeding period.

Based on a review of the available data on the ground levels, the underlying geology and ground and surface water regimes in and around the mitigation area, it would not be feasible to create wetland across the majority of the mitigation area. Therefore the options for the mitigation area need to focus on alternative non-wetland foraging habitats that published data has demonstrated are also extensively used for foraging by marsh harriers.

Recognising the opportunistic nature of marsh harriers, which is likely to mean that the harrier diets' reported may in part reflect the relative abundance of prey items in the foraging areas, the options considered have ranged from maximising small mammal abundance across the mitigation area, to maximising the breeding small farmland bird population.

Although it was concluded in the 2015 study that the approach to maximising small mammals is likely to provide more prey items than the approach to maximising breeding farmland birds, it has been proposed

that an approach that combines measures that would maximise small mammal abundance whilst also maximising breeding bird numbers as well would be preferred.

The optimised scheme presented in 2015 primarily comprised provision of tussocky and acid grassland, with the acid grassland and associated scrub foci distribution designed to provide stepping-stone habitat to facilitate more rapid colonisation by rabbits from outside the mitigation area. Areas of wild bird seed cover and nectar rich flower mixes were also provided and distributed widely to provide food sources for birds, mammals and invertebrates across the site.

However, following a workshop and receipt of comments from stakeholders, feedback was that the optimised scheme presented in 2015 combining the provision of habitat favouring both small mammals (including rabbits) and birds was favoured, but that the designs could be enhanced. The following specific principles were to be taken into account in the design:

- Create habitats to maximise marsh harrier prey (small mammals including rabbits and breeding birds) abundance and availability (as opposed to just maximising abundance);
- Take account of the way marsh harriers hunt, typically ambush hunters surprising their prey; and
- Design must be practical to deliver and manage.

Additionally it is necessary to develop an approach that quantifies the benefit to marsh harrier to inform selection of the preferred design option.

Guided by the principles above, and stakeholder comments, a review of small mammal and bird densities supported by different habitats and habitat features was undertaken. This has informed the production of a series of six designs (and variations) and development of simple metrics to quantify the benefit of each of the designs to marsh harrier to inform selection of the preferred design option.

Following review of the characteristics of the habitats, and approach to hunting, used by marsh harrier and the results of the metrics assessing the relative benefit of the habitats provided and abundance and availability of prey items, Options 2 and 3 are predicted to lead to the greatest increases in the numbers of small mammals, rabbits and birds present, whilst delivering significant opportunities for harriers to ambush prey by breaking up the sight lines through the provision of scrub belts, earth banks and scrub foci. Taking into account the predominant orientation of the scrub belts and banks, Options 2a and 2b are preferred, with 2b delivering additional foraging corridors relative to 2a.

The practicality of creating the extent of banks included in the design options is being investigated with the final heights dependent on the availability of logs around which to build them.

Figures

Key

- Mitigation area boundary
- ELS wildflower seed and nectar mix
- Wildflower and nectar seed mix planting
- Existing hedge
- Tall tussocky grassland
- Short grassland
- Scrub foci
- Hedge / scrub belt / bank combined
- Stand alone bank
- Water

0 m 250 m

Scale 1:5,000 @ A3

Sizewell C
Marsh Harrier Mitigation Area
Feasibility Report

Figure 3.1
Option 1

August 18

wood.

H:\Projects\40773 Sizewell C Fen Meadow Compensation and Marsh Harrier Mitigation Strategies\Drawings\ACAD\40773-Shr02.dwg Originator: JACQUI.PARKIN

Key

- Mitigation area boundary
- ELS wildflower seed and nectar mix
- Wildflower and nectar seed mix planting
- Existing hedge
- Tall tussocky grassland
- Short grassland
- Scrub foci
- Hedge/ scrub belt / bank combined
- Stand alone bank
- Water

0 m 250 m

Scale 1:5,000 @ A3

Sizewell C
Marsh Harrier Mitigation Area
Feasibility Report

Figure 3.2
Option 2

August 18

wood.

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Key

- Mitigation area boundary
- ELS wildflower seed and nectar mix
- Wildflower and nectar seed mix planting
- Existing hedge
- Tall tussocky grassland
- Short grassland
- Scrub foci
- Hedge / scrub belt / bank combined
- Stand alone bank
- Water

Note:
North to south hedge / band can be tweaked eastwards

0 m 250 m

Scale 1:5,000 @ A3

Sizewell C
Marsh Harrier Mitigation Area
Feasibility Report

Figure 3.3
Option 2a

August 18

wood.

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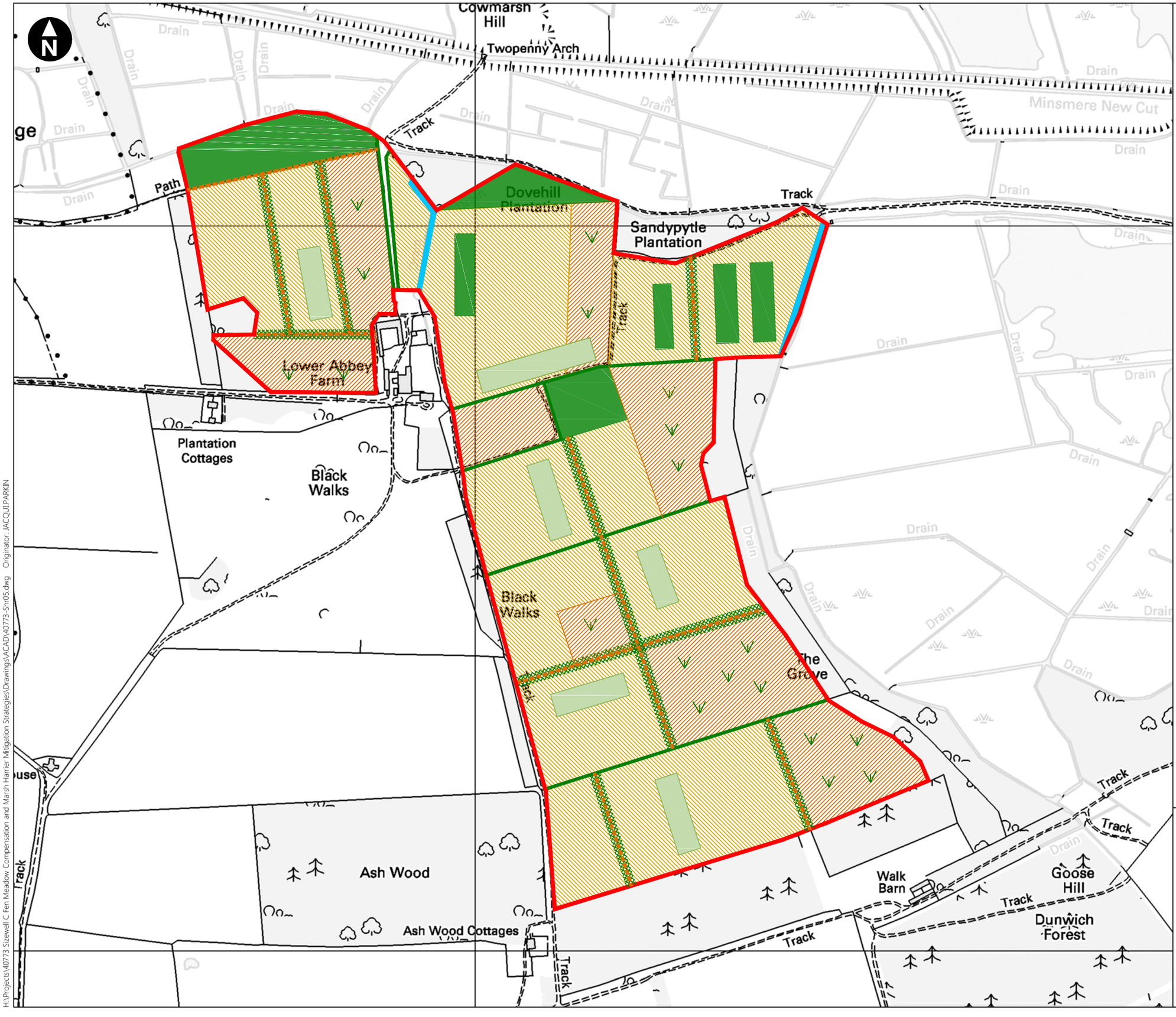

Key

- Mitigation area boundary
- ELS wildflower seed and nectar mix
- Wildflower and nectar seed mix planting
- Existing hedge
- Tall tussocky grassland
- Short grassland
- Scrub foci
- Hedge / scrub belt / bank combined
- Stand alone bank
- Water

Note:
North to south hedge / band can be tweaked eastwards

0 m 250 m

Scale 1:5,000 @ A3

Sizewell C
Marsh Harrier Mitigation Area
Feasibility Report

Figure 3.4
Option 3

August 18

wood.

H:\Projects\40773 Sizewell C Fen Meadow Compensation and Marsh Harrier Mitigation Strategies\Drawings\ACAD\40773-Shr05.dwg Originator: JACQUI.PARKIN

Cowmarsh Hill
Twopenny Arch
Minsmere New Cut
Track
Path
Dovehill Plantation
Sandypytle Plantation
Lower Abbey Farm
Plantation Cottages
Black Walks
Ash Wood
Ash Wood Cottages
The Grove
Walk Barn
Goose Hill
Dunwich Forest
Drain

Key

- Mitigation area boundary
- ELS wildflower seed and nectar mix
- Wildflower and nectar seed mix planting
- Existing hedge
- Tall tussocky grassland
- Short grassland
- Scrub foci
- Hedge / scrub belt / bank combined
- Stand alone bank
- Water

Note:
North to south hedge / band can be tweaked eastwards

0 m 250 m

Scale 1:5,000 @ A3

Sizewell C
Marsh Harrier Mitigation Area
Feasibility Report

Figure 3.5
Option 3a

August 18

wood.

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Key

- Mitigation area boundary
- ELS wildflower seed and nectar mix
- Wildflower and nectar seed mix planting
- Existing hedge
- Tall tussocky grassland
- Short grassland
- Scrub foci
- Hedge / scrub belt / bank combined
- Stand alone bank
- Water

0 m 250 m

Scale 1:5,000 @ A3

Sizewell C
Marsh Harrier Mitigation Area
Feasibility Report

Figure 3.6
Option 4

August 18

wood.

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Appendix A
Sizewell C Marsh Harrier Mitigation Area Feasibility Report (Amec Foster Wheeler Environment and Infrastructure UK Ltd, 2015)

EDF Energy

Sizewell C

Marsh Harrier Mitigation Area Feasibility Report

November 2015

Amec Foster Wheeler Environment
& Infrastructure UK Limited

Report for

Steve Mannings
Acting Head of Planning
EDF Energy
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Document revisions

No.	Details	Date
0	**Incomplete draft**	**20/05/15**
1	Un-reviewed draft	31/07/15
2	**Draft for Comment**	**07/08/15**
3	Draft for comment following workshop	14/10/15
4	**Final**	**5/11/15**

Contents

1. Introduction

1.1 Background

Marsh harrier (*Circus aeruginosus*) is an interest feature of the Minsmere - Walberswick Special Protection Area (SPA) during the breeding season. The harriers breed exclusively in reedbed habitat located to the north of the New Cut but they are known to forage widely for food over the Minsmere South Level and also the EDF Energy estate, including Sizewell Marshes Site of Special Scientific Interest (SSSI).

Activities associated with the construction of Sizewell C are not predicted to affect the breeding sites north of the New Cut but have the potential to result in the temporary displacement of marsh harriers from the foraging areas to the south of the New Cut.

The extent to which disturbance-related temporary displacement will occur is the subject of another study. However EDF Energy has recognised that there will be a need to mitigate for this during construction of the power station; a period that could extent to 10 years.

The proposed approach to the mitigation is to undertake habitat creation and targeted land management activities on arable farmland, to enhance habitat so that it supports abundant prey species for marsh harriers. However, as measures will be required for a limited duration (10 years) they do not need to be permanent.

1.2 Summary of initial vision

An area at the northern end of the Sizewell estate has been identified as available for use within a mitigation scheme. The area encompasses the fields extending from the east of Ash Wood to the north as far as and including Sandypytle, Dovehill, Lower Abbey Farm Marsh and the field to the west of this (see Appendix A).

Following a site visit, attended by EDF Energy, Suffolk Wildlife Trust, Freedom, Amec Foster Wheeler and Hyder, on 28th January 2015 and a desk study a Design Brief and Specification for the creation of marsh harrier habitat has been produced by Hyder (see Appendix A).

The Design Brief and Specification (Hyder, 2015) set out an initial vision for what the enhanced foraging habitat could comprise, and detailed the tasks that Hyder considered necessary to complete a feasibility study of the proposals.

The study proposed a scheme comprising '*four distinct core elements, provided as an integrated package of marsh harrier mitigation, as follows:*

- *Creation of shallow scrapes supporting open water and aquatic and emergent vegetation to provide suitable nesting habitat for water birds such as moorhen and mallard, whilst also providing habitat structure that persists during the winter months.*
- *Creation of lowland heath, scrub and acid grassland, to enhance populations of farmland birds and small mammals and provide habitat structure that persists into the winter months.*
- *Creation of rough tussocky arable grass margins to increase the population of voles and other small mammals, and the sowing of game cover and seed crops to boost populations of farmland birds.*
- *Creation of larger areas of tussock-forming grassland supporting plant species typical of coastal floodplain in Suffolk.*

In addition to the core elements above, it is also proposed to alter the management of Lower Abbey Marsh to allow existing wetland vegetation and rough grassland to increase in extent. Whilst this will only be a modest contribution, it will increase the area of wetland habitat available for foraging harriers.'

The report was accompanied by two Figures that identified the area proposed for creation of marsh harrier foraging habitat in relation to the Sizewell C Main Construction Site and also an indicative scheme drawing of the core elements together.

1.3 Study objectives

Amec Foster Wheeler has been asked to review the initial vision set out in the Design Brief and Specification produced by Hyder and to develop detailed proposals.

The key objective for the study is to develop a proposal that will maximise the number of marsh harrier prey items that the mitigation area will support should marsh harriers be displaced from other areas of habitat in the usual foraging range, with a focus on the breeding season.

A secondary objective is for the proposal to be developed such that it minimises any implications related to the development planning system and from cultural heritage.

To develop this it is has been necessary to undertake the following tasks:

- Review marsh harrier ecology, and in particular the habitat and feeding requirements of marsh harrier, focussed on the summer period;
- Review available baseline ecological, hydrological, topographical and agricultural management data for the proposed mitigation area;
- Review and develop the initial vision to provide detailed habitat and management proposals.

This final report has also been informed by discussions at two workshops with Natural England on the Habitats Regulations Assessment in respect of potential for marsh harrier disturbance arising from construction of Sizewell C.

1.4 Report structure

The structure of this report is as follows:

- Section 2 of the report presents a review of marsh harrier ecology;
- Section 3 describes the proposed marsh harrier mitigation area;
- Section 4 presents a review of options for marsh harrier habitat in the proposed mitigation area;
- Section 5 presents the proposed design layout and features of marsh harrier habitat; and
- Section 6 presents a brief summary.

2. Marsh Harrier ecology

In order to determine the appropriate habitat types and management prescriptions to propose for the area it is important to understand marsh harrier ecology in the locality, and particularly in respect of prey items taken during the breeding season.

2.1 The local population of Marsh Harrier

Marsh harrier is described as a fairly common summer visitor and passage migrant in Suffolk, with increasing numbers over-wintering (Mason 2014[1]). Given the size of the home range and distances breeding birds will regularly travel to provision their young (c.3.5km), most of the marsh harriers recorded foraging in the areas potentially subject to disturbance by the construction are likely to be derived from Minsmere. Marsh harriers are polygamous, with a single male often provisioning more than one nest. The marsh harrier population at Minsmere has remained reasonably stable since the 1990s to date, with eight successful nests (with fledged young) recorded in 1999 (Lowe 2000[2]), compared to seven in 2013 and 2012 (Mason 2014) and 12 in 2011 (Mason 2012[3]). There are also a varying number of unsuccessful nests recorded; though it is not known what proportion of these relate to later repeated attempts that are successful.

2.2 Marsh Harrier breeding cycle

The marsh harrier breeding season generally starts in late March and April though as the season progresses in June-July, the adult birds generally forage over a wider range (Takacsova 2007[4], Underhill-Day 1990[5]), During the post-breeding period in August-September, the adult and juvenile birds disperse from their breeding sites, and from August-October, passage birds may also occur along the Suffolk coast. In recent years, there has been an increasing trend for birds to stay at Minsmere (and along the wider Suffolk coast) through the winter, During winter, the birds use communal roost sites, located in reedbed, scrub and tall crops, with a peak count of ten birds was recorded at the Minsmere roost in December 2013 (Mason 2014). During the post-breeding and winter periods, marsh harrier tend to forage over much wider areas than in the breeding season, though there is very limited information on the precise distances involved. It is during this non-breeding period, that birds from outside Minsmere (such as North Warren and Orford) are most likely to utilise the Sizewell C main development site area.

2.3 Marsh Harrier foraging habitat

Hyder (2015) has reviewed marsh harrier foraging habitat indicating that marsh harriers are mainly regarded as a wetland species, and the majority of foraging activity takes place over wetland habitat (e.g. wet grassland, reedbed, wet ditches). This is typically the case at Sizewell where the majority of flight activity (used as a measure of foraging activity) has been observed over such wetland habitats. However, studies from the UK and Europe suggests that marsh harriers are adaptable, and will often make use of additional types of habitat for foraging; including arable farmland, providing that prey availability is not compromised

[1] Mason, N. (Ed) (2014). Suffolk Birds 2013. Published by the Suffolk Naturalists' Society, compiled by the Suffolk Ornithologists' Group

[2] Lowe, G. (Ed) (2000). Suffolk Birds 1999. Published by the Suffolk Naturalists' Society, compiled by the Suffolk Ornithologists' Group.

[3] Mason, N. (Ed) (2012). Suffolk Birds 2011. Published by the Suffolk Naturalists' Society, compiled by the Suffolk Ornithologists' Group.

[4] Takacsova, M. (2007). On Habitat selection of the Marsh Harrier in the agricultural region (SW Slovakia, the Danubian Lowlands). Act *Zoologica Universitatis Comenianae.* 47(1): 57-63, 2007.

[5] Underhill-Day, J.V. (1990).The status and breeding biology of marsh harrier *Circus aeruginosus* and Montagu's harrier *Circus pygargus* in Britain since the 1900. PhD Thesis, Council for National Academic Awards.

(Cardador 2011[6], Men'shikova 2005[7]). Men'shikova (2005) even suggests that marsh harrier foraging success can be greater in non-wetland areas than within wetland habitat. Carador (2011) found that, following a dramatic decline in marsh harrier numbers in the Ebro basin between 1960 and 1980, there has been a moderate population increase. The recovery of this species was very noticeable in farmland habitat, even in areas dominated by intensified crops. Luo et al (2010[8]) found marsh harriers to be more abundant hunting in grassland habitats, over any other habitat. The harriers were mostly found over high quality grassland with low levels of grazing and no trampling. This was where most of the harrier's main prey was located (in this study area the harriers main prey were passerine birds and pheasants). Takacsova (2007) studied marsh harriers in an area composed of cereal cropping and some areas of reedbed. Although reedbed was the most favoured foraging habitat (particularly for females) arable cropping was also used extensively (see Appendix A for more detail).

2.4 Local populations of prey species

When considering habitat creation for the purpose of increasing the potential foraging opportunities for marsh harrier it is important to understand what prey species are being taken, and what habitats they currently or could potentially utilise. It is important that the measures do not result in an increase in numbers of a 'less important' prey species at the expense of a more 'important' one, or temporal differences in the presence of potential prey species. The evidence base presented in Appendix A shows that a wide range of avian and mammalian prey species are taken as food by marsh harrier.

Underhill-Day (1985[9]) and Moynes S. & J. (1998-2000[10]) provide detailed breakdowns of the prey species taken, many of which are known to breed and winter at Minsmere and in the Sizewell area. Underhill-Day found that young birds, young game birds (e.g. pheasants) and small mammals made up the majority of marsh harrier prey items. Carador (2014) found that marsh harrier foraging in traditional farmland had a diet of 60% small mammals and 35-40% birds, whilst in intensive farmland the diet was 80% small mammals and 15-20% birds.

Other author's work summarised in Appendix A reports diets comprising similar prey items but different relative compositions. It is important to recognise that marsh harriers are generally opportunistic feeders, hunting using both visual and acoustic cues and taking what they can find, although they do also hunt more methodically by flying along linear features e.g. hedgelines / ditches, looking to flush passerines. Based on either foraging approach the harrier diet's reported will in part at least reflect the relative abundance of prey items in the foraging areas.

Nonetheless, three groups of prey are consistently identified as being the most important food items: small songbird/passerine species (adults and young), young water bird and game birds, and small mammals (including the young of larger mammal species). Some of these species are associated with freshwater wetland habitats and others with agriculture and dry semi-natural habitats (arable crops, grassland, scrub and heath).

Though no specific study has been undertaken into the prey species of marsh harrier taken at Minsmere, the adults and/or young of the following species are likely to form an important part (this list is not exhaustive):

- Wetland habitats: wildfowl (e.g. mallard) and passerines (e.g. reed bunting).

[6] Cardador, L., Carrete, M., & Mañosa, S. (2011). Can intensive agricultural landscapes favour some raptor species? The Marsh harrier in north-eastern Spain. *Animal Conservation*, *14*(4), 382-390.

[7] Men'shikova, S. V. (2005). *Hunting habitats of harriers in agricultural landscapes of the Leningrad Region. Proceedings of the Workshop, Kostomuksha, Karelia.*

[8] Luo, Z. K., Hou, Y., Wu, F. Q., Wu, S. B., & Wang, T. H. (2010). Habitat preference and prey selection of Marsh harrier (Circus aeruginosus) in overwintering area of southeast China. *Acta Zoologica Academiae Scientiarum Hungaricae*, *56*(2), 173-186.

[9] Underhill-Day, J.C. (1985). The food of breeding Marsh Harriers *Circus aeruginosus* in East Anglia. Bird Study, 32: 3, 199 — 206

[10] Moynes, S & J. *Tay R.G Report 1998 – 2000 Marsh Harriers in the Tay Reedbeds*.

- Lowland grassland: scrub, tussocky neutral and acid grassland: meadow pipit, linnet, field vole and rabbit.
- Arable: pheasant, red-legged partridge, lapwing, skylark, linnet, rabbit and brown rat.

The key to a successful scheme will be to provide habitats and management prescriptions that maximise the populations of some or all of these species during the marsh harrier breeding period (April to July).

3. Marsh Harrier mitigation area

3.1 Site description

The proposed marsh harrier habitat creation area is located at the northern end of the EDF Energy estate immediately to the south and east of the Minsmere-Walberswick Heaths and Marshes SSSI. It encompasses seven fields including East Bridge Walk, Dovehill, Sandypytle, Lower Abbey Farm Marsh, Little Mount, Great Mount Walk and Ashwood / Nuclear and comprises an area of approximately 47ha.

The Eastridge-Minsmere footpath crosses the field to the west of Lower Abbey Farm Marsh and passes along the northern edge of Dovehill. It is shielded from Sandypytle by Sandypytle plantation.

3.2 Review of available data

No specific intrusive investigations have been carried out at the site, however a number of investigations for the Sizewell C site include data of relevance to this study:

- Site Investigations for the proposed Sizewell C;
- Baseline surface water and groundwater monitoring;
- Digital Terrain Modelling and Topographic survey data undertaken by NNB GenCo (provided by RHDHV);
- Surface Water Conceptualisation Report (RHDHV, 2015); and
- Ecological data collected previously for the Sizewell Estate, including the proposed mitigation area.

Additionally a rapid topographic survey was undertaken of the northern end of the site by Amec Foster Wheeler using hand held GPS equipment in May 2015.

3.3 Environmental setting

Topography and drainage

The proposed mitigation area encompasses several fields at the northern end of the Sizewell Estate, extending from the east of Ash Wood to the north as far as and including Sandypytle, Dovehill, Lower Abbey Farm Marsh and the field to the west of this (Figure 3.1).

Ground elevation is highest (approximately 10 - 20 mAOD) in the south and west of the mitigation area, and reduces to the north and east with lowest ground elevations (approximately 1 - 3 mAOD) around the eastern and northern boundaries. Ground levels are lowest, around 1.0 mAOD, in the very northeast corner of the mitigation area but rise relatively rapidly moving away from the boundaries. Ground elevation continues to rise to the west and south of the mitigation area, while ground elevations in the adjacent Minsmere-Walberswick Heaths and Marshes SSSI to the north and east, are predominantly lower, typically below 1 mAOD in the grazing marsh and reedbed areas.

The mitigation area is bounded to the north and east by ditches. The northern boundary ditch is known as the IDB Drain No.7, the eastern boundary ditch is known as the Tank Drain (RHDHV, 2015[11]).

The IDB Drain No.7 flows from west to east and drains the Minsmere South Levels (part of the Minsmere - Walberswick Heaths and Marshes SSSI). The IDB Drain No. 7 drains by gravity to the Leiston Drain which flows north and discharges to the sea via Minsmere sluice (approximately 200 m north of the confluence with

[11] Royal HaskoningDHV (2015), Sizewell C Main Development Site: Surface Water Conceptualisation – Final Draft

the IDB Drain). Water levels in the Leiston Drain, controlled by the Minsmere sluice, are recorded to be approximately -0.1 mAOD.

The Tank Drain drains the lowland area to the north of Goose Hill, also within the Minsmere South Levels, and flows north along the eastern boundary of the site to join the IDB Drain No.7 in the north east corner of Sandypytle Field. Flow from the Tank Drain to the IDB Drain No.7 is controlled by a sluice which is operated by the RSPB.

A prominent shallow valley feature exists, running from south to north, in the north west of the mitigation area. This feature contains Lower Abbey Farm Marsh and a short ditch which also drains to IDB Drain No.7. Flow from the marsh into the ditch is also controlled by a sluice.

Geology and soils

The Soil Survey Map of Eastern England indicates that soil association 551g (Newport 4) is present across the mitigation area. Soils of this type are described as: *"Deep, well drained sandy soils. Some very acid soils with bleached subsurface horizons especially under heath or in woodland. Risk of wind and water erosion."*

The British Geological Survey (BGS) geological map indicates that the majority of the mitigation area is free from superficial deposits. Peat deposits are mapped to the north and east of the site across the Minsmere - Walberswick Heaths and Marshes SSSI. A strip of glacial sands and gravels of the Lowestoft Formation is mapped across the higher ground in the south and west of the site.

The solid geology below the mitigation area is the Quaternary Crag Group which varies regionally between 0 and 60 m in thickness and has been recorded in the range of 29-42 m thickness at the Sizewell C site. The Crag is composed predominantly of interbedded fine- to medium-grained sands and clays, with an upwardly decreasing proportion of shelly beds. At its base, the Crag rests unconformably on Palaeogene deposits which overlie the Cretaceous Chalk in this area.

Water levels

Groundwater levels

The regional groundwater flow direction within the Crag is generally in an easterly direction towards the coast. However, zones of groundwater discharge, including the Minsmere River and tributaries, the Minsmere-Walberswick Heaths and Marshes SSSI, and Sizewell Marshes SSSI act to control the local flow directions.

Where the Crag overlies Palaeogene deposits, as at Sizewell, the Crag is isolated from the deeper Chalk aquifer. Seasonal water table fluctuations in the Crag are generally less than 1 m due to the high storage coefficient of the aquifer, and groundwater contours reflect topography where the Crag is underlain by Palaeogene clays. Groundwater discharge from the Crag is generally of a diffuse nature as springs or directly into surface watercourses and ditches.

Groundwater level and quality monitoring is ongoing at a series of boreholes in the vicinity of Sizewell C. Data (2014-2015) from the nearest boreholes to the mitigation area, located within approximately 500 m, indicate groundwater levels in the sands and gravels/Crag of around 1.6 – 1.9 mAOD to the west of the site (BP6, BP7, BP9), and 1.0 – 1.2 mAOD to the south of the site (BP23). At the borehole nearest to Lower Abbey Farm (BP27), groundwater levels are slightly lower (1.4 – 1.7 mAOD) than other boreholes to the west reflecting the lower topography within this part of the site.

The Environment Agency also monitor Crag groundwater levels at a nest of three boreholes within Minsmere – Walberswick Heaths and Marshes SSSI (TM46/656, 656A and 656B) located to the east of the southeast corner of the site. Data for the period 2008 to 2013 indicate groundwater levels in the shallow Crag borehole (656b) range from 0.25 mAOD to around 0.65 mAOD (1.07 – 0.67 mbgl), with an annual range of approximately 0.3 m.

In summary, the available data suggest that groundwater levels below the mitigation area could range from around 0.5 to 2m AOD. This suggests a depth to low (summer) groundwater levels ranging from

approximately 0.5 m (north - east corner of mitigation area) to over 10 m (west and southwest of mitigation area). However, ground levels in the north east corner of the site increase rapidly away from the site boundaries and therefore summer groundwater levels across the majority of the site are considered likely to be more than 1 m below ground levels. The depth to high (winter) groundwater levels ranges from <0.5 m (immediate north-east corner of area) to around 10 m (west and southwest of the mitigation area).

Surface Water Levels and Flows

There is no surface water level monitoring or flow data available for the mitigation area. Topographic data indicate that water levels in the IDB Drain No. 7 (measured in May 2015) are around 0.08 mAOD along the northern boundary of the site. Ground levels adjacent to this are recorded at around 2 mAOD in the west and 1 mAOD in the north east corner. Data from the rapid topographic survey, indicates that water levels in the Tank Drain are maintained at around 0.5 mAOD by the sluice pipe operated by the RSPB, which controls flow from the Tank Drain to the IDB Drain. Ground levels on the western bank are around 1 m AOD in the immediate vicinity of the drain, but rise relatively quickly to over 1.5 mAOD within approximately 25 m of the drain. The land to the east of the drain, Minsmere South Levels, was not surveyed, but is lower in elevation than the mitigation area.

At the bottom of Lower Abbey Farm Marsh, the rapid topographic survey suggests that water levels are maintained at around 0.3 mAOD, approximately 0.7 mbgl in the immediate vicinity of the ditch.

From the available data, water levels in the ditches appear to be below groundwater levels and are therefore providing some base level control over groundwater levels on the site. It is likely that the Crag aquifer contributes groundwater to these ditches as baseflow.

Ecology

Habitats

Approximately 60% of the proposed mitigation area comprises very intensively managed arable farmland bounded by belts of planted trees and species-poor (gappy) hedgerows (AMEC, 2012[12]). This was, until recently nearly 100% of the area, however acid grassland was planted in Great Mount Walk in October 2014 and was also planted in Ashwood / Nuclear in April 2015. The grassland in both these fields is in the early stages of establishment. Lower Abbey Farm Marsh comprises semi-improved neutral grassland that is marshy on its eastern and northern boundaries where the grassland abuts the adjacent ditch.

The east of the mitigation area is bounded by a belt of semi-natural broadleaved woodland, east of which is the Minsmere South Levels, an extensive area of wet meadows and marshland intersected by reed-lined ditches. To the south is an area of moderate-age (c.10 years) conifer plantation woodland, and to the south-west, Ash Wood, a mature, mainly deciduous woodland. Further north along the western boundary are more arable fields, the Black Walks (an area of short, rabbit grazed acid grassland) and Lower Abbey farmstead. Along the north boundary are Sandypytle and Dovehill Plantations, which comprise small blocks of wet, deciduous woodland, adjacent and to the north of which are the marshes and main reedbed of Minsmere RSPB nature reserve.

The Minsmere reedbed to the north of the New Cut provides the main breeding grounds for the marsh harrier population, whilst the area to the south of the New Cut (in particular the South Levels and Sizewell Marshes) also provide important hunting grounds for the harriers throughout the year.

[12] AMEC (2012). Sizewell C New Nuclear Power Station: Terrestrial and Freshwater Ecology and Ornithology. DRAFT Extended Phase 1 Habitat Survey Report 2007-2012. Report by AMEC Environment & Infrastructure UK Limited for EDF Energy

Birds

A breeding bird survey, incorporating territory mapping methods, was undertaken across the entire mitigation area in 2012 (AMEC, 2012)[13]. The survey recorded relatively low densities of a limited range of common and widespread species. Species recorded holding territories in the arable fields were limited to 4 skylark, with 15 other territories recorded (see Table 3.1).

Table 3.1 Breeding bird territory counts in the mitigation area

Species	Breeding territory number (Mitigation Area)
Skylark	4
Stock dove	2
Starling	4
Whitethroat	4
Goldfinch	2
Linnet	1
Yellowhammer	2
Total territories	19
Area (ha)	47
Territories/ha	0.4

Based on these data the number of breeding territories across the proposed mitigation area has been calculated as 0.4/ha.

In contrast, in 2012 the other habitats present around the arable land, marginal to the proposed mitigation area, supported a varied community of breeding bird species, typical of the mosaic of different habitats present, including deciduous woodland, scrub and wet grassland. The greatest densities of territories and number of species were found in the areas of scrub and woodland. Species holding territories in these habitats, but adjacent to the arable, included blue tit, chiffchaff, great tit, jay, pheasant, woodpigeon and whitethroat in the habitats immediately marginal to the arable (hedgerows, scrub and woodland). The numbers of territories of typical harrier prey species present in the areas in 2012 is summarised in Table 3.2 below.

Table 3.2 Breeding bird territory counts for harrier prey species in woodland, hedgerow, scrub and wetland vegetation located within 200m of the mitigation area

Species	Breeding territory number (Habitats within 200m of the mitigation area)
Mallard	4
Pheasant	7
Moorhen	2
Lapwing	1
Redshank	1

[13] AMEC (2012). Sizewell C New Nuclear Power Station: Arable Reversion Areas, Breeding Bird Survey Report 2012. Report by AMEC Environment & Infrastructure UK Limited for EDF Energy.

Species	Breeding territory number (Habitats within 200m of the mitigation area)
Stock dove	6
Woodpigeon	20
Sedge warbler	3
Reed warbler	4
Whitethroat	7
Magpie	7
Jackdaw	1
Carrion crow	3
Chaffinch	30
Greenfinch	3
Goldfinch	3
Linnet	3
Yellowhammer	2
Reed bunting	1
Total territories	108
Area of survey (ha)	45
Territories/ha	2.4

Game Management

The land within the Sizewell Estate is not managed for game shooting, though large-scale game-rearing and organised shooting occurs on Potters Farm, adjacent to the west of the Estate. Therefore pheasants and red-legged partridge routinely occur on the EDF estate in elevated numbers relative to areas with no nearby game management.

Mammals

No specific surveys to assess the population size or species composition of small mammals have been undertaken within the mitigation area. However, small mammal trapping studies have been carried out on land immediately to the south of the mitigation area which have found that a wide range of species occur, including field and bank vole, wood mouse, yellow-necked mouse, and pygmy, common and water shrew. From this survey work it is apparent that good populations (see Section 4.3) of field and bank vole, wood mouse and common shrew are present in areas with appropriate habitat structure around the mitigation area. However, the absence of any extensive areas of rough grassland and extensive diverse hedges with tussocky grass margins within the mitigation area will preclude any large-scale populations of small mammals from inhabiting the area.

Rabbits are an abundant species on the Sizewell Estate and surrounding farmland. The sandy soils lend themselves well to the excavation of rabbit burrows, which are particularly evident on permanent grassland, and the perimeters of arable fields. Though likely to be present in the mitigation area, the absence of any extensive areas of permanent grassland within the mitigation area will limit the numbers of rabbits inhabiting the area relative to areas with permanent grass, though the arable crops would be expected to be utilised by foraging animals.

Land use (current crop rotation and management)

The arable areas are very intensively managed for crops with a rotation that includes potatoes, sugar beet, wheat, barley and field scale vegetables, such as onions, carrots and turnips. However, marginal areas of East Bridge Walk, Dovehill, Sandypytle and Little Mount, comprising approximately 5.16ha of the proposed mitigation area, have been entered into an Entry Level Stewardship (ELS) Agreement and are planted annually with wild bird seed mix or flowering nectar mix.

The flowering nectar mix will be of benefit to invertebrates during the late spring and summer months, which in turn will be attractive to insect eating bird species.

The wild bird seed mix areas provision seed eating birds during the autumn and winter. Although not supporting the birds during the breeding season, providing food over the winter will benefit the populations enabling more individuals to survive the winter to breed the following spring, as shown by Siriwardena et al, (2007)[14].

Lower Abbey Farm Marsh (0.71ha) is in ELS, as permanent grassland with low inputs, and is grazed. Neither Great Mount Walk or Ashwood / Nuclear are in ELS and both of which have recently been planted with acid grassland (see above).

Current value of the proposed mitigation area for Marsh Harriers

Though the proposed mitigation area is bounded in part by habitats that are likely to provide more opportunities for marsh harrier prey species, the mitigation area itself currently is used of limited value for the harriers. This assessment is based primarily on the following factors:

- The area has until very recently been predominantly intensively managed arable, although it now has a significant component of acid grassland although this has little structure being on the early stages of establishment.
- There is very limited wet grassland present, currently restricted to a small area of Lower Abbey Farm Marsh, and ditch habitat is also restricted to alongside Lower Abbey Farm Marsh and also the eastern edge of Sandypytle.
- The arable habitat was shown to support a very limited breeding bird population, particularly in comparison to other areas where habitat management measures have been undertaken to increase farmland bird populations, such as at Hope Farm (covering 181ha) in Cambridgeshire, managed by the RSPB (RSPB 2012)[15]. Here a wide range of cropping and habitat management measures have been undertaken aimed at increasing the numbers of farmland birds. The measures taken include provision of skylark plots, field margins and over-winter stubbles and fallow ground. Indices have been calculated to measure the change in the breeding and wintering bird numbers at Hope Farm, which has shown a three-fold increase in the breeding population and a six-fold increase in winter, from 2000-11. For key species such as skylark, the density of territories/100ha was eight territories in the mitigation area in 2012 and 23 at Hope Farm (in 2011), and for yellowhammer four and 18 territories respectively. Other key farmland species such as grey partridge, linnet and reed bunting were not recorded breeding within the mitigation area, though the latter two species are known to breed on the Sizewell Estate and on Minsmere nature reserve. Linnet and reed bunting occurred at densities of 14 and 9 territories/100ha respectively at Hope Farm.
- The existing habitats in the proposed mitigation area (predominantly arable, acid grassland in the early stages of establishment with gappy species poor hedges) do not provide the varied habitat structure needed to support an abundance of small mammals.

[14] Siriwardena, G.M., Stevens, D.K., Anderson, G.Q.A., Vickery, J.A., Calbrade, N.A. & Dodd, S. (2007). The effect of supplementary winter seed food on breeding populations of farmland birds: evidence from two large-scale experiments. *Journal of Applied Ecology* **44**: 920-932

[15] RSPB (2012). Hope Farm, Farming for Food and Wildlife. RSPB, Sandy

4. Review of options for Marsh Harrier habitat

Section 2 of the report has presented a review of the published habitat and prey requirements of marsh harriers whilst Section 3 has presented the available information on the current habitats and species present and the management of the area.

As indicated in Section 2, though no specific study has been undertaken into the prey species of marsh harrier taken at Minsmere, the adults and/or young of the following species are likely to form an important part (this list is not exhaustive):

- Wetland habitats wildfowl (e.g. mallard) and passerines (e.g. reed bunting).
- Lowland grassland: scrub, tussocky neutral and acid grassland: meadow pipit, linnet, field vole and rabbit.
- Arable: pheasant, red-legged partridge, lapwing, skylark, linnet, field vole, rabbit and brown rat.

The key objective for the study is to develop a proposal that will maximise the number of marsh harrier prey items that the mitigation area will support, should marsh harriers be displaced from other areas of habitat in their usual foraging range, with a focus on the harrier breeding season.

Recognising the opportunistic nature of marsh harriers, which is likely to mean that the harrier diets' reported may in part reflect the relative abundance of prey items in the foraging areas, it is suggested that the options range, at one end of the scale, from maximising small mammal abundance across the mitigation area, to maximising the breeding small bird population at the other end of the scale.

A review of how these two extreme ends of the scale could be delivered is presented below, although it should also be noted that measures for one species group will typically also benefit the other to a greater or lesser degree (depending on the measure).

In respect of the potential for habitat creation approaches to be useful for provisioning marsh harriers during the breeding season, the following factors require consideration:

- Habitat composition and structure appropriate to the target species and also to foraging harriers. For example, dense cover or particularly tall crops are likely to prevent harriers accessing prey items even if they are abundant;
- Speed of habitat establishment – and hence potential to support the target species in the timescales necessary for mitigating effects of construction-related disturbance. A habitat that takes more than one season to establish may be problematic, if changes are required because it is not as effective as expected;
- Population dynamics of the potential prey items. Studies have shown that small mammal populations typically peak in November, but more importantly to this study, they are at their minimum in May[16] (which is when marsh harrier will be provisioning young chicks). Nonetheless, based on analysis of feeding remains (e.g. Underhill-Day, 1985), small mammals comprise a significant proportion of the harrier's diet during the breeding season. Rabbits could be an important source of food during the harrier breeding season as they start breeding early in the year (Jan/Feb). However, rabbits are considered to be a pest and under the Pests Act 1954, and as a result landowners/occupiers have a legal obligation to control rabbits on their land, and for taking steps to prevent rabbits from causing damage. As a result it is considered that rabbits should not be encouraged without also implementing measures to protect neighbouring agricultural land sitting outside the Sizewell estate from potential damage. Overall bird numbers (including potential harrier prey species) start to increase from April as they hatch and start to fledge (harriers taking both adults and young).

[16] Flowerdew, J.R., Shore, R.F., Poulton, S.M.C., Sparks, T.H., 2004. Live trapping to monitor small mammals in Britain. Mammal Rev. 34, 31–50.

- It is also important to support species during the non-breeding period. Supporting the populations of birds and mammals throughout the year will give the greatest chance of maximising the numbers of breeding individuals present at the start of the breeding season. This was demonstrated for farmland birds by, for example, Siriwardena et al (2007).

4.1 Options for habitat provision in the mitigation area

A review of marsh harrier foraging habitats was presented in Section 2.2. This indicated that marsh harriers are typically regarded as a wetland species, and that the majority of foraging activity takes place over wetland habitat (e.g. wet grassland, reedbed, wet ditches), which is typically the case at Sizewell where the majority of flight activity (used as a measure of foraging activity) has been observed over such wetland habitats. However, there is also evidence that marsh harriers will often make use of additional types of habitat for foraging; including arable farmland and grassland habitats.

Given the association of marsh harriers with wetlands, ideally wetland habitat would be created across the mitigation area. However review of the available data on the ground levels, the underlying geology and ground and surface water regimes in and around the mitigation area indicates that this would not be feasible across the majority of the mitigation area for the reasons listed below:

- Groundwater levels are nearest to the surface in the extreme northeast corner of the area (north east corner of Sandypytle). However ground levels rise rapidly away from the field margins in this area, and ground levels are generally much higher across the remainder of the area, with a much greater depth to water table. This means that significant dig depth would likely be required to intersect the water table anywhere except the very northeast corner of the mitigation area, where the dig depth required would still likely exceed 0.5 m to reliably intersect the groundwater table and ensure creation of continuously wet conditions.
- If it was considered that the required depth of dig in the north east corner was acceptable, the soils and underlying geology of the mitigation area are generally unsuited to wetland creation, being predominantly free draining sands. This would not be an ideal substrate in which to try and establish wetland vegetation, potentially meaning that import of an appropriate substrate would be required.
- Nonetheless, if it was considered that the depth of dig was acceptable, and the substrate issues could be overcome, the area of wetland that could potentially be created would likely be less than 1 ha. The benefit of this in the context of the 47 ha of the mitigation area would be extremely limited and analysis of costs and benefits would be unlikely to be favourable.

Therefore the options for the mitigation area are to focus on alternative non-wetland foraging habitats that published data has demonstrated are also extensively used for foraging by marsh harriers. The types of habitat chosen should be based on the ability to maximise harrier prey species during the harrier breeding season and opportunities for maximising small mammal abundance and / or breeding bird abundance in non-wetland terrestrial habitats are reviewed below. However, woodland is not considered further for the area as it is not a habitat utilised by foraging marsh harriers.

4.2 Maximising breeding small bird abundance in the mitigation area

Data on typical numbers of breeding territories per hectare for different habitat types is limited and dependant on many factors including geographical location, landscape and small-scale habitat requirements.

Review of density of breeding bird territories

The proposed mitigation area at Sizewell is currently farmed intensively for arable crops and, when surveyed in 2012, supported 0.4 territories / ha. It would be expected, based on professional judgement, that numbers of territories in lowland rough grassland and Sandlings grassland / heath (two other possible habitats for the site), would not be significantly greater than this. Indeed, a survey of Broom Covert, an area of Sandlings grassland/heath and scrub, on the Sizewell Estate in 2012, yielded a breeding territory density of potential harrier prey species only a little higher than that for the intensive arable land (0.69 / ha) based on the

numbers of comparable species that would be likely to be accessible to marsh harrier and hence included in their diet.

Wetland areas would be likely to support a greater abundance of passerine breeding bird territories per hectare than either arable or Sandlings grassland/heath and scrub for example and additionally would support breeding wildfowl species, however, on the mitigation area the extent of wetland habitat likely to be achievable is very limited (as detailed in Section 4.1) and hence would be unlikely to make a significant contribution to the overall numbers of breeding territories within the mitigation area.

It is however possible to considerably increase the number of breeding bird territories present, relative to both the intensive arable management currently employed and also above that for Sandlings grassland/heath and scrub (another potential alternative habitat for the mitigation area but not considered further due to low breeding farmland bird densities), through sensitive management of arable land for birds. For example, the RSPB's Hope Farm is an arable system that has been subject to sensitive management since 2000, for the benefit of birds. Measures undertaken have provided birds with safe places to nest, food in spring and summer for the chicks and food and shelter over the winter. This has resulted in a three-fold increase in the number of breeding bird territories (considering the 19 species on the Farmland Bird Index), from 122 territories (0.67/ha) in 2000 to 291 (1.6/ha) in 2011 around 1.6 territories/ha. Additionally, the number of wintering birds has increased 6-fold over the same period (to 2011). Whilst some of these will be migratory, many will also be resident birds moving into an area optimised for their presence (providing abundant food and shelter). Providing food sources year round for farmland birds is key to maximising the survival of birds through the winter and hence the breeding population the following spring.

It is considered that employing management measures and cropping in the mitigation area, similar to those used at Hope Farm, would enable significantly increased breeding territory densities to be achieved at Sizewell although the relative paucity of hedge habitat in the area would likely prevent achievement of the same densities.

Possible approach to maximising breeding bird territory numbers

If it was decided that the most appropriate approach to mitigating for the effects of construction of Sizewell C was to provide habitat to maximise the number of breeding farmland birds, then a variety of measures, based on those prescribed for the Entry and Higher Level Agri-environment schemes would be adopted. In summary these would include:

- General crop management measures such as:
  - Spring-grown crops (such as barley, rye, oats, wheat or triticale) that could be sown to provide breeding sites for ground-nesting birds, such as lapwing and skylark. Peas or field beans could be grown as a break crop. All these crops could be harvested by standard combine without the need for specialist equipment.
  - A variety of suitable crop types could be sown in any one season to maximise the potential habitat available to wildlife. No one crop type will be sown across the mitigation area in any one season.
  - Fertiliser and pesticide use. The use of fertilisers, herbicides and pesticides will be minimised to encourage the growth of arable weeds and insect prey for birds and mammals.
- Grassy buffer strips, which have been shown to increase the numbers of breeding farmland birds, but also provide valuable habitat for small mammals. These could be sown with a fescue mixture to ensure a tussocky sward.
- Beetle Banks, which provide habitat for ground-nesting birds, small mammals and insects. These are also useful for dividing up large arable fields and creating 'internal field boundaries'.
- Wild bird seed and nectar flower mixes (in the form of blocks or strips) which will provide important food resources for farmland birds, especially in winter and early spring, and will

maximise the production of small seeds suitable as bird food in either annual or annual/biennial mixtures, while also providing a source of invertebrates for birds.

- Bare areas (including skylark plots). Arable fields support more breeding skylarks, which favour spring-sown crops, than any other habitat. Large, open fields are preferred, where the birds nest on the ground in vegetation less than 50cm high, so winter cereals soon become unsuitable for breeding.
- Uncropped, uncultivated areas which will provide foraging habitats for farmland birds such as partridges, skylark, linnet and yellowhammer, and mammals including brown hare.
- Stubbles, which are left overwinter, followed by natural regeneration to provide vital winter food sources for seed-eating birds, and spring and summer foraging and nesting habitat for other farmland birds. Stubbles also provide valuable habitat for other farmland wildlife including small mammals.

An indicative layout of these habitats focussed on maximising breeding bird numbers in the mitigation area is provided in Figure 4.1. The composition of the area (ha of each habitat) is provided in Table 4.1 below.

Table 4.1 Approximate extent of each habitat represented on Figure 4.1

Habitat	Approximate Habitat Area (ha)
Grassy buffer strips / tussocky grassland	13
Beetle bank (tussocky grassland)	0.4 (2000m length x 2m width)
Short acid grassland	n/a
Wild bird seed cover	4
Bare ground	3
Stubble	5
Existing wetland	0.7
Arable (not including stubble or bare ground)	20
Nectar rich flower mix	1
Total	47

4.3 Maximising small mammal abundance in the mitigation area

Small mammals considered for this site comprise principally field vole and rabbit as these are the species found most frequently in marsh harrier feeding remains (data from Underhill-Day, 1985) that could occur in the mitigation area. Although brown rat is also frequently found in marsh harrier feeding remains rats are a pest species and they are a significant predator of the eggs and chicks of ground nesting bird and hence taking measures to increase this species would be undesirable.

Review of small mammal densities

Published Information

Published data on the population densities of small mammals in different habitats are limited and difficult to interpret. However, it is well known that small mammal numbers are generally low in intensively managed arable land.

For example Harris *et al*. (1995)[17] reports for field vole that '*Estimating field vole numbers is also complicated by populations being very patchily distributed at the landscape level. This clumped distribution means that they are easily missed by trapping (D.J. Jefferies pers. comm.), and so density estimates for such a patchily distributed species are largely meaningless. Although the species is both widespread and abundant, there are few estimates of population density, and most density estimates are from isolated fragments of suitable habitat, and so are probably atypical. Tapper (1979) calculated a density of 100 per ha for spring populations in suitable grasslands in southern England, with peak densities of 300 per ha. Ferns (1979) recorded 97 per ha in spring in a young larch plantation, reaching a peak of 128 per ha in early winter. Whilst field voles occur in the grassy banks of arable hedgerows, densities are low (Tew 1994). Densities vary from 1 to 15 per ha in mixed farmland in Morayshire (M.L. Gorman pers. comm.).'* Other studies indicate that field vole densities may be 25-45 / ha in road verges and 25-250 / ha in rough grassland in Kielder Forest, although there are significant uncertainties in the densities quoted (reported in Flowerdew *et al.*, 2004[18]).

Butet and Leroux (2001)[19] studied vole numbers and the relationship between these and the breeding success of Montagu's harrier in western French wetlands. These authors found significant differences in vole densities between arable crops (mean 43 voles/ha) compared to grazed or mown pastures (mean 51/ha) and abandoned pasture land (mean 102 / ha). The authors found that mean vole numbers, pooled across the habitat types present in the study area, of less than 100/ha led to reduced breeding success of the harriers.

Other authors have reported that grassland supports more voles than arable land, for example Kok's *et al*. (2007)[20] indicates that their vole index was twice as high in fallow grassland (set-aside) than arable land. Also, Broughton *et al.* (2014)[21] assessed the benefits to four small mammal species (including field vole) of providing 6m wide field margins (sown with a simple grass mix to provide semi-natural habitat for small mammals, invertebrates and birds, typical of ELS options (e.g. option EE3)) compared to the provision of margins typical of conventionally farmed land (2m wide margin measured from the centre of a hedge, or 1m from the top of a ditch). Vole (and other small mammal) numbers increased significantly from year 0 to year 1 relative to the conventional farming approach, and the mean abundance of field voles in autumn continued to significantly exceed those of the conventional farm in years 2-6 (based on analysis of numbers in the autumn). A number of authors have studied diversity and relative abundance of small mammal species in landscapes of varying agricultural intensity, concluding in general that although overall diversity tended not to be that different between the different intensity situations, the number of animals present did vary, with more animals present in less intensively managed situations (e.g. Michel, Burel and Butet (2006)[22] and Moro and Gadal (2007)[23]). This is most likely due to the habitat diversity and increased niches available in a more diverse habitat structure.

For rabbits, Harris *et al*. (1995), provides the following summary: '*The most suitable habitats are areas of short grasses, whether these are natural or agricultural. However, they* [rabbits] *are found in a wide variety of habitat types. Densities vary seasonally, with numbers relatively stable over winter (<1 to 15 per ha) followed by highly variable summer peaks (<1 to 40 per ha) (Tittensor 1981). Summer peaks are higher on sandy soils, and over-winter, numbers are higher on sand and chalk than on clay soils (Cowan 1991). The following density estimates were available for over-wintering rabbit populations in specific habitat types:*

[17] Harris, S. et al. (1995). A review of British mammals: Population estimates and conservation status of British mammals and other cetaceans. JNCC.

[18] Flowerdew, J.R. et al. (2004). Live trapping to monitor small mammals in Britain. Mammal Rev. 34(1), 31-50.

[19] Butet, A. and Leroux, A.B.A. (2001). Effects of agriculture development on vole dynamics and conservation of Montagu's harrier in western French wetlands. Biological Conservation 100, 289-295.

[20] Koks, B.J. et al. (2007). Do voles make agricultural habitat attractive to Montagu's Harrier *Circus pygargus*?

[21] Broughton, R.K. et al. (2014). Agri-environment scheme enhances small mammal diversity and abundance at the farm-scale. Agriculture, Ecosystems and Environment 192, 122–129.

[22] Michel, N., Burel, F. and Butet, A. (2006). How does landscape use influence small mammal diversity, abundance and biomass in hedgerow networks of farming landscapes? *ACTA Oecologia.*

[23] Moro, D. and Gadal, S. (2007). Benefits of habitat restoration to small mammal diversity and abundance in a pastoral agricultural landscape in mid-Wales. Biodivers Conservation 16:3543–3557

- *8.4 animals per ha on chalk grassland, Oxfordshire, based on a capture/mark/recapture study averaged over six winters (Cowan 1984);*
- *14-22 per ha on sand dunes, Holy Island, Northumberland, based on marking and population counts (MacDonald 1989);*
- *2.1 per ha on sand dunes, East Lothian, using Leslie's trap out method (Kolb 1991a);*
- *1.7 per ha on forestry/hill grazing, Borders, using marking and Leslie's trap out method (Kolb 1991b); hill farm/open grazing, Borders, using Leslie's trap out method - (H.H. Kolb pers. comm.); and*
- *12.6 per ha on grassland/broom, Strathmore, Tayside, using Petersen/Bailey capture/mark/recapture calculations (H.H. Kolb pers. comm.).'*

Typical rabbit densities in arable fields are not available although arable areas typically do not support extensive cover for rabbits. A study into the effectiveness of habitat management in the recovery of low-density populations of wild rabbit (Godinho, 2013[24]) found that the relative location of a warren to feeding areas was an important factor in determining the number of rabbits present, as was the substrate type. There is on-going research in East Anglia focussed on increasing rabbit numbers in Breckland heaths as rabbit numbers have crashed in recent years and this is affecting the quality of the heath vegetation for stone curlew (D. Bell, UEA, pers. comm.). In respect of habitat preferences, rabbits prefer short grass areas, with fescues and forbs. For example *Festuca rubra*, amongst other grass species (e.g. *Elymus repens, Arrhenatherum elatius, Poa trivialis* in one palatability trial), has been found to be highly palatable in a number of studies, whilst *Rumex acetosella, Rumex acetosa, Taraxacum officinale* and *Trifolium repens* for example have also been found to be highly palatable (Diaz, 1999[25]). Mowing to keep grass short can help when rabbit numbers are not sufficiently high to keep grass height down. Sandy substrate is ideal for rabbits as this is soft for burrowing and provision of cover (e.g. scrub, tree branches or brashings) in fields helps the rabbits to colonise new areas, as these can provide stepping stone habitat (D. Bell, pers. comm.). It can also help if the cover is located on a slope and the soil is turned over or disturbed before scrub, branches or brashings are placed as this provides soft burrowing conditions. This strongly suggests that provision of cover, through development of patches of scrub, e.g. bramble and hawthorn, or increased length of hedgerow or reinforcement of existing hedgerows, is likely to lead to an increase in the number of warrens present, and hence the number of rabbits supported in an area.

Data from Sizewell Estate

There are no small mammal density data for the proposed mitigation area but some limited data are available for arable margins in areas south of Ashwood. As an example, a mark, release, recapture exercise undertaken in April 2015 in margins comprising a hedge with 2.5m of well-established tussocky grassland either side, has revealed densities of small mammals[26] of 0.055 animals / m^2. If pro-rata'd this would equate to a density of 550 animals / ha (i.e. 2000m of similar hedgerow flanked by tussocky grassland) in similar habitat. Field vole contributed 83 animals / ha which is in line with published information whilst greater densities than this of common shrew, bank vole and wood mouse were recorded. It should be noted however that these species tend to be more strongly associated with hedges than field vole.

Summary

Based on the references discussed above, available data suggest that:

- Grassland, and in particular rough grassland, does support more field voles than arable land.

[24] Godinho et al. (2013). Effectiveness of habitat management in the recovery of low-density populations of wild rabbit. Eur J Wildl Res. Published online June 2013.

[25] Diaz, A. (2000). Can plant palatability trials be used to predict the effect of rabbit grazing on the flora of ex-arable land? Agriculture, Ecosystems and Environment 78: 249–259.

[26] Combination of wood mouse, bank vole, field vole, yellow necked wood mouse, common shrew, pygmy shrew, water shrew,

- Although the uncertainty in the figures must be stressed, the density of field voles may increase between 3 and 10-fold per unit area, if arable is replaced with good quality rough grassland.
- Established tussocky grassland margins associated with hedgerows on Sizewell estate can support a diverse population of small mammals at densities in line with published estimates.
- Typical rabbit densities in arable fields are not available and therefore indicating what sort of increase may be expected by a change in habitat type is not possible. However, the favoured habitat for rabbits is reported to be areas of short grasses, whether these are natural or agricultural. A change from arable to short grassland is likely to allow colonisation of the area by a rabbit population, or an increase in rabbit numbers as appropriate to the location.
- An increase in the extent of scrub or hedgerow or provision of other cover (e.g. brashings) and reinforcement of existing hedgerows, in the mitigation area relative to the existing arable cultivation, is likely to lead to an increase in the habitat available for creation of warrens and encourage / facilitate rabbit colonisation from areas outside the mitigation area (e.g. Black Walks where rabbits are abundant.
- The favoured habitat for rabbits is likely to be less favoured by field voles as this will not provide the required structure / cover for the voles. Work by Sumption and Flowerdew (1985)[27] recorded significant increases in vole numbers in areas where rabbit numbers had crashed following outbreaks of Myxomatosis as grassland habitat developed from short grazed to tussocky, with increased invertebrate densities amongst other changes.

Possible approach to maximising small mammal numbers

If it was decided that the most appropriate approach to mitigating for the effects of construction of Sizewell C was to provide habitat to maximise the number of small mammals inhabiting the mitigation area, then a variety of measures would be adopted. However the best habitats for voles and rabbits are not the same.

To maximise the numbers of small mammals, it is suggested that habitats appropriate for field voles could be focussed upon, as the number of animals per hectare achievable, is likely to be much greater than that for rabbits. However it is recognised that rabbits are larger than voles and therefore would likely provide a better return for the harriers than voles, in respect of energy expended per prey item caught and therefore, whilst recognising the requirements of the Pests Act 1954, it is considered appropriate that habitats for rabbit are also provided as part of the proposals.

It is therefore suggested that to maximise the number of small mammals in the mitigation area, a combination of habitats should be provided, as follows:

- Rough grassland covering approximately 80% of the 47ha mitigation area. This should comprise a range of grass species including tussock forming species such as tufted-hair grass (*Deschampsia cespitosa*), Yorkshire fog (*Holcus lanatus*), tall fescue (*Festuca arundinacea*), cock's-foot (*Dactylis glomerata*), false oat-grass (*Arrhenatherum elatius*) and Timothy (*Phleum pratense*), supplemented by flowering forbs such as yarrow (*Achillea millefolium*), common knapweed (*Centaurea nigra*), agrimony (*Agrimonia eupatoria*) and ribwort plantain (*Plantago lanceolata*);
- Short sward acid grassland comprising, for example, red fescue (*Festuca rubra*), sheep's fescue (*Festuca ovina*), fine-leaved sheep's fescue (*Festuca filiformis*), sweet vernal grass (*Anthoxanthum odoratum*), common bent (*Agrostis capillaris*) and wavy hair grass (*Deschampsia flexuousa*), with additional patches of scrub planted / maintained across approximately 20% of the mitigation area, in fields that already support rabbits and to provide stepping stone habitat to facilitate colonisation by rabbits from outside the mitigation area (e.g. from Black Walks where rabbits are abundant); and
- Reinforced hedges and scrub foci. New hedges would not be planted due to the period of years taken for these to establish adequately to support small mammals (or breeding farmland birds)

[27] Sumption, K. J. and Flowerdew, J. R. (1985). The ecological effects of the decline in Rabbits *(Oryctolagus cuniculus L.)* due to myxomatosis. Mammal Review, 15: 151–186

in this area and there being a notable issue with deer grazing of hedges on the Sizewell estate which, unless fenced, would dramatically slow hedgerow development such that they would probably not develop sufficiently within the period that the mitigation habitat is required. However hedges already present could be reinforced through placement of brashings and logs for example in hedgerow gaps and at appropriate points at the bases of existing hedges to provide instantly enhanced habitat structure for small mammals. Additionally scrub foci, formed through a combination of limited planting and / or placement of brashings and logs, would be created in areas of short grassland as foci for rabbit activity and also to facilitate the spread of rabbits from areas outside the mitigation area. They could also be located in the areas of tussocky grassland.

An indicative layout of these habitats is provided in Figure 4.2. The composition of the area (ha of each habitat) is provided in Table 4.2 below.

Table 4.2 Approximate extent of each habitat represented on Figure 4.2

Habitat	Approximate Habitat Area (ha)
Tussocky grassland	37.3
Beetle bank (tussocky grassland)	n/a
Short acid grassland	9
Wild bird seed cover	n/a
Bare ground	n/a
Stubble	n/a
Existing wetland	0.7
Arable (not including stubble or bare ground)	n/a
Nectar rich flower mix	n/a
Total	47

4.4 Review of advantages and disadvantages of the potential approaches

Based on a simple analysis of the potential number of voles and rabbits supported per unit area of suitable grassland, it is suggested that the approach to maximising small mammal numbers would provide significantly more potential prey items for provisioning foraging harriers, relative to the number of breeding bird territories that sensitively farmed arable will deliver. However, the clear advantage of this approach needs to be considered in the context of some potentially significant disadvantages. These principally comprise:

- Numbers of small mammals present, are typically lowest in May (when they would need to be highest in order to provide prey for breeding harriers provisioning their young);
- Mammal populations are known to fluctuate, showing either annual or cyclical fluctuations. The reasons for the fluctuations are not known with certainty, despite extensive work by researchers, although research has narrowed the likely causes to direct environment factors;
- Deer are likely to limit the development of scrub on site, albeit these could be fenced out of planted areas;
- Tussocky grassland would take 2-5 years to fully establish. If this was then found not to support the expected significant increase in small mammals, an alternative approach would need to be adopted very rapidly and would need to provide almost instant results.

Conversely the measures suggested for maximising breeding bird numbers have the following advantages:

- They are readily implemented, with the habitats established within the growing season i.e. they do not take multiple years to establish.
- They will reliably provide increased numbers of prey items when the harriers would need them, rather than maximum numbers occurring after the breeding season as for small mammals.
- A number of the measures that benefit breeding farmland birds also benefit small mammal numbers.

However a potentially significant disadvantage of a focus on breeding farmland birds is that is the converse of the stated advantage of maximising small mammal numbers, in that focussing on birds would likely provide significantly fewer potential prey items for provisioning foraging harriers, relative to the number of small mammals that a combination of tussocky and short acid grassland will support.

Overall, although the approach to maximising small mammals is very likely to provide more prey items, there are some disadvantages with this approach that makes its likelihood of success less certain. Therefore it is suggested that an approach that combines measures that would maximise small mammal abundance whilst maximising breeding bird numbers as well would be preferred.

The habitats and management measures proposed to deliver the combined approach is discussed in Section 5.

5. Proposed design layout and features of Marsh Harrier habitat

It was concluded in the previous section that an approach to habitat creation that combines measures to optimise small mammal abundance whilst also optimising breeding bird numbers, within the context of the habitat possibilities in the mitigation area, would be preferred.

The following sections detail the measures that it is proposed to implement. The indicative design focusses on providing:

- Extensive areas of tussocky grassland (for voles and other small mammals and also farmland birds such as meadow pipit and skylark) and short acid grassland (for rabbits) designed to include stepping-stone habitat to facilitate more rapid colonisation by rabbits in particular, from outside the mitigation area;
- Re-inforced hedges and establishment of scrub foci to provide enhanced habitat for rabbit warren creation and, as indicated above, include stepping-stone habitat to facilitate more rapid colonisation by rabbits in particular, from outside the mitigation area;
- Areas of wild bird seed cover and nectar-rich flower mixes (in the form of blocks or strips) will provide important food resources for farmland birds, especially in winter and early spring, and will maximise the production of small seeds suitable as bird food in either annual or annual/biennial mixtures, while also providing a source of invertebrates for birds.

This approach recognises that the grassland will maximise the number of small mammals and that it will support more breeding birds/ha than the very intensively managed arable land currently present, although potentially not as many as arable areas in low intensity cultivation and including a variety of measures of benefit to breeding birds as presented in Section 4.2. However, overall the number of potential marsh harrier prey items will be significantly increased compared to the current situation.

5.1 Proposed design

Tussock forming grassland

Extensive tussocky grassland is proposed, as indicated on Figure 5.1. The following measures would be undertaken to maximise the value of the grassland to foraging marsh harrier, by increasing the numbers of birds and mammals that use them.

- The grassland will be established during the first 12 months. This would comprise a range of grass species including tussock forming species such as tufted-hair grass (*Deschampsia cespitosa*), Yorkshire fog (*Holcus lanatus*), tall fescue (*Festuca arundinacea*), cock's-foot (*Dactylis glomerata*), false oat-grass (*Arrhenatherum elatius*) and Timothy (*Phleum pratense*), supplemented by flowering forbs such as yarrow (*Achillea millefolium*), common knapweed (*Centaurea nigra*), agrimony (*Agrimonia eupatoria*) and ribwort plantain (*Plantago lanceolata*).
- Typical grass seed application rates on the Sizewell estate have been low (ca 15-30kg/ha) to allow for natural colonisation of other species within the sward. However it is considered that for the mitigation area the sward needs to be established as rapidly as possible, albeit there is considered to be scope for variety and therefore a range of application rates are proposed, up to 50-60kg/ha.
- Without intervention the grassland would take 2-5 years to develop a tussocky structure. To increase the speed of sward development is it proposed to use a one-off application of fertiliser which will give the sward a boost of growth but which is not expected to adversely affect the sward diversity. Additionally, depending on the climatic conditions, irrigation could be used in the first summer of establishment to ensure rapid growth.

- The grassland should be sown to allow a minimum of 2 year's growth before it is required, to ensure that suitable small mammal populations have had an opportunity to establish.
- Regular cutting in the first 12–24 months may be needed to control annual weeds and encourage grasses to tiller. After this period the grassland will only be cut to control any woody growth, and no more than once every two years.
- Herbicides to spot-treat or weed-wipe will only be used for the control of injurious weeds (i.e. creeping and spear thistles, curled and broad-leaved docks or common ragwort) or invasive non-native species (e.g. Himalayan balsam, rhododendron or Japanese knotweed).

Acid grassland

Areas of acid grassland will provide suitable conditions for the formation of extensive rabbit warrens, with the young rabbits providing a valuable food source to marsh harriers, particularly during the breeding season. The following measures will be applied as follows:

- A short sward acid grassland mix will be sown. The species mix will include red fescue (*Festuca rubra*), sheep's fescue (*Festuca ovina*), fine-leaved sheep's fescue (*Festuca filiformis*), sweet vernal grass (*Anthoxanthum odoratum*), common bent (*Agrostis capillaris*) and wavy hair grass (*Deschampsia flexuousa*) and also forbs such as sheep's sorrel (*Rumex acetosella*) and dandelion (*Taraxacum officinale*).
- No fertiliser or manures will be applied, and herbicides will only be applied to spot-treat or weed-wipe for the control of injurious weeds (i.e. creeping and spear thistles, curled and broad-leaved docks or common ragwort); invasive non-native species (e.g. Himalayan balsam, rhododendron or Japanese knotweed); or bracken.
- Mowing of the grass should be undertaken, as appropriate, to ensure that it remains sufficiently short when rabbit numbers are low.

The latest techniques devised by the RSPB during their arable conversion work at Minsmere and elsewhere, will be applied to reduce the soil fertility as required.

Reinforced hedgerows and scrub foci

New hedges would not be planted but those present would be reinforced through placement of brash and log piles to provide instant habitat structure and encourage populations of small mammals in the short term as vegetation develops. These will rapidly add structure for small mammals and rabbits in hedgerow gaps and at appropriate points at the bases of existing hedges.

Additionally areas of scrub foci, formed through a combination of limited planting (e.g. bramble, hawthorn and blackthorn) and / or placement of brashings and logs, would be created extensively in areas of acid grassland to complement existing hedgerow habitats and also as stepping-stone habitats to facilitate rabbit colonisation from off-site. They could also be established in the areas of tussocky grassland.

The scrub foci will be located on slope areas if present, or localised areas of slope could be simply created. Additionally the ground will be disturbed / turned over immediately prior to placement of the brashings / logs to provide a soft substrate for rabbits to burrow in.

This reinforcement would not be a permanent feature, with future hedgerow treatment dependent upon the future landscape vision for the Sizewell estate.

Beetle banks

Beetle banks are ridges supporting tussocky grass, generally about 2m wide, which run from one side of a field to the other. Beetle banks are typically used in arable fields to provide habitat for use by ground-nesting birds, small mammals and insects. However they could be included in the mitigation area, in the tussocky grassland, as they would provide additional structure and habitat niches that would be used, as in arable land, by ground-nesting birds, small mammals and insects. They are not indicated on Figure 5.2 as they would be located within the areas of tussocky grass already shown.

The following measures would be undertaken to maximise their value to wildlife:

- An earth ridge between 2m and 4m wide and about 0.4m high will be created. This can be created by careful two-directional ploughing. Alternatively, bed-forming equipment can be used, if available (except on archaeological features).
- A same species mix and planting densities described for the tussocky grassland would be used.
- Herbicides to spot-treat or weed-wipe will only be used for the control of injurious weeds (i.e. creeping and spear thistles, curled and broad-leaved docks or common ragwort) or invasive non-native species (e.g. Himalayan balsam, rhododendron or Japanese knotweed).
- If needed, the grass will be cut several times during the first summer to help its establishment. Thereafter, it will only be cut as necessary to prevent the encroachment of woody and suckering species. To avoid causing soil compaction, cutting will not take place when the soul is wet.
- Fertiliser would only be applied once (as discussed above).

Wild bird seed cover and nectar flower mixes

Areas of wild bird seed cover (in the form of blocks or strips) will provide important food resources for farmland birds, especially in winter and early spring, and will maximise the production of small seeds suitable as bird food in either annual or annual/biennial mixtures, while also providing a source of invertebrates for birds. Wild bird/game cover and the nectar rich flower options are will be planted in fixed locations although the actual seed mixes can be amended annually.

The following measures would be undertaken to maximise their value to wildlife:

- Any areas of soil compaction will be removed prior to establishment, except on archaeological features.
- The wild bird cover will be sown in blocks and/or strips (along contours where possible and at least 6 m wide and between 0.4ha and 3ha in size) at the edges of fields. The strips or blocks will be well distributed across the mitigation area.
- A balanced combination of at least three small-seed bearing crops (chosen from barley, triticale, quinoa, linseed, millet, mustard, fodder radish and sunflower) will be sown. No single species will make up more than 70% by weight of the mix and the combination must cover a range of crop groups to minimise any pest and disease impacts. Large-seeded crops (maize) and game covers (giant sorghum or sweet clover) will not be sown.
- The crop mixture will be retained until at least 1 March before re-establishment in spring, which could be annually or every other year (biennial crops), to maintain sufficient seed production to feed birds during the late autumn/early winter.
- In the first year, the seed mix will be sown at the optimum time for the chosen species mixture, which may be autumn or spring.
- The blocks/strips of wild bird seed cover will be rotated with nectar flower mixtures.
- Herbicides will only be used to spot-treat or weed-wipe for the control of injurious weeds (i.e. creeping and spear thistles, curled and broad-leaved docks or common ragwort) or invasive non-native species (e.g. Himalayan balsam, rhododendron or Japanese knotweed). Non-residual, non-selective herbicides may be used prior to sowing to help re-establishment.
- Insecticides (and only environmentally sympathetic ones) will only be applied during establishment where there is a strong risk of failure due to a severe pest attack.

Blocks or strips of sown nectar-rich plant species will be sown to increase the invertebrate food source to birds during the breeding season. Specific management will be applied to these areas, as follows:

- A mixture of at least four nectar-rich plant species (e.g. red clover, alsike clover, bird's-foot-trefoil, sainfoin, musk mallow and common knapweed) will be sown, with no single species making up more than 50% of the mix by weight.
- The blocks and/or strips will be least 6 m wide, and sown in early spring or late summer.
- Regular cutting and removal of cuttings may need to be undertaken in the first 12 months after sowing to ensure successful establishment of sown species.
- The mix will be re-established as necessary, to maintain a sustained nectar supply, typically after three years.

5.2 Extent and distribution of the optimised habitats proposed

An indicative distribution of the measures discussed above in an optimised scheme is provided in Figure 5.1 with the areas detailed in Table 5.1.

Table 5.1 Extent of each habitat represented on Figure 5.1

Habitat	Approximate Habitat Area (ha)
Tussocky grassland / Grassy buffer strips	29.1
Beetle bank (tussocky grassland)	0.2
Short acid grassland	9
Wild bird seed cover	6
Existing wetland	0.7
Nectar rich flower mix	2
Total	47

The optimised scheme comprises measures that are of benefit to both small mammals and also breeding birds, through provision of breeding habitats and also food sources throughout the year.

The mitigation area will primarily be tussocky and acid grassland, with the acid grassland and the associated scrub foci distribution designed to provide stepping-stone habitat to facilitate more rapid colonisation by rabbits from outside the mitigation area. The wild bird seed cover and nectar rich flower mixes are distributed widely to provide food sources for birds, mammals and invertebrates across the site.

It is considered that the proposed approach will lead to significant elevated marsh harrier prey items (small mammals and breeding birds) being present in the area when the habitats are established and that this will draw marsh harriers to forage over the mitigation area.

6. Summary

Marsh harrier is an interest feature of the Minsmere - Walberswick Special Protection Area (SPA) during the breeding season. The harriers breed exclusively in reedbed habitat located to the north of the New Cut but they are known to forage widely for food over the Minsmere South Level and also the EDF Energy estate, including Sizewell Marshes Site of Special Scientific Interest (SSSI).

Activities associated with the construction of Sizewell C are not predicted to affect the breeding sites north of the New Cut but have the potential to result in the temporary displacement of marsh harriers from the foraging areas to the south of the New Cut.

The extent to which disturbance-related temporary displacement will occur is the subject of another study. However EDF Energy has recognised that there will be a need to mitigate for this during construction of the power station; a period that could extent to 10 years.

The proposed approach to the mitigation is to undertake habitat creation and targeted land management activities on 47ha of arable farmland, to enhance habitat so that it supports abundant prey species for marsh harriers.

Though no specific study has been undertaken into the prey species of marsh harrier taken at Minsmere, the adults and/or young of the following species are likely to form an important part (this list is not exhaustive):

- Wetland habitats: wildfowl (e.g. mallard) and passerines (e.g. reed bunting).
- Lowland grassland: scrub, tussocky neutral and acid grassland: meadow pipit, linnet, field vole and rabbit.
- Arable: pheasant, red-legged partridge, lapwing, skylark, linnet, rabbit and brown rat.

The mitigation area is currently under intensive arable production and is considered to be of low value to marsh harriers. The key to a successful scheme will be to provide habitats and management prescriptions that maximise the populations of marsh harrier prey species during the marsh harrier breeding period (April to July). To achieve this requires consideration of:

- Habitat composition and structure;
- Speed of habitat establishment;
- Population dynamics of the potential prey items; and
- Support to species during the non-breeding period.

Based on a review of the available data on the ground levels, the underlying geology and ground and surface water regimes in and around the mitigation area, it is concluded that it would not be feasible to create wetland across the majority of the mitigation area. Therefore the options for the mitigation area need to focus on alternative non-wetland foraging habitats that published data has demonstrated are also extensively used for foraging by marsh harriers.

Recognising the opportunistic nature of marsh harriers, which is likely to mean that the harrier diets' reported may in part reflect the relative abundance of prey items in the foraging areas. Therefore options considered have ranged from maximising small mammal abundance across the mitigation area, to maximising the breeding small farmland bird population at the other end of the scale.

The approach to maximising breeding farmland birds has proposed adopting a number of measures proven through the ELS and HLS schemes to benefit both breeding and wintering birds in arable landscapes whilst providing habitat structure that does not prevent marsh harrier foraging activity. It is important to note that the measures would be implemented solely for the purpose of maximising breeding bird (and small mammal) numbers. There would be no requirement for a financial return from the crops.

The approach to maximising small mammal numbers would focus on provision of a combination of tussocky grassland and short acid grassland with hedge and scrub foci for the benefit voles and rabbits.

Although it is concluded that the approach to maximising small mammals is likely to provide more prey items than the approach to maximising breeding farmland birds, the latter may more reliably provide increased prey abundance and there are some potentially significant disadvantages with the mammal focussed approach that makes its likelihood of success less certain. Therefore it has been proposed that an approach that combines measures that would maximise small mammal abundance whilst also maximising breeding bird numbers as well would be preferred.

The optimised scheme primarily comprises provision of tussocky and acid grassland, with the acid grassland and the associated scrub foci distribution designed to provide stepping-stone habitat to facilitate more rapid colonisation by rabbits from outside the mitigation area. Areas of wild bird seed cover and nectar rich flower mixes are also provided and distributed widely to provide food sources for birds, mammals and invertebrates across the site.

It is considered that the proposed approach will lead to significant elevated marsh harrier prey items (small mammals and breeding birds) being present in the area when the habitats are established and that this will draw marsh harriers to forage over the mitigation area. The use of measures that benefit both mammals and birds allows a degree of flexibility in the event that small mammal or breeding bird numbers do not increase to the extent expected or that monitoring indicates that one type of prey is favoured by harriers over the other sufficiently to consider alteration to the scheme.

Figures

INTERNAL BUSINESS COLLABORATOR REFERENCE
NOT APPLICABLE FOR ALL FIGURES

NOTES:

KEY

- SITE BOUNDARY
- MONITORING BOREHOLE
- INVESTIGATION BOREHOLE
- EA BOREHOLE

TOPOGRAPHY (m)

-1 - 0.5	6.1 - 7
0.6 - 1	7.1 - 8
1.1 - 2	8.1 - 9
2.1 - 3	9.1 - 10
3.1 - 4	10.1 - 15
4.1 - 5	15.1 - 20
5.1 - 6	20.1 - 25.1

REVISION	DATE	DRAWN	CHECKED	REASONS FOR REVISION/COMMENTS	APPROVED

DOCUMENT:

SIZEWELL
MARSH HARRIER HABITAT

DRAWING TITLE:

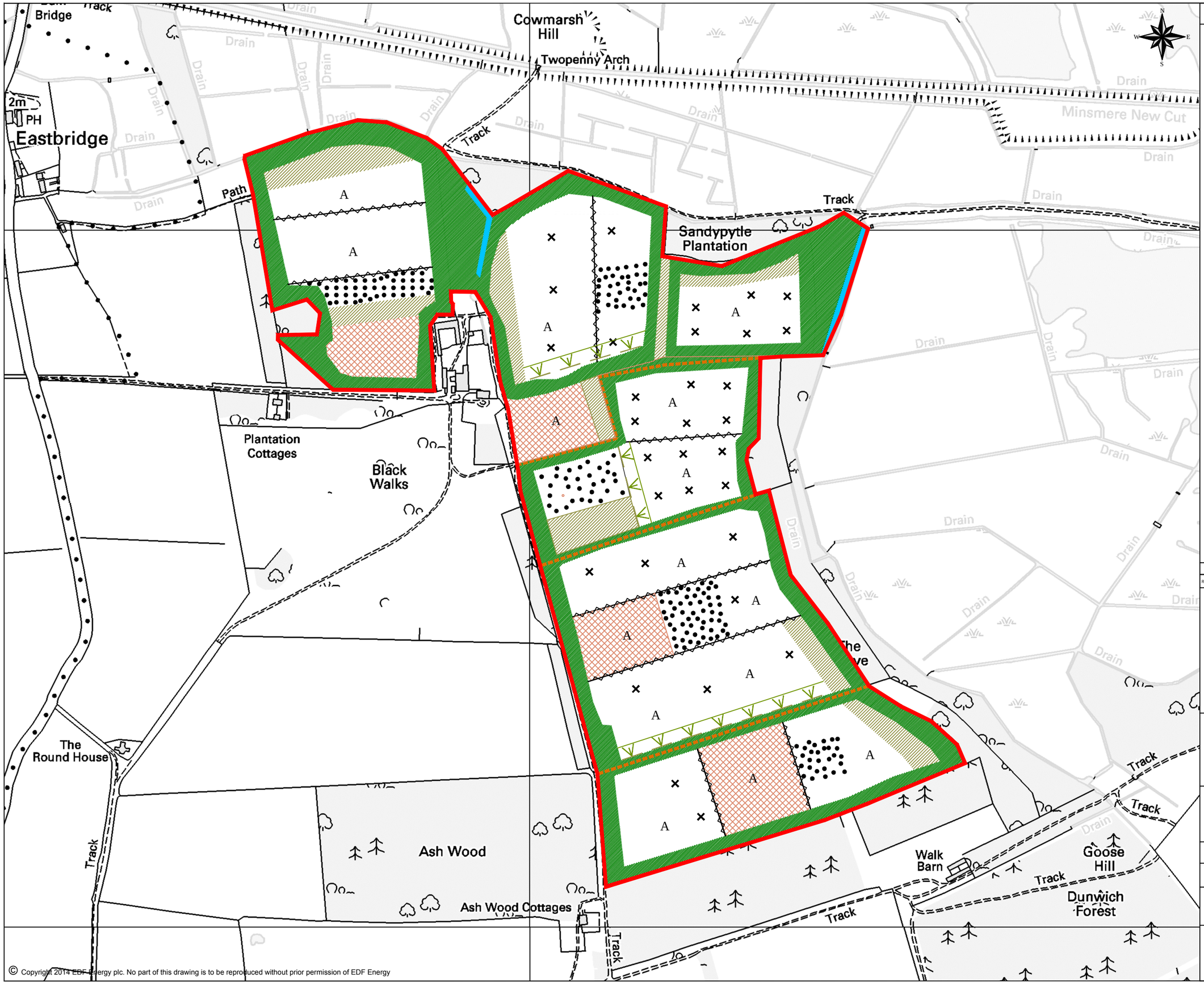
SITE INFORMATION

DRAWING NO: FIGURE 3.1
REVISION: 1.0
DATE: OCT 2015
DRAWN: S.W.
SCALE: 1:10000 @A3

SCALE BAR
0 0.1 0.2 0.3 0.4 0.5 KM

DRAWING SECURITY CLASSIFICATION:

☐ PROTECTIVE MARKING REQUIRED
☒ NOT PROTECTIVELY MARKED



INTERNAL BUSINESS COLLABORATOR REFERENCE
NOT APPLICABLE FOR ALL FIGURES

NOTES:

KEY

- MITIGATION AREA BOUNDARY
- NECTAR RICH FLOWER MIX
- WILDBIRD PLANTING
- SKYLARK PLOTS
- BARE GROUND
- A ARABLE
- EXISTING WETLAND
- STUBBLE
- TUSSOCKY GRASSLAND
- REINFORCED HEDGES
- BEETLE BANK

REVISION	DATE	DRAWN	CHECKED	REASONS FOR REVISION/COMMENTS	APPROVED

DOCUMENT:
SIZEWELL
MARSH HARRIER HABITAT

DRAWING TITLE:
MAXIMISED FOR BREEDING BIRDS (INDICATIVE)

DRAWING NO: FIGURE 4.1
REVISION: 1.0
DATE: JULY 2015
DRAWN: J.P.
SCALE: 1:5000@A3

SCALE BAR
0 m — 250 m

DRAWING SECURITY CLASSIFICATION:
☐ PROTECTIVE MARKING REQUIRED
☒ NOT PROTECTIVELY MARKED

37035-Sht01a.dwg

INTERNAL BUSINESS COLLABORATOR REFERENCE
NOT APPLICABLE FOR ALL FIGURES

NOTES:

KEY

- MITIGATION AREA BOUNDARY
- SCRUB PLANTING/PLACEMENT OF BRASHINGS, LOGS
- EXISTING WETLAND
- ACID GRASSLAND
- TUSSOCKY GRASSLAND
- REINFORCED HEDGES

REVISION	DATE	DRAWN	CHECKED	REASONS FOR REVISION/COMMENTS	APPROVED

DOCUMENT:

SIZEWELL
MARSH HARRIER HABITAT

DRAWING TITLE:

MAXIMISED FOR SMALL MAMMALS (INDICATIVE)

DRAWING NO: FIGURE 4.2
REVISION: 1.0

DATE: OCT 2015
DRAWN: J.P.
SCALE: 1:5000@A3

SCALE BAR
0 m — 250 m

DRAWING SECURITY CLASSIFICATION:

☐ PROTECTIVE MARKING REQUIRED
☒ NOT PROTECTIVELY MARKED

Bridge
Track
Cowmarsh Hill
Twopenny Arch
Drain
2m
PH
Eastbridge
Minsmere New Cut
Path
Track
Sandypytle Plantation
Plantation Cottages
Black Walks
The Round House
Track
Ash Wood
Ash Wood Cottages
Track
Walk Barn
Goose Hill
Dunwich Forest
Track
Track
Track
N
W
E
S

INTERNAL BUSINESS COLLABORATOR REFERENCE
NOT APPLICABLE FOR ALL FIGURES

NOTES:

KEY

- MITIGATION AREA BOUNDARY
- SCRUB PLANTING/PLACEMENT OF BRASHINGS, LOGS
- NECTAR RICH FLOWER MIX
- WILDBIRD PLANTING
- EXISTING WETLAND
- ACID GRASSLAND
- TUSSOCKY GRASSLAND
- REINFORCED HEDGES

REVISION	DATE	DRAWN	CHECKED	REASONS FOR REVISION/COMMENTS	APPROVED

DOCUMENT:

SIZEWELL
MARSH HARRIER HABITAT

DRAWING TITLE:

OPTIMISED FOR SMALL MAMMALS AND BREEDING BIRDS (INDICATIVE)

DRAWING NO: FIGURE 5.1
REVISION: 1.0
DATE: OCT 2015
DRAWN: J.P.
SCALE: 1:5000@A3

SCALE BAR
0 m — 250 m

DRAWING SECURITY CLASSIFICATION:

☐ PROTECTIVE MARKING REQUIRED
☒ NOT PROTECTIVELY MARKED

37035-Sht02b.dwg

Appendix A
Marsh Harrier foraging habitat creation (Hyder, 2015)

NNB Genco

Sizewell C

Marsh Harrier Foraging Habitat Creation

Design Brief and Specification

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NNB Genco

Sizewell C

Marsh Harrier Foraging Habitat Creation

Design Brief and Specification

Author	Mark Lang
Checker	Jon Davies
Approver	Jon Davies
Report No	UA004506-S-EX120
Date	16 February 2015

CONTENTS

1 Introduction

The proposed construction of Sizewell C has the potential to affect marsh harriers by displacing them from areas of habitat that they currently use for foraging. In order to mitigate for this potential effect, it is proposed to undertake habitat creation and land management activities on existing arable farmland, to enhance habitat so that it supports abundant prey species for marsh harriers. The objective being to maximise the contribution that this mitigation package would deliver for marsh harriers, should marsh harriers be displaced from other areas of habitat.

This document sets out an overall vision for what the enhanced foraging habitat could comprise, and details the tasks required to complete a feasibility study of the proposals.

2 Setting an overall vison

The overall objective for the scheme is to provide an abundant supply of prey species for breeding marsh harrier in close proximity to their nesting location, during the period April to August, to ensure that breeding marsh harrier have access to sufficient prey for raising young.

Whilst marsh harriers are an interest feature of the Minsmere to Walberswick Special Protection Area (SPA), only during the breeding season, they are present all year round. Therefore, secondary objectives would be to:

- Provide enhanced foraging during the winter months.
- Not to conflict with the long-term landscape vision for the EDF Sizewell estate (see Section 3)

Hardy et al (2006) provides a summary of the marsh harrier breeding cycle as follows:

Breeding activity	**Peak period**
Courtship	Late March to early April
Egg laying	Late April to mid-May
Incubation	Late May to mid-June
Hatching	Late May to late June
Young in nest	Late May to late July
Fledging	Late June to late July
Juvenile dispersal	August to September

Marsh harriers breed within the reed bed at Minsmere and have been shown to use the Minsmere South Levels and Sizewell Marshes for foraging. Both these areas support a mosaic of wet grassland, open water ditches, and areas of taller emergent vegetation such as dense Common Reed (*Phragmites australis*) for foraging. Both the Minsmere South Levels and Sizewell Marshes may be subject to disturbance from construction activities, potentially displacing marsh harriers from foraging.

The home range of breeding marsh harrier can vary greatly, for example Carador (2009) found that male home ranges varied from 14ha to 7812ha, Takacsova (2007) recorded minimum home ranges of 37ha for male harriers and 22ha for female. Underhill-day (1990) recorded males hunting up to 7km from the nest site, whilst Wikowski recorded forging distances of 3.5km and 6km from the nest site. Although harriers can forage widely, they are more likely to make use of habitat in close proximity to the nesting location, Takacsova (2007) noted that during the breeding season the hunting area was reduced and the harriers took advantage of local abundances in prey items, such as small mammals more easily caught.

A study by Underhill – Day (1985) investigated the diet of marsh harriers in East Anglia during the summers of 1983-1984; this concluded that young birds, young game birds (e.g. pheasants) and small mammals made up the majority of marsh harrier prey items. Carador (2014) found that marsh harrier foraging in traditional farmland had a diet of 60% small mammals and 35-40% birds, whilst in intensive farmland the diet was 80% small mammals and 15-20% birds. Therefore, the proposed habitat creation should aim to increase the abundance of small mammals and young birds during the marsh harrier breeding period (April to July).

There is a large body of evidence (see Appendix 2) showing that the provision of wide grass margins around arable fields, and the provision of game/bird cover and seed crops can significantly boost the populations of small mammals and farmland bird species.

Marsh harriers are regarded as a wetland species, and the majority of foraging activity takes place over wetland habitat (e.g. wet grassland, reed bed, wet ditches). This is certainly the case at Sizewell where the majority of flight activity (used as a measure of foraging activity) has been observed over such wetland habitats. However, a body of evidence from the UK and Europe (see Appendix 1 for more details) suggests that marsh harriers are adaptable, and will make use of additional types of habitat for foraging; including arable farmland, providing that prey availability is not compromised. Some studies even suggest that marsh harrier foraging success can be greater in non-wetland areas than within wetland habitat. Cardador (2011) found that the recovery of marsh harrier populations in Spain has been noticeable in farmland habitats, even in areas dominated by intensified crops, whilst Luo et al (2010) found marsh harrier's abundant hunting over grassland habitats. Takacsova (2007) studied marsh harriers in an area composed of cereal cropping and some areas of reed bed. Although reedbed was the most favoured foraging habitat (particularly for females) arable cropping was also used extensively. See Appendix 1 for more details).

Further information on the foraging range, habitat preferences and the composition of marsh harrier diet is provided in Appendix 1, whilst further information on arable margins and wild bird/game cover and seed cropping are outlined in Appendix 2.

2.1 Scheme components

It is envisaged that the scheme would comprise four distinct core elements, which would be provided as an integrated package of marsh harrier mitigation, as follows:

- Creation of shallow scrapes supporting open water and aquatic and emergent vegetation to provide suitable nesting habitat for water birds such as moorhen and mallard, whilst also providing habitat structure that persists during the winter months.

- Creation of lowland heath, scrub and acid grassland, to enhance populations of farmland birds and small mammals and provide habitat structure that persists into the winter months.

- Creation of rough tussocky arable grass margins to increase the population of voles and other small mammals, and the sowing of game cover and seed crops to boost populations of farmland birds.

- Creation of larger areas of tussock-forming grassland supporting plant species typical of coastal floodplain in Suffolk.

In addition to the core elements above, it is also proposed to alter the management of Lower Abbey Marsh to allow existing wetland vegetation and rough grassland to increase in extent. Whilst this will only be a modest contribution, it will increase the area of wetland habitat available for foraging harriers.

Figure 1 identifies the area identified for creation of marsh harrier foraging habitat in relation to the Sizewell C Main Construction Site, whilst Figure 2 presents an indicative scheme drawing of the various core elements together.

3 Integration with long term landscape vision for the EDF Sizewell Estate

The long-term landscape aspirations for the EDF Sizewell Estate, following the completion of the construction of the C Station, are to restore the landscape to habitats characteristic of the Suffolk Sandlings, namely acid grassland and lowland heath. The objectives for the creation of marsh harrier foraging habitat should not prejudice these long term aspirations.

4 Design objectives to conceptualise vision

This section presents some design objectives for each element of the scheme to aid the studies required to fully develop and conceptualise the proposed mitigation.

4.1 Creation of open water and shallow scrapes

This habitat is proposed at Sandypytle (Note 4 on Figure 2), as this is a relatively low lying field, and there is a natural depression within the landform of the field. The following objectives would be considered in this area:

- Potential creation of a series of naturalistic shallow scrapes within Sandypytle to allow natural retention of shallow water to a maximum depth of 50cm during the winter (October to March). Consideration should be given to what could be achieved without triggering a planning application.

- If possible, allow surface water (up to 30-40cm in depth) to persist during the spring to early summer period (April to late June) to provide suitable breeding conditions for wildfowl.

- Scrapes should involve the minimum of earth movement but aim to create as large an area of surface water retention as possible within the existing landform.

- How best to use the existing surface water abstraction and associated infrastructure to supplement the retention of surface water.

- Establish tall (50cm in height and greater) emergent vegetation on the edge of the open water comprising species such as Common Reed, Reed Canary Grass, Soft Rush and large sedge species.

- Allow aquatic vegetation to establish within the open water to provide seed and other food sources for wildfowl species such as moorhen and mallard.

- Undertake works to facilitate the expansion of Common Reed growing on the eastern boundary into a larger area of the field.

- Creation of shallow scrapes and establishment of wetland vegetation should occur at least two years in advance of construction works, to allow vegetation to establish sufficiently to support small mammals and wildfowl. Therefore works should be planned to commence in 2016.

- Design of scrapes should allow them to persist for up to 10 years, this being the predicted length of the construction programme. At the end of the construction period, the design of scrapes should allow easy conversion of the field to lowland heath and acid grassland.

4.2 Creation of lowland heath

The landform at Dovehill lends itself more to the creation of acid grassland and heathland mosaic, whilst Great Mount Walks lends itself to the creation of acid grassland (See Note 3 and 6 respectively on Figure 2). The objectives for these two areas would be as follows:

- Create a mosaic of lowland heath, scrub and short sward acid grassland within Dovehill.

- Sow short sward acid grassland mix.

- Spread heather brashings of local (Suffolk) provenance in suitable locations to encourage heather establishment as well as plant and invertebrate species indicative of Suffolk Sandlings heath.

- Create short sward acid grassland in Great Mount Walks.

- Provide log and brash piles to encourage populations of small mammals in the short term as vegetation develops.

- Allow development of small areas (less than 0.5ha) of bare ground to encourage development of a diverse assemblage of arable weeds and invertebrate species.

- Creation of lowland heath is a long-term process and should begin as early as is practicable to enable the establishment of vegetation and development of a good habitat structure of benefit to nesting birds and small mammals.

- Management of scrub and heath will be required to maximise the populations of breeding farmland bird species that are present.

4.3 Creation of grass margins and sowing bird cover and seed crops

Note 5 on figure 2 illustrates the proposed creation of arable crops, bare ground and rough grass margins, the objectives for which would be as follows:

- Create wide (20-30m) grass margins around all the arable fields to create dense tussocky grassland suitable to support populations of voles and other small mammals. (see appendix 2).

- The sowing of the grass margins should be timed to allow a minimum of 2 year's growth before they are required, to ensure that suitable small mammal populations have developed.

- Grass margins to be managed on a suitable rotation to maximise populations of farmland birds, voles, rabbits and other small mammals.

- Sow bird/game cover and bird seed crops to create a mosaic of 2-3 crop types within each arable field, aiming to provide a food source for a wide diversity of farmland and /or game birds (for example young pheasant) during the period April to July.

- Choice of cropping should aim to maximise populations of farmland and game birds (see appendix 2).

- Crops chosen should also aim to provide a food source for small mammal populations during the period April to July ((see appendix 2)..

- The sowing of the cropping should be timed to begin at least a year in advance of when it will be required, so that local farmland bird populations have had the chance to increase before the mitigation is required.

- Incorporate areas of bare ground up to 1ha in extent to benefit ground-nesting bird species such as skylark and lapwing, as well as providing conditions suitable for arable weeds to develop, as a source of seeds and invertebrates for farmland birds.

- Manage arable cropping to ensure some seeds and other food sources are available to encourage retention of farmland birds during the winter period.

4.4 Creation of tussock coastal floodplain grassland

In the remaining habitats, tussocky coastal floodplain grassland would be created, as follows

- Allow development of larger areas of tussock grassland (Notes 1, 2 and 4 on Figure 2) supporting grass and other plant species indicative of Suffolk Coastal Floodplain Grassland.

- Manage grassland to maximise populations of small mammals and wildfowl.

- Establishment of coastal floodplain grassland should be timed to allow at least 2 growing seasons before it will be required to allow for sufficient vegetation establishment.

5 Further steps required

This section outlines the further studies required to complete the conceptualisation of the vision.

5.1 Creation of open water and shallow scrapes

A number of studies will be required to inform the extent of open water and scrape creation that is feasible, these are listed below:

- Liaise with the Archaeology and Cultural Heritage lead to establish what constraint (if any) Cultural Heritage may pose, for example by limiting the depth to which the scrapes can be excavated.

- Liaise with EDF over any permissions and licencing that may be required, for example consent for works adjacent to an existing Site of Special Scientific Interest (SSSI).

- Conduct a hydrological study to examine the feasibility of maintaining water levels in a scrape within Sandypytle field.

- Review of the main river abstraction consent held by EDF which could be used to artificially maintain water levels within a scrape during the critical period (April to late June). Review equipment and infrastructure required to maintain water levels using pumped abstraction.

- Review field drainage records (if any) to ascertain if drains could be modified to aid the retention of surface water.

- Produce a design and specification for scape construction taking into account the factors identified above.

- Produce a specification for the establishment of emergent vegetation around the margins of the scrapes.

- Produce a specification for the sowing and establishment of coastal flood plain grassland.

5.2 Creation of lowland heath and acid grassland

- Review the lowland heath creation carried out elsewhere within the EDF estate and produces a specification for the sowing and establishment of acid grassland and lowland heath on Dove Hill field.

- Produce a habitat creation plan outlining where to establish the componemnts of heath creation (Scrub, acid grassland and heather heath) within Dove Hill Field, and acid grassland at Great Mount Walks.

- Produce a long-term (10 years) management plan to aid the establishment of lowland heath and acid grassland, using the Ecology and Landscape Management Plan produced for Aldhurst farm as a template for what is required.

5.3 Creation of grass margins and sowing bird cover and seed crops

- Review the existing higher level stewardship provisions for the arable land where habitat creation is proposed and what the implications are for the habitat creation proposals.

- Review the options available for sowing game/wild bird cover and seed crops and identify the mix of cropping that will support the highest density of farmland birds. (see appendix 2).

- Produce a sowing and establishment specification for the creation of game/wild bird cover and seed cropping. This should include a crop rotation plan for the duration of the period the mitigation is required. (see appendix 2).

- Produce a sowing and establishment specification for the creation of tussocky grass margins to the arable fields. This should include a management rotation to maintain conditions suitable for the voles and other small mammals.

Produce a sowing and establishment specification for the creation of tussock coastal floodplain grassland.

6 References

Jon Hardey et al (2006) Raptors: A field guide to survey and monitoring. Published by Scottish Natural Heritage 2006.

J. C. Underhill-Day (2009). The food of breeding Marsh Harriers *Circus aeruginosus* in East Anglia. RSPB, The Lodge , Sandy, Bedfordshire, SG19 2DL Published online: 24 Jun 2009.

Figures

Figure 1 identifies the area identified for creation of marsh harrier foraging habitat in relation to the Sizewell C Main Construction Site

Figure 2 presents an indicative scheme drawing of the various core elements together.

Appendices

Appendix 1

Marsh harrier home range, habitat preferences and diet

This literature review is intended to provide evidence that the proposed habitat creation measures will be of benefit to foraging marsh harriers during the breeding season, by a combination of:

- Being in close proximity to their breeding location
- Being within the typical home range of foraging marsh harriers
- Evidence that marsh harriers will forage over arable habitat
- Evidence that the measures outlined will boost prey species that have been found within the diet of marsh harriers

Home Range Size and Foraging Range

Reference	Key Points
(Witkowski, 1989).	• Home range consisted of 160 ha, 125 ha of which was meadow, pasture and crop fields and 35 ha of pond surface area. • Two males were able to be radio-tracked with one males hunting territory located at 3.5km from the nest for 2 successive years and the other was 6km from the nest
Cardador (2009)	• Study took place in an agricultural area of the Ebro basin in Spain where the population has risen from 8 pairs in 1997 to 53 pairs in 2008. The study site consists of arable, non-irrigated cereal crops, irrigated fields, dry fruit trees and irrigated fruit trees. • Found that male home ranges varied from only 14ha to 7812ha.
Altenberg et al 1981	• 3 males were tracked, with home ranges being between 310ha to 2610 ha, depending on the nesting period
Schipper 1977, Thiollay 1970)	• Studies found a home range between 250-500ha
Sternalski, 2008	• Dispersal home ranges for juvenile birds. From 1378 ha for males and 1318 ha for females. The dispersal distance from the nest was an average of 2.1km for males and 0.85km for females
(Underhill-Day, 1990)	• In East Anglia, the home range of males varied with the stage of the breeding cycle from 569 ha during courtship to 1,407 ha during the post-fledging period (Underhill-Day, 1990). Males may hunt up to 7 km from their nesting territory. Females have smaller home ranges, but these increase in size when they start to feed young (from 100–1,300 ha).
S and J Moynes Tay R.G Report 1998 – 2000	• Males have been observed hunting up to 9km from the nest. • Where the Tay is 4km wide this appears to be sufficient to discourage harriers from crossing, they will cross where Tay is only 1-2 km wide.
Melinda Takacsova (2007).	• Minimal foraging range of the female was 22 hectares and the male's 37 hectares in the year of 2003 but in 2004 it was larger (♀32 ha, ♂42 ha) and in 2005 (♀ 44 ha, ♂ 68 ha).

Marsh harrier habitat usage

Reference	Key Points
Witkowski, 1989	• Home range consisted of 160 ha, 125 ha of which was meadow, pasture and crop fields and 35 ha of pond surface area. • Males predominantly hunted on terrestrial habitats, females in aquatic habitats.
Cardador 2011	• Marsh harriers in Spain had suffered a dramatic decline between 1960 and 1980 and since then there has been a moderate population increase of approximately 10%. The recovery of this species has been very noticeable in farmland habitat, even in areas dominated by intensified crops. • Study took place in an agricultural area of the Ebro basin where the population has risen from 8 pairs in 1997 to 53 pairs in 2008. The study site consists of arable, non-irrigated cereal crops, irrigated fields, dry fruit trees and irrigated fruit trees. A total of 617 wetlands have been described over the study area, with 92% are artificial ponds and reservoirs related to agricultural irrigation. • The results indicate that the raptors using the habitat for breeding and hunting in the adjacent farmland can take advantage of agricultural intensification, providing food availability is not compromised. • Marsh harriers react positively to some degree of intensification, and could potentially be described as a winning species in a world of change.
Luo et al, 2010	• Harriers were most abundant hunting in grassland habitats over any other habitat. The harriers were mostly found over high quality grassland with low levels of grazing and no trampling. • This was where most of the harrier's main prey was located (in this study area the harriers main prey were passerine birds and pheasants).
Cardador 2014	• Found that the diet of marsh harriers in this region varied dependent on the type of farming, with harriers foraging on traditional farmland having a diet of approx. 60% small mammals and 35-40% birds and harriers • Foraging in intensive farmland having a diet consisting of approx. 80% small mammals and 15-20% birds.
Men'shikova, S. V. (2005)	• Marsh harriers forage on wetland habitat predominantly in April and move away from these habitats as the year goes on. • After fledging the juveniles hunted almost exclusively in stubble fields for 10-14 days after fledging. • For both males and females the use of wetland was highest in April (approx. 65% for males and 100% for females) and this significantly dropped as the breeding season progressed (less than 20% of use by males for period May-Aug and less than 20% for females from Jun-Sept). • Male marsh harriers spent the most time hunting in (approx. 50% from Jun to Aug) and females preferentially hunted in pastures (between 30%-60% Jul-Sep). • Young harriers spent less than 15% of their time hunting in wetland habitat within the first 30 days of fledging, spending approx. 60% of the time hunting within hayfields. • Hunting success of marsh harriers in wetland habitats was small, only

Reference	Key Points
	approx. 18% of hunts were successful, whereas in hayfields, pastures and abandoned field this figure was over 50%. • Overall, marsh harriers spent only 13.5% of their time hunting in natural wetland habitats, compared to 50.1% in hayfields, 16.1% in pastures and 19.4% in abandoned farmland.
Underhill-Day, 1990	• In 1983 only 10% of nests were located in crops whereas by 1995 nearly 20% of nests were located in crops. • In 1983 only 11% of nests were located in crops, ditches or small remnant reed beds in predominantly arable areas, increasing to 55% of nests in 1995. • Data shows that crop nesting marsh harriers are as successful as those harriers nesting in reed beds.
S and J Moynes Tay R.G Report 1998 – 2000	• Much of the habitat within the Tay nesting territories is arable with improved grassland. • Ground north of A90 supports grassland and scrub and therefore more value to foraging harriers. • Reedbed also provide a large proportion of prey, in particular along the edge where water rail broods forage.
Melinda Takacsova (2007).	**Key Headlines** • Studied area was characterized by agricultural crops with an area of 132 hectares and 5 hectares area of the marshland. This bird of prey mainly uses treeless dry – cereal croplands (wheat, rye), agricultural products such as sugar beet, sunflower, shamrock, maize and the area of marshland (reed, bat). • They completely avoided forests. **Detailed habitat Usage analysis** **2003** • the females were located at 7 types of habitats (maize, sugar beet, colza, Wheat, shamrock, rye and marsh). The most preferred agricultural crops were marsh (39 %), maize (21 %), rye (14%) and wheat (14%). • They mostly hunted mainly over reed – beds. Báldi & Kisbenedek (1998) showed marshes such as the most important biotope determining their occurrence. Uttendörfer (1952) described the most preference hunting area of the females was marsh and of the males were marsh and agricultural fields - this results confirmed Pinowski & Ryszkowski (1961) too. • Males were observed at 8 types of habitats (maize, rye, sunflower, shamrock, sugar beet,colza, wheat and marsh). They preferred low crop of stature as maize (22 %), rye (17 %), marsh (15 %) and wheat (11 %). Probably the reason why they preferred this crop was the abundance of small mammals (voles). **2004** • the females were located at 7 types of habitats (marsh, sugar beet, rye, Shamrock, maize, wheat and sunflower). Females were recognized in the following breeding habitats which were marsh (29 %), shamrock (22 %) – broad occurrence of voles, rye (15 %) and sugar beet (11 %). Their appearance was not seen in colza. • Males were observed at 8 types of habitats (marsh, sugar beet, rye, shamrock, maize, wheat, sunflower and colza). • Males preferred mostly marsh (20 %), wheat (17 %), sugar beet (16 %) and

Reference	Key Points
	shamrock (12 %) • The males brought food to the female during incubation and hunted mostly in shamrock. **2005** • Females were seen at 8 types of habitats (colza, sunflower, maize, shamrock, rye, wheat, sugar beet and marsh). The observation showed preference of habitat such as marsh (32 %), sugar beet (15 %), shamrock (14 %) and rye (12 %). • Females were observed only twice in sunflower. They completely avoided forests and tree groups. • Females concentrated during hunting vicinity of marsh and water surface. • Males were observed at 8 types of habitats (marsh, shamrock, sugar beet, rye, maize, wheat, sunflower and colza). Males preferred shamrock (21 %), marsh (19 %), maize (16 %) and wheat (13 %). • During the breeding season their hunting area were reduced and they took advantage of local abundances. At that time they concentrated on small mammals which were easily caught.

Marsh harrier diet

Reference	Key Points
Brezinski, 2007	• Three nests studied for diet of nestlings, across all three nest 56% of prey items consisted of microtus voles. In total 73& of food items delivered to the nest were mammals, but only totalled 23% of the total biomass consumed. • A total of 23% of the food items delivered to the nestlings were birds, but this consisted of over 74% of the biomass consumed.
Underhill-Day, 1985	• Looked at the prey of marsh harriers in East Anglia over the summers of 1983-84 using three different methods: pellet analysis, analysing prey remains and sightings of prey carried by birds. A table summarising the findings is located below:

Reference	Key Points

	June	*July*	*August*
Pellets			
Small birds	27.5	44.9	31.8
Young gamebirds-waterbirds	30.3	31.4	31.8
Mammals	35.8	19.6	29.6
Other	6.4	4.1	6.8
Total prey items	109	194	88
	Mcy/June	*July*	*August*
Prey remains			
Small birds	22.3	32.9	26.4
Young gamebirds-waterbirds	20.2	40.9	43.4
Mammals	42.6	18.8	17.0
Other	14.9	7.4	13.2
Total prey items	94	149	53
	April/ May	*June*	*July/ August*
Sightings			
Small birds	11.7	2.8	6.7
Young gamebirds-waterbirds	9.2	12.9	16.2
Mammals	26.5	6.6	3.9
Other and unidentified	52.6	77.7	73.2
Total prey items	196	457	414

Detailed list of prey items given:

Reference	Key Points
	Table 1. Marsh Harrier prey identified from pellets, prey remains and sightings 1983–84

	Pellets				*Prey remains*				*Sightings*			
	Nos	%	*Wt*	%	*Nos*	%	*Wt*	%	*Nos*	%	*Wt*	%
Reed Bunting *Emberiza schoeniclus*	8	2.0	146	0.3	3	1.0	55	0.1	2	0.6	37	0.1
Meadow Pipit *Anthus pratensis*	17	4.3	340	0.6	6	2.0	120	0.3	7	2.2	140	0.3
House Sparrow *Passer domesticus*	11	2.8	297	0.5	4	1.4	108	0.2	2	0.6	54	0.1
Unidentified small birds	45	11.5	1125	2.2					36	11.2	900	2.1
Greenfinch *Carduelis chloris*	1	0.3	28	0.1	4	1.4	111	0.2				
Skylark *Alauda arvensis*	12	3.1	456	0.9	8	2.8	304	0.6	7	2.2	266	0.6
Starling juvenile *Sturnus vulgaris*	11	2.8	770	1.5	39	13.2	2730	5.9	4	1.3	280	0.6
Starling adult *Sturnus vulgaris*	34	8.7	2788	5.3	13	4.4	1066	2.3	5	1.5	410	0.9
Shelduck pullus *Tadorna tadorna*	6	1.5	282	0.5	13	4.4	611	1.3	6	1.9	282	0.7
Partridge pullus *Alectoris rufa-Perdix perdix*									4	1.3	204	0.5
Lapwing pullus *Vanellus vanellus*									4	1.3	340	0.8
Moorhen pullus *Gallinula chloropus*									4	1.3	380	0.9
Pheasant pullus *Phasianus colchicus*									42	13.1	4452	10.3
Cuckoo *Cuculus canorus*	2	0.5	228	0.4	3	1.0	342	0.7				
Mallard pullus *Anas platyrhynchos*					13	4.4	1625	3.5	25	7.8	3125	7.2
Tufted Duck pullus *Aythya fuligula*					2	0.7	250	0.5				
Turtle Dove *Streptopelia turtur*	2	0.5	290	0.5	7	2.4	1015	2.2	1	0.3	145	0.3
Red-legged Partridge juvenile *Alectoris rufa*									6	1.9	1008	2.3
Pheasant pullus/juvenile *Phasianus colchicus*	76	19.4	15,428	29.6	58	19.6	11,774	25.2				
Oystercatcher pullus *Haematopus ostralegus*					1	0.3	205	0.4	2	0.6	410	0.9
Lapwing *Vanellus vanellus*	1	0.3	228	0.4	1	0.3	228	0.5	4	1.3	912	2.1
Duckling sp. pullus/juvenile Anatidae	31	8.0	7378	14.2								
Black-headed gull *Larus ridibundus*					1	0.3	276	0.6				
Moorhen juv/adult *Gallinula chloropus*	6	1.5	1794	3.4	21	7.1	6279	13.4	16	5.0	4784	11.1
Pheasant juvenile *Phasianus colchicus*									33	10.3	9900	22.9
Duckling sp. juvenile Anatidae									2	0.6	740	1.7
Grey Partridge *Perdix perdix*					2	0.7	748	1.6				
Coot juvenile *Fulica atra*	3	0.8	1200	2.3					1	0.3	400	0.9
Stock Dove *Columba oenas*	3	0.8	1200	2.3	8	2.8	3200	6.9				
Red-legged partridge *Alectoris rufa*	2	0.5	968	1.9	3	1.0	1452	3.1	3	0.9	1452	3.4
Oystercatcher *Haematopus ostralegus*									1	0.3	519	1.2
Wood Pigeon *Columba palumbus*	6	1.5	3144	6.0	1	0.3	524	1.1	1	0.3	524	1.2
Pheasant *Phasianus colchicus*									1	0.3	600	1.4
Field Vole *Microtus agrestis*	19	4.9	722	1.4	1	0.3	38	0.1				
Unidentified small mammal									50	15.6	1500	3.5
Water Vole *Arvicola terrestris*	4	1.0	400	0.8	6	2.0	600	1.3				
Rabbit *Oryctolagus cuniculus*	69	17.7	10,143	19.5	58	19.5	8526	18.2	21	6.6	3087	7.1
Weasel *Mustela nivalis*									4	1.3	604	1.4
Common Rat *Rattus norvegicus*	9	2.3	2070	4.0	1	0.3	230	0.5	18	5.6	4140	9.5
Stoat *Mustela erminea*					1	0.3	267	0.6	1	0.3	267	0.6
Brown Hare juvenile *Lepus capensis*	1	0.3	300	0.6	10	3.4	3000	6.4	4	1.3	1200	2.8

Blanco, J. C., González, J. L., & Hiraldo, F. (1990).	• A study of wintering marsh harriers in the south of Spain found that marsh harrier diet consisted of 19.4% small mammals, 32.8% rats, 4.8% ducks, rallids (rails) -waders 13.5%, with 15.4% other bird species.
Luo et al, 2010	• In this study area the harrier's main prey was passerine birds and pheasants.
Brzeziński, M., & Żmihorski, M. (2009).	• The diet of the marsh harrier varied throughout the breeding season with 63.5% of all prey items consumed being passerines in the nestling period, dropping to 20.9% during the fledging period. • Water birds in the harrier diets consisted of 24.1% of the number of prey items during the nestling stage and this increased to 40% of the prey items consumed during the fledging stage. • Mammals in the harrier diet consisted of only 6.6% of the prey items consumed in the nestling stage, rising to 25.8% during the fledging stage. • When the weight of the prey items were taken into account, passerines contributed only 13.5% of the diet of marsh harriers in the nestling stage

Reference	Key Points
	Compared with 56.9% for water birds and 16.9% for mammals. • During the fledging stage, passerines contributed only 2.5% of the biomass consumed, whereas water birds decreased to 44.6% and mammals consisted of 38.1% of the biomass consumed.
Cardador 2014	• Found that the diet of marsh harriers in this region varied dependent on the type of farming, with harriers foraging on traditional farmland having a diet of approx. 60% small mammals and 35-40% birds. • Harriers foraging in intensive farmland having a diet consisting of approx. 80% small mammals and 15-20% birds.
S and J Moynes Tay R.G Report 1998 – 2000	• Majority of prey items provided by male relatively small such as passerines (Reed bunting and sedge warbler) and wader chicks. • Females capable catching larger prey items including brown rats and young rabbits. The remains of large Carrion Crow and Woodpigeon chicks have also been observed in nests, as have game bird chicks. • A male was seen in 1994 taking Bearded Tit chicks from a nest and returned to the nest until, presumably, all the chicks had been removed. • In June, when most pairs have chicks to feed, juvenile Common Starlings feature quite prominently in the diet. <u>List of confirmed prey items as follows</u>: Common Reed Bunting - important Sedge Warbler - important Common Starling - important Common Sky Lark - important Northern Lapwing (pulli) - important Common Redshank (pulli)important Eurasian Oystercatcher(pulli) - important Duck species *Anatidae sp.* (pulli) - important Common Pheasant(pulli) - important Grey Partridge (pulli) - important Brown Rat - important Carrion Crow (pulli) - regularly Carrion - regularly taken by adults,important for fledged young. Bearded Tit - unknown Winter Wren unknown Blue tit - unknown Common Linnet -unknown Eurasian Teal - unknown Water Rail - unknown Common Coot - unknown Common Wood Pigeon - occasionally Rabbit - occasionally
Melinda Takacsova (2007).	• Main component of the food were small mammals (Microtus sp., rarely Lepus europaeus), birds (Phasianus colchicus, Vanellus vanellus), fishes and fewer lizards and frogs.

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Appendix 2

Review of efficacy of providing arable margins and wildbird cover/seed cropping.

The evidence for the efficacy of the following measures (planting grass margins around arable fields and sowing bird/game cover and food crops) in boosting populations of small mammals and farmland/game bird species has come from the conservation evidence website. http://www.conservationevidence.com/

About Conservation evidence

"Conservation Evidence is a free, authoritative information resource designed to support decisions about how to maintain and restore global biodiversity. We summarise evidence from the scientific literature about the effects of conservation interventions such as methods of habitat or species management. We also publish new evidence in our online journal *Conservation Evidence*.

Our ongoing review process extracts evidence continually from important conservation journals (such as Conservation Biology, Biological Conservation, Ecology, Journal of Applied Ecology, Oryx) and from systematic reviews published by the Collaboration for Environmental Evidence. We also search through more specialist journals and unpublished literature to focus on particular species groups or habitats. At present we are working through the back contents of 30 major journals and developing synopses of evidence on reptile conservation, carnivore conservation, forest conservation, plant conservation and freshwater invasives management (see the methods page).

The idea is to give conservationists easy access to the latest and most relevant knowledge to support their conservation policy or management decisions.

Conservation Evidence is based at the University of Cambridge, UK, with collaborators and advisers in all continents of the world."

Plant grass buffer strips/margins around arable or pasture fields

Key messages

- Nine studies from the UK (including seven replicated studies of which two were controlled, and two reviews) found that planting grass buffer strips (some margins floristically-enhanced) benefits birds, resulting in increased numbers, densities, species richness and foraging time.
- Five studies from Finland and the UK (including two replicated, controlled trials and a review), found that planting grass buffer strips benefits small mammals: including increased activity and numbers.

Supporting Evidence

Note that the supporting evidence included a huge quantity of information; therefore I have only focused, on those papers that showed positive benefits to birds and small mammals. Numbers referer to the case studies summarised by conservation evidence. Note a small number of studies showed no positive correlation, but the vast majority were positive proving the efficacy of grass margins.

2

A replicated, controlled study in 1995-1996 in Cambridgeshire, UK (Clarke et al. 1997) found that more bird individuals (average 20% of all individual birds recorded) and more bird species (average 56% of all

bird species counted in 1995-1996) used the sown set-aside strips than the adjacent crop area (average 7% individuals and 33% species) in both years. Across all habitats 44 species were recorded in 1995 and 31 spp. in 1996. However, the highest proportions of both individuals and species were recorded in field boundaries (average 68% of all individuals and 8% of all spp.). The highest species richness was found in the most species rich grass mix. The seed mixture 'Tübinger Mischung' designed to provide nectar for bees (*Apidae*) and containing only wildflowers attracted the largest number of birds but the lowest number of bird species. Yellowhammer *Emberiza citrinella*, red-legged partridge *Alectoris rufa* and pheasant *Phasianus colchicus* were the most recorded species in set-aside strips. Note that no statistical analyses were performed on these data. Five seed mixtures were sown on 15 set-aside areas (minimum 20 m x 100 m) in autumn 1993 and 1994. Seed mixtures contained only grass species (three mixes of three to six species), a mix of grasses and wildflowers (six grass and eight wildflower species) or only wildflowers (11 species). Birds were recorded during 15 minute point counts on 10 occasions between June and September 1995 and July and October 1996. Individual bird locations were recorded in three categories: field boundary, set-aside strip or crop. After each count, the strips were walked to flush any birds present but not visible during the count.

9

A replicated study from 1992 to 1998 in England (Brown 1999) found that small mammal activity was significantly greater in field margins than in open fields in both organic (142 vs 86 mammals respectively) and conventional systems (139 vs 78). There was no difference between systems. The same trend was seen in both systems for wood mouse *Apodemus sylvaticus* (margins: 40-80%; field: 20-60% of population activity), bank vole *Myodes glareolus* (75-95% vs 5-25%) and common shrew *Sorex arenaeus* (40-90% vs 10-60%). The difference between activity in the margin and field was greater during winter than summer. Seeded margins showed a rapid increase in activity over four years for wood mouse (year 1: 15-16 trapped; year 4: 28-30), bank vole (year 1: 2-8; year 4: 16-36) and common shrew (year 1: 6-7; year 4: 18-19). Two to four new field margins were sampled within organic and conventional fields at two farms, in Essex and Leicestershire. Mark-recapture programmes were undertaken using Longworth traps over 10 nights each season from 1992 to 1998. Traps were set at 0, 1, 2, 3, 4, 5, 10, 20, 40 m into the field, replicated five times at each site. Additional, 'one-off' trapping sessions were undertaken over one year at five pairs of organic/conventional farms.

11

A 1999 review of research into field margins in northwest Europe (de Snoo & Chaney 1999) found that biodiversity was enhanced by establishing grass margins. Three studies found that establishing grass margins increased beneficial predatory invertebrates. Another study found no increase in invertebrate predators, but a higher abundance of field mice *Apodemus spp*., skylark *Alauda arvensis*, meadow pipit *Anthus pratensis*, blue-headed wagtail *Motacilla flava flava* and linnet *Carduelis cannabina* in grass margins compared to normal crop edges, particularly when the grass was tall. However, one study in the Netherlands reported that in the short-term most newly created grass margins are less species rich than existing verges.

13

A 2000 literature review (Aebischer et al. 2000) found that the UK population of cirl buntings *Emberiza cirlus* increased from 118-132 pairs in 1989 to 453 pairs in 1998 following a series of agri-environment schemes designed to provide overwinter stubbles, grass margins, and beneficially managed hedges and set-aside. Numbers on fields under the specific agri-environment scheme increased by 70%, compared with a 2% increase elsewhere.

17

A 2001 paired site comparison study in south Devon (Peach et al. 2001) found that fields with 6 m grass margins were associated with increases in cirl bunting *Emberiza cirlus* numbers. Six of seven Countryside Stewardship Scheme plots that had 6 m grass margins and were within 2.5 km of former cirl bunting territories gained birds, whereas there were declines of 20% in cirl bunting numbers on land not-participating within the Countryside Stewardship Scheme. Forty-one 2 x 2 km² squares containing both

land within the Countryside Stewardship Scheme and non-Countryside Stewardship Scheme land were surveyed in 1992, 1998 and 1999. Each tetrad was surveyed at least twice each year, the first time during mid-April to late May and the second time between early June and the end of August.

18

A replicated, controlled study in winter 1999-2000 and summer 2000 in the West Midlands, UK (Buckingham et al. 2002) found 16 times higher winter densities of seed-eating birds (larks *Alaudidae,* finches *Fringillidae*, buntings *Emberizidae* and sparrows *Passeridae)* within 6 m of boundaries of fields with Countryside Stewardship Scheme grass margins than on fields without (1.1 vs 0.1 birds/ha). Twice as many blackbirds *Turdus merula* were found near the boundaries of fields without CSS grass margins than those with grass margins (1.8 vs 0.9 birds/ha). A total of 388 grass fields on 23 pastoral farms were surveyed four times each in winter and in summer. No statistical analysis was performed.

21

A controlled study from 1995 to 1997 and 1999 in Oxfordshire, UK (Perkins et al. 2002) found that yellowhammers *Emberiza citrinella* spent significantly more time foraging in grass margins and field boundaries than other habitats. A significantly greater number of foraging visits per unit area of available habitat were made to grass margins and field boundaries than to all other habitat types. There was no significant difference between use of grass margins and field boundary habitats or between cut and uncut grass margins. However, greater use was made of both cut and uncut grass margins combined than field boundaries. Total area surveyed was 142.8 ha in 1995-1997 and 107.0 ha in 1999. Five habitat types were studied on one mixed arable and pastoral farm: cut or uncut grass margins (2 or 10 m wide, at edge of arable field), field boundaries, arable fields (winter-sown cereals) and grass fields (pasture, silage and hay).

32

A replicated, controlled trial in North Yorkshire, UK (Shore et al. 2005) found more bank voles *Clethrionomys glareolus* and common shrews *Sorex araneus* on sown grass field margins in autumn than on control cropped margins, but no such differences in spring. There were 13-14 and 26-38 bank voles/autumn trapping period on 3 m and 6 m margins respectively, compared to 0-1 voles on control margins. There were 14-15 and 10-13 common shrews/autumn trapping period on 3 m and 6 m margins respectively, compared to 1-4 common shrews on control margins. Wood mice *Apodemus sylvaticus* were found in similar numbers on all margin types in autumn and spring (0-29 mice/trapping period). Four 3 m-wide and four 6 m-wide field margins were established in autumn 1997 and sown with a mix of grasses on one arable farm. Small mammals were trapped in spring (April-May) and autumn (September-October) 1999 and 2000 on sown field margins and four conventional cropped field edges (controls). On four separate nights in each trapping period, twenty Longworth traps were set 10 m apart on each margin, 10 along the edge furthest from the crop, and 10 placed 2 m into the crop. This study was carried out at the same experimental site as Telfer et al. 2000, Carvell et al. 2004.

42

A replicated study in 1999 and 2003 in East Anglia and the West Midlands, England (Stevens & Bradbury 2006) found that a combination of creating uncultivated and planted margins around fields was strongly positively associated with four out of twelve farmland bird species analysed. These were skylark *Alauda arvensis* (a field-nesting species) and chaffinch *Fringilla coelebs*, whitethroat *Sylvia communis* and yellowhammer *Emberiza citrinella* (all boundary-nesting species). The study did not distinguish between uncultivated and planted margins. The study was carried out on 256 arable and pastoral fields on 84 farms.

43

A replicated study in 2003 and 2004 in England (Askew et al. 2007) found that sown grass field margins tended to have higher numbers of small mammals than set-aside. Numbers of captured small mammals were highest in 2 m margins (2.9-4.4 individuals), followed by 6 m margins (2.5-3.6) and set-aside (1.6-2.0). Numbers of small mammals captured were correlated with sward height in 2 m margins. In 2003, significantly more common shrews *Sorex arenaeus* were captured in 2 m margins (1.4 individuals) than

set-aside (0.6) and more wood mice *Apodemus sylvaticus* were found in 6 m margins (1.1) than set-aside (0.5). The trend was similar for bank voles *Clethrionomys glareolus* in 2004: 6 m margins (1.6), 2 m margins (1.4) and set-aside (0.5). Species richness did not differ significantly (1.7-2.0). Species richness, total number of small mammals captured, and the number of bank voles and common shrews captured was higher in 6 m margins cut every 2-3 years compared to those cut annually, although this was only significant for common shrews in 2003. Following establishment, 2 m margins were cut at 2-3 year intervals. For 6 m margins, eight 2 m strips at the edges of margins were cut annually and 12 were cut every 2-3 years. Twelve small mammal traps were set within 20 plots per treatment (1 m from the habitat boundary) for four days in November-December 2003-2004. Mammals were individually fur-clipped and released.

47

A randomized, replicated, controlled trial from 2002 to 2006 in eastern England (Henderson et al. 2007) (same study as Pywell et al. 2007, Ramsay et al. 2007) found that the management of sown grass field margins affected bird use more than the seed mix used. Bird densities were higher on disturbed and grass-specific herbicide-treated plots than on cut plots (no actual bird densities given, only model results). Bird densities were linked to densities of diurnal ground beetles (Carabidae), especially in disturbed and grass-specific herbicide-treated plots. The number of birds using the margins in summer increased by 29% between 2003 and 2006. In winter, there were twice as many birds on cut margins than uncut margins, and twice as many birds in the second year than the first. Field margin plots (6 x 30 m) were established using one of three seed mixes: Countryside Stewardship mix (seven grass species), tussock grass mix and a mixture of grasses and wildflowers designed for pollinating insects. The margins were managed in spring from 2003 to 2005 with one of three treatments: cut to 15 cm, soil disturbed by scarification until 60% of the area was bare ground, treated with grass-specific herbicide at half the recommended rate. There were five replicates of each treatment combination, at two farms. Birds were surveyed five to eight times between April and July from 2002 to 2006. In the winters of 2004-2005 and 2005-2006, birds were surveyed on 6 m-margins on 10 farms with two seed mixes (tussocky grass and fine grass). Margins were either cut in autumn or uncut. There were four replicates of each treatment combination per farm.

52

A 2007 literature review in Leicestershire, UK (Stoate & Moorcroft 2007) found that grass margins contained large numbers of overwintering invertebrates such as rove beetles (*Staphylinidae)* and ground beetles (*Carabidae*) as well as high numbers of yellowhammer *Emberiza citrinella* and whitethroat *Sylvia communis* nests; yellowhammer had higher survival than in adjacent hedgerows.

58

A replicated and controlled habitat selection study in 2003-2005 in south-western Finland (Yletyinen & Norrdahl 2008) found that field voles *Microtus agrestis* in riparian field margins moved on average longer distances in narrow (?5 m) filter strips than in wide (>15 m) buffer zones. Home range sizes tended to be larger in narrow than in wide margins, although these differences were not significant. Field voles were most frequently found in control plots where vegetation was left uncut with no supplementary food or cover added, in both narrow and wide riparian field margins. Crop fields and all mown habitat types were used significantly less by field voles in wide buffer zones than in narrow filter strips. Overall, mown plots were used less than unmown plots. In wide buffer zones, voles used mown habitats proportionally significantly less than other available habitats, whereas in narrow filter strips there was no difference in use between mown and unmown plots. Supplementary food appeared to attract voles in unmown plots in both wide and narrow riparian field margins, but not in mown plots. Mown plots with supplementary food provided were avoided by voles in wide margins. Riparian field margin width did not affect the proportional use of crop fields and field margin habitats from late autumn to spring (summer use not tested). Field margins were created under an agri-environment scheme prior to the study. In mid-June 2005, one 210 m-long section in each of four riparian field margins was divided into fourteen 15 m-long experimental plots, half of which were mown to <20 cm. Food and/or cover was added to mown/unmown plots (total eight treatments). Trapping and radio-tracking field voles started two weeks after habitat manipulation. Radio-tracking for the seasonal habitat-use analysis was done in summer (June 2003), late autumn (December 2003), winter (January 2004) and spring (April-May 2005).

59

A replicated study in May-August 2004-2006 in Aberdeenshire, Scotland (Douglas et al. 2009) found that yellowhammers *Emberiza citrinella* appeared to use cut field margins (sown or naturally regenerated) significantly more in late than early summer for foraging. Cut patches were used more frequently in margins with swards >60 cm tall. The authors suggest that yellowhammers used cut patches disproportionately as the uncut sections grew taller and so reduced access to invertebrates.

64

A 2009 literature review of European farmland conservation practices (Vickery et al. 2009) found that sown grass margins had higher arthropod diversity than adjacent crops, and also held higher abundances of soil invertebrates. The availability of bird food-species was also higher than in crops, although use of grass-only strips by several bird species (yellowhammer *Emberiza citrinella*, red-legged partridge *Alectoris rufa*, greenfinch *Carduelis chloris*, linnet *C. cannabina*) was lower than for margins planted with wildflower mixes.

65

A replicated study in February 2008 in East Anglia, England (Davey et al. 2010) found that field margins managed under agri-environment schemes had a positive influence on 19 out of 24 farmland bird species. However, only yellowhammer *Emberiza citrinella* and possibly blackcap *Sylvia altricapilla* showed a strong positive response to agri-environment scheme margins affecting species densities. Great tit *Parus major* and common starling *Sturnus vulgaris* showed weak positive responses. Field margins were categorized as grassy/weedy, bare/fallow or wild-bird cover (although very few fields had wild bird cover) and most were managed under the Entry Level Stewardship scheme. Ninety-seven 1 km2 plots were included in the study. All field boundaries within each square were walked and all birds present mapped. Squares were visited twice; once in April to mid-May, and once in mid-May to June.

66

A replicated site comparison study in 2004-2008 across England (Ewald et al. 2010) found that grey partridge *Perdix perdix* brood size was negatively associated with the proportion of a site under planted grass buffer strips (association significant in 2008). The ratio of young:old partridges was negatively related to the proportion of grass strips in 2005 and 2008. However, year-on-year changes in partridge density and overwinter survival were positively correlated with the proportion of grass buffer strips on a site, this relationship was significant from 2006 to 2007 (year-on-year changes) and 2005-2006 (overwinter survival). Spring and autumn counts of grey partridge were made at 1,031 sites across England as part of the Partridge Count Scheme.

67

A replicated site comparison study in three regions in England (Field et al. 2010) found that hedges alongside wildflower-rich grass field margins ('floristically enhanced' margins) under Higher Level Stewardship had more yellowhammers *Emberiza citrinella* (estimated 0.4 birds/m) compared to hedges without a grass margin (estimated 0.2 birds/m). Hedges alongside unenhanced grass margins, either conventionally managed or managed under Entry Level Stewardship, did not have more yellowhammers. Surveys were carried out on 69 farms with Higher Level Stewardship in East Anglia, the West Midlands and the Cotswolds and on 31 farms across all three regions with no environmental stewardship.

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Sowing wildbird cover or seed mixtures

Background information and definitions
The loss of food supplies, especially seeds, is thought to be a key driver of farmland bird declines. Plants that provide seed food and cover for wild birds include maize, sunflower and cereals. Wild bird cover crops are often planted in blocks or 6 m-wide strips and left unharvested. These are sometimes called ‘game crops’ or ‘game cover crops’. They may also provide benefits for other farmland wildlife.

Key messages

- Thirty individual studies investigated the effects on birds of sowing wild bird seed or cover mixture, 21 studies found positive effects. Fourteen studies from the UK (including one systematic review and nine replicated controlled trials of which four randomized, and three reviews) found that fields sown with wild bird cover mix had higher abundance, density, species diversity and species richness of birds than other farmland habitats. Six studies from the UK (including one review and two replicated studies) found that birds showed a preference for wild bird cover and used it significantly more than other habitats. One review found the grey partridge population increased substantially on farms where conservation measures including cover crops were in place.
- Nine replicated studies from France and the UK reported mixed or negative effects of wild bird cover on birds compared to other farmland habitats. Six studies found that mixtures including kale or a mixture of kale and/or other species attracted the largest number of bird species or highest bird abundance.
- One replicated trial from the UK found that small mammal activity was higher in wild bird cover than in the crop in winter but not in summer.

Supporting evidence

1
A study of habitat use by yellowhammers *Emberiza citrinella* in 1993, 1995 and 1997 on a mixed farm in Leicestershire, UK (Stoate & Szczur 1997) found that in summer, yellowhammers used both cropped and uncropped habitats, including wild bird cover, and in winter wild bird cover was used more than all other habitats relative to its availability. In summer, wild bird cover strips (8 m wide) were used significantly more than wheat or field boundaries (2 m-wide), but less than barley. In winter, cereal-based wild bird cover was used significantly more than all other habitats and kale-based Brassica spp. bird cover was used significantly more than cereal and rape crops. A 15% area of the arable land was managed for game birds. Yellowhammer nests were observed for 1.5-2 hours when nestlings were 4-10 days old and 5-15 foraging trips per nest were plotted in May-June 1993 and 1995. A 60 ha area of the farm was also walked seven times in November-December and February-March 1997 and habitat use was recorded.3
A 2000 literature review from the UK (Aebischer et al. 2000) found that populations of grey partridge Perdix perdix were 600% higher on farms where conservation measures aimed at partridges were in place, compared to farms without these measures (Aebischer 1997). Measures included the provision of conservation headlands, planting cover crops, using set-aside and creating beetle banks.

4
A small study of set-aside strips from 1995 to 1999 at Loddington, Leicestershire, UK (Boatman & Bence 2000) found that set-aside sown with wild bird cover was used by nesting Eurasian skylark *Alauda arvensis* and butterflies *(Lepidoptera*) significantly more than other habitats. The majority of skylark territories found were within set-aside strips (margins or midfield) sown with wild bird cover (1995: 76%, 1996: 65%, 1997: 71%, 1999: 55%), although the habitat covered only 8-10% of the area. The habitat was also used more for foraging than all habitats, except linseed Linum usitatissimum. Transects along wild bird cover set-aside strips also had more butterfly records than any other habitat in 1997 and 1998 (28-40% vs 1-18%). Wild bird cover was sown with either cereal-based or kale-based Brassica spp. mixtures. Skylark territories were recorded in 1995-1997 and 1999 and nests were located in 1999 and foraging trips observed for two 1.5 hour periods. Two butterfly transects were walked weekly from April-September.

5

A replicated, randomized study from 1998 to 2000 of annual and biennial crops in Norfolk, Hertfordshire and Leicestershire, UK (Boatman & Stoate 2002) found that bird species tended to use a variety of crops. Yellowhammers *Emberiza citrinella* used mainly cereals. Greenfinch *Carduelis chloris* tended to use borage *Borago officinalis*, sunflowers *Helianthus spp*. and mustard *Brassica juncea*. Crops used by several bird species included kale *Brassica oleracea, quinoa Chenopodium quinoa,* fat hen *Chenopodium album and* linseed *Linum usitatissimum. Buckwheat Fagopyron esculentum* was used a small amount and, apart from greenfinch, few others used sunflower *or* borage. Crops were sown in a randomized block design with three replicates at each of the three farms. Plots were 20 or 50 m x either 12 or 16 m. Numbers of birds feeding in, or flushed from, each plot were recorded before 11:00 at weekly intervals from October-March 1998-2000.

9
A study of different set-aside crops on a farm in Leicestershire, UK (Murray et al. 2002), found that Eurasian skylark *Alauda arvensis* and yellowhammer *Emberiza citrinella* used wild bird cover set-aside (kale *Brassica napus* set-aside, cereal set-aside, annual/biennial crop strips) more than expected compared to availability. Skylarks also used wild bird cover more than unmanaged set-aside, broad-leaved crops and other habitats. Yellowhammer used wild bird cover strips more than expected. Cereal set-aside wild bird cover was used significantly more than beetle banks, kale set-aside wild bird cover, unmanaged set-aside and other habitats. Wild bird cover strips were used significantly more than kale set-aside, unmanaged set-aside and other habitats. Field margin and midfield set-aside strips were sown with kale-based and cereal-based mixtures for wild bird cover and beetle banks. Other habitat types were: unmanaged set-aside, cereal (wheat, barley), broad-leaved crop (beans, rape) and other habitats. Thirteen skylark and 15 yellowhammer nests with chicks between 3-10 days old were observed. Foraging habitat used by the adults was recorded for 90 minutes during three periods of the day. This study was part of the same experimental set-up as Moreby (2002), Moreby & Southway (2002).

10
A small replicated controlled study from May-June 1992-1998 in Leicestershire, UK (Stoate 2002) found that the abundance of nationally declining songbirds and species of conservation concern significantly increased on a 3 km2 site where 20 m-wide mid-field and field-edge strips were planted with game cover crops (alongside several other interventions). However, there was no overall difference in bird abundance, species richness or diversity between the experimental and three control sites. Numbers of nationally declining species rose by 102% (except for Eurasian skylark *Alauda arvensis* and yellowhammer *Emberiza citrinella*). Nationally stable species rose (insignificantly) by 47% (eight species increased, four decreased). The other interventions employed at the same site were managing hedges, beetle banks, supplementary feeding, predator control and reducing chemical inputs generally.

11
A replicated, randomized, controlled study over the winters of 1998-2001 on 161 arable farms across England (Boatman et al. 2003) (same study as (Henderson et al. 2004)) found that, overall, all bird species analysed exhibited higher densities on wild bird cover crops than on conventional crops except Eurasian skylark *Alauda arvensis*, which preferred cereal stubbles. Although all species showed non-random and different wild bird cover crop preferences, kale Brassica spp. was preferred by the greatest number of species. Additionally, bird abundance was significantly greater on wild bird cover crops located adjacent to hedgerows than those located midfield. Ten annual crops and four biennial crops were planted each year at each of 192 sites with 3 replicates/crop. At 11 and 13 sites in 1999-2000 and 2000-2001 respectively, strips containing the same crop were grown in pairs, one against a hedgerow and one infield, to determine location preference.

12
A replicated site comparison study of 88 farms in East Anglia and the West Midlands, UK (Browne & Aebischer 2003) found that between 1998 and 2002 there was no difference in the decrease in autumn densities of grey partridge *Perdix perdix* on farms that planted wild bird cover mixtures and farms that did not. Surveys for grey partridge were made once each autumn in 1998 and 2002 on 88 farms: 38 farms that planted wild bird cover and 50 farms that did not.

13
A replicated, controlled study over the winters of 1997-1998, 1998-1999 and 2000-2001 on one arable, autumn-sown crop farm in County Durham, England (Stoate et al. 2003) found that farmland bird abundance was significantly higher in wild bird cover crops than commercial crops (420 birds/km2 in wild bird cover vs 30-40/km2 for commercial crops). Of 11 species with sufficient data for analysis, all species-year combinations exhibited significant preferences for wild bird cover crops. Of the wild bird cover crops, kale *Brassica napus* crops were preferred by nine species and quinoa *Chenopodium quinoa* crops by six species;

cereals and linseed *Linum usitatissimum* were also used. The wild bird cover crops were planted in c. 20 m-wide strips along one edge of arable wheat, barley or oilseed rape fields. There were approximately 15 experimental and 15 control fields. Bird counts were conducted twice monthly from October-March in 1997-1998 and three times per month from October-December as well as twice monthly from January-March in 1998-1999 and 2000-2001.

17
A replicated, randomized study from November 2003 to March 2004 in 205 cereal stubble fields in arable farmland in south Devon, UK (Defra 2004) found no clear changes in habitat use by seed-eating birds after the establishment of wild bird cover crops on some stubble fields. The target species, cirl bunting *Emberiza cirlus*, made insignificant use of wild bird cover crops (average of 2 individuals/plot). Only two plots contained more than five individuals and use of the habitat dropped drastically in March, which the authors suggest makes the habitat a poor alternative to stubbles. High numbers of other seed-eating species including chaffinch *Fringilla coelebs* and yellowhammer *Emberiza citrinella* were recorded on the wild bird cover crops, especially those containing a mixture of rape, millet, linseed *Linum usitatissimum*, kale *Brassica spp*. and quinoa *Chenopodium quinoa* (maximum seed-eating bird count 491 on wild bird cover vs 191 on barley fields). Only song thrush Turdus philomelos abundance was significantly positively related to wild bird cover presence. However, few stubble fields contained wild bird cover crops (13 fields with 24 wild bird cover strips) and the results may have been confounded by low sample size.

18
A replicated, randomized, controlled study over the winters of 1998-2001 in 192 plots of arable fields in lowland England (Henderson et al. 2004) (same study as (Boatman et al. 2003)) found significantly higher density and diversity of farmland birds on wild bird cover crops than conventional crops. Although there were no significant differences between wild bird covers containing a single plant species and conventional crops, bird density was 50 times higher on ‘preferred’ wild bird covers. Kale *Brassica oleracae viridus*-dominated wild bird covers supported the widest range of bird species (especially insectivores and seed-eaters), quinoa *Chenopodium quinoa*-dominated wild bird covers were mainly used by finches and tree sparrows *Passer montanus* and (unharvested) seeding cereals were mainly used by buntings. Sunflowers *Helianthus spp*., phacelia *Phacelia spp*. and buckwheat *Fagopyron esculentum* were the least preferred wild bird covers. All species, except Eurasian skylark *Alauda arvensis*, corn bunting *Miliaria calandra* and rook *Corvus frugilegus*, were significantly denser on wild bird cover. The differences between wild bird covers were more marked in late-winter as kale and quinoa *Chenopodium quinoa* retained seeds for longer periods. Within each plot, one wild bird cover and up to four conventional crops were surveyed at least once.

19
A replicated, randomized, controlled study from November-February in 2000-2001 and 2001-2002 on 20 arable farms in eastern Scotland (Parish & Sotherton 2004a) found that farmland bird abundance and diversity were significantly higher in fields containing wild bird cover crops (0.6-4.2 ha sampled annually) than fields with set-aside, fields with overwinter stubble or fields with conventional crops. Bird density was up to 100 times higher/ha in wild bird cover crops than on control fields. Wild bird cover crops attracted 50% more species than set-aside and stubble fields and 91% more than conventional fields. Of eight species with sufficient data for individual analysis, seven were consistently significantly more abundant in wild bird cover than in control crops. However, Eurasian skylarks *Alauda arvensis* were significantly more abundant in set-aside and stubble fields. The authors point out that many of the species that favour wild bird cover crops are those currently causing concern because of their declining populations.

20
A replicated, randomized, controlled study from June-September 2001-2002 of 21 cereal farms in eastern Scotland (Parish & Sotherton 2004b) found that farmland birds were significantly more abundant on fields containing wild bird cover crops than on fields with conventional crops. A total of 25 species were recorded, with up to 80 times more birds seen in wild bird cover than conventional crops. Over all month-crop combinations bird density was significantly higher on wild bird cover crops for all groups except finches in July. Bird density increased steadily over all months of the study on wild bird cover crops, but remained relatively constant on conventional crops. Wild bird cover crops contained up to 90% more weed species, and 280% more important bird-food weeds, than conventional crops. The wild bird cover crops were composed mainly of kale Brassica spp., quinoa *Chenopodium quinoa* and triticale *Triticosecale spp*. and were sown in 20 x 650 m strips. A random sample of 4.9 ha of conventional crops was made on each farm.

21

A review of the results of four projects conducted from 1998 to 2004 on wild bird cover crops planted in arable farms in England (Stoate et al. 2004) found that the density and diversity of bird species increased significantly when wild bird cover crops were included in the farm. Four studies reported greater use of wild bird cover crops than of commercial crops during winter (October-March). One study reported an increase in bird abundance when wild bird cover crops were introduced into areas that previously lacked them. Kale *Brassica napus* and quinoa *Chenopodium quinoa* were used by the most species. Buckwheat *Fagopyron esculentum* was rarely used by species in any of the studies. Millet was used by more species than any other cereal. Three other studies also found that the location of wild bird covers within the whole-farm configuration had an effect on bird densities. Wild bird covers located close to hedges were favoured. Four studies found that a mixture of wild bird cover crops will produce the highest bird density and diversity.

22
A replicated, controlled, paired sites study over winter 1997-1998 and summer 1999-2000 in arable farmlands in southern England and the Scottish lowlands (Sage et al. 2005) found that songbird density and species richness were higher in wild bird cover crops in both seasons. In total, more species were recorded in wild bird cover winter crops than control plots (26 vs 10 species). Similarly, summer wild bird cover crops contained more species than control plots (14 vs 10 species). Songbird abundance was significantly higher on wild bird cover winter (10-50 individuals/ha vs 1) and summer (3 individuals/ha vs 0.4) crops. There was a significantly higher abundance of declining songbird species in the kale *Brassica oleracea* and quinoa *Chenopodium quinoa*, but not cereal wild bird cover crops. Winter wild bird cover plots were sown with kale, quinoa or cereal, while summer wild bird cover plots were predominantly triticale. Thirty experimental and 30 control plots were used in winter, with six experimental and six control plots in summer.

23
A replicated study in 1999 and 2003 on 256 arable and pastoral fields across 84 farms in East Anglia and the West Midlands, England (Stevens & Bradbury 2006), found that only two of twelve farmland bird species analysed were positively associated with the provision of wildlife seed mixtures, overwinter stubble or set aside. These were Eurasian skylark *Alauda arvensis* (a field-nesting species) and Eurasian linnet *Carduelis cannabina* (a boundary-nesting species). The study did not distinguish between set-aside, wildlife seed mixtures or overwinter stubble, classing all as interventions to provide seeds for farmland birds.

25
A randomized, replicated, controlled trial from 2003 to 2006 in southwest England (Defra 2007) found that plots of permanent pasture sown with a wild bird seed mix attracted more foraging songbirds (dunnock *Prunella modularis*, wren *Troglodytes troglodytes*, European robin *Erithacus rubecula*, seed-eating finches (*Fringillidae*) and buntings (*Emberizidae*)) than 12 control plots, managed as silage (cut twice in May and July, and grazed in autumn/winter). Dunnocks, but not chaffinches *Fringella coelebs* or blackbirds *Turdus merula*, nested in hedgerows next to the sown plots more than expected, with 2.5 nests/km compared to less than 0.5 nests/km in hedges next to experimental grass plots. Twelve experimental plots (50 x 10 m) were sown on four farms with a mix of crops including linseed *Linum usitatissimum* and legumes. There were twelve replicates of each management type, monitored over four years. This study was part of the same experimental set-up as (Pilgrim et al. 2007, Potts et al. 2009, Holt et al. 2010).

27
A randomized, replicated, controlled trial from 2003 to 2006 in southwest England (Pilgrim et al. 2007) found that plots of permanent pasture sown with a mix of crops including linseed *Linum usitatissimum* and legumes attracted more birds, and more bird species, than control treatments, in both summer and winter. Three plots (50 x 10 m) were established on each of four farms in 2002 re-sown in new plots each year and monitored annually from 2003 to 2006. Legumes sown included white clover Trifolium repens, red clover T. *pratense*, common vetch *Vicia sativa* and bird's-foot trefoil *Lotus corniculatus*. There were twelve replicates of each treatment. This study was part of the same experimental set-up as (Defra 2007, Potts et al. 2009, Holt et al. 2010).

29
A replicated trial in 2004 and 2005 on four farms in England (Pywell et al. 2007) found that plants, insects, mammals and birds all used sown wild bird seed mix plots more than wheat crop at some times of year. The number of flowers and flowering species, the abundance and number of species of butterflies (Lepidoptera) and the number of bumblebee species *Bombus spp*., were all higher in the wild bird mix than in the crop. Small mammal activity was higher in the wild bird mix in winter (around 25 mammals/100 trap nights in wild bird mix, compared to around 8 in the crop), and higher in the crop in summer (around 10 mammals caught in the crop, compared to less than one on average in the wild bird mix). The number of birds and bird species

were higher in the wild bird mix than the crop in December and January (around 100 birds of over three species per count on average in the wild bird mix, compared to less than 10 birds or <1 species in the crop), but not in February and March. Eurasian linnet *Acanthis cannabina* (at three sites) and reed bunting *Emberiza schoeniclus* (at one site) were the most abundant bird species recorded in the wild bird mix. A seed mix containing white millet *Echinochloa esculenta*, linseed *Linum usitatissimum*, radish *Raphanus sativus* and quinoa *Chenopodium quinoa* was sown in a 150 x 30 m patch in the centre of an arable field (winter wheat) on each of four farms in Cambridgeshire, Bedfordshire, Oxfordshire and Buckinghamshire, in April 2004 and 2005. Plants, bees and butterflies were counted in summer 2005. Small mammals were trapped in November-December 2005 and May-June 2005. Birds were counted once a month between December 2004 and March 2005.

30
A 2007 systematic review identified five papers investigating the effect of winter bird cover on farmland bird densities in the UK (Roberts & Pullin 2007). There were significantly higher densities of farmland birds in winter on fields with winter bird cover than on adjacent conventionally managed fields. The meta-analysis included experiments conducted between 1998 and 2001 from two controlled trials and one randomized control trial.

32
A replicated, randomized, controlled study in September, November, December and February in 2004-2005 in seven grassland farms (87-96% grass) in western Scotland (Parish & Sotherton 2008) found that songbirds responded significantly more positively to wild bird cover crops in grassland compared to arable regions. Average songbird densities were two orders of magnitude greater in wild bird cover crops than conventional crops (average 51 birds/ha vs 0.2). The average density of songbirds in wild bird cover in the grassland region was more than double that in wild bird cover in the arable region at the same time of year (average 61 and 29 birds/ha respectively). Average bird densities in grassland conventional crops were just 14% of that in the arable region. On each site, an average of 1.2 ha of wild bird cover and 10.3 ha of conventional crops was randomly sampled. Arable farm data from a previous study was used for comparison.

33
A replicated experiment in northeast Scotland over three winters 2002-2005 (Perkins et al. 2008), found that unharvested seed-bearing crops were most frequently selected by birds (28% of all birds despite these patches occupying less than 5% of the area surveyed). For nine species, seed-bearing crops were used more than expected (based on available crop area) in at least one winter. Outside agri-environment schemes (the Rural Stewardship Scheme and Farmland Bird Lifeline), cereal stubble was the most selected habitat. In total, 53 lowland farms (23 in Rural Stewardship Scheme, 14 in Farmland Bird Lifeline, and 16 not in a scheme) were assessed. Over 36,000 birds of 10 species were recorded.

35
The second monitoring year of the same study as (Pywell & Nowakowski 2007) in the UK (Pywell & Nowakowski 2008) found that wild bird seed mix plots had more birds in winter (86 birds/plot, of six species on average) than control cereal plots, plots sown with wildflower seed mix or plots left to naturally regenerate (2 birds/plot or less, and 0.4-1.6 species/plot on average). Wild bird seed plots also had more bumblebee Bombus spp. and butterfly (Lepidoptera) individuals and species than naturally regenerated or control cereal plots and more vacuum-sampled invertebrates than control plots. Wild bird seed plots had eight plant species/m2, 40 bumblebees and four bumblebee species/plot, 18 butterflies and six butterfly species/plot, compared to three plant species/m2, no bumblebees and one butterfly/plot on control cereal plots. Control plots had 254 vacuum-sampled canopy-dwelling invertebrates/m2 on average, compared to 840-1,197/m2 on other treatments. Plants were monitored in three 1 m2 quadrats/plot in June 2007. Butterflies, bumblebees and flowering plants were recorded in a 6 m-wide transect six times between July and September 2006 and 2007. Invertebrates in the vegetation were vacuum sampled in early July 2007. Farmland birds were counted on each plot on four counts between December 2007 and March 2008. The crop control in year two was winter wheat.

36
A 2009 literature review of agri-environment schemes in England (Natural England 2009) found that high densities of seed-eating songbirds and Eurasian skylark *Alauda arvensis* were found on land planted with wild bird seed or cover mix and on stubble fields. A survey in 2007-2008 found that densities of seed-eating songbirds were highest on wild bird seed or cover mix, compared to other agri-environment scheme options.

38

A 2009 literature review of European farmland conservation practices (Vickery et al. 2009) found that margins sown with wild bird cover had high numbers of some invertebrates which are important bird food, but lower numbers than on margins sown with a wildflower mix. Cover crops such as quinoa *Chenopodium quinoa* and kale *Brassica oleracea* provided more food for seed-eating birds in late winter than other field margin types and supported large numbers of some songbird species.

39
A controlled study in 2002-2009 on mixed farmland in Hertfordshire, England (Aebischer & Ewald 2010), found that the estimated population density of grey partridges *Perdix perdix* was significantly higher on land sown with wild bird cover than on conventional arable crops. This study also examined the densities found on land under various agri-environment schemes and set aside (which were higher than those on wild bird cover) and the impact of predator control and supplementary food provision. Grey partridges were surveyed in March and September using dawn and dusk counts starting in 2001. Land cover within the project area was mapped and categorized as: conventional arable land, arable in agri-environment schemes, non-arable, or set-aside (which was further divided into non-rotational, wild bird cover, other rotational).

40
A 2010 follow-up review of experiments on the effects of agri-environment measures on livestock farms in the UK (Buckingham et al. 2010), found that in one experiment in southwest England (the Potential for Enhancing Biodiversity on Intensive Livestock Farms PEBIL project BD1444, also reported in (Defra 2007)) found small insect-eating birds preferred field margins sown with a diverse mixture of plants that provided seed food; compared to grass margins subject to different management techniques, despite there being no difference in the number of insects between the two sets of treatments. The preference for wild bird cover was attributed to easier accessibility (less dense ground cover). The review assessed results from four experimental projects (one incomplete at the time of the review) in the UK.

41
A replicated site comparison in 2005 and 2008 of 2,046, 1 km squares of agricultural land across England (Davey et al. 2010a) (same study as (Davey et al. 2010b)) found that four of eight regions had at least two farmland birds that showed positive responses to wild bird cover and overwinter stubble fields. Across all 15 bird species thought to benefit from these interventions, only one region (the north west) showed significantly more positive responses than would be expected by chance. Some species responded positively in some regions and negatively in others.

42
A replicated site comparison study in 2005 and 2008 of 2,046, 1 km² plots of lowland farmland in England (Davey et al. 2010b) (same study as (Davey et al. 2010a)) found that three years after the 2005 introduction of two agri-environment schemes, Countryside Stewardship Scheme and Entry Level Stewardship, there was no consistent association between the provision of wild bird cover and farmland bird numbers. European greenfinch *Carduelis chloris*, stock dove *Columba oenas*, starling *Sturnus vulgaris* and woodpigeon *Columba palumbus* showed more positive population change (population increases or smaller decreases relative to other plots) in the 9 km² and 25 km² areas immediately surrounding plots planted with wild bird cover mix than in the area surrounding plots not planted with wildlife seed mixture. Although Eurasian linnet *Carduelis cannabina* and rook *Corvus frugilegus* also showed positive associations with wild bird cover mix at the 25 km² scale, plots with wild bird cover were associated with a greater decline in grey partridge *Perdix perdix* populations at both scales between 2005 and 2008. The 2,046 1 km² lowland plots were surveyed in both 2005 and 2008 and classified as arable, pastoral or mixed farmland. Eighty-four percent of plots included some area managed according to Entry Level Stewardship or the Countryside Stewardship Scheme. In both survey years, two surveys were conducted along a 2 km pre-selected transect route through each 1 km² square.

43
A replicated site comparison study from 2004 to 2008 in England (Ewald et al. 2010) found that the ratio of young-to-old grey partridges *Perdix perdix* was higher in 2007 and 2008 on sites with higher proportions of wild bird cover. Brood sizes were also related to wild bird cover in 2008 only. Overwinter survival was positively related to wild bird cover in 2004-2005, but negatively in 2007-2008. There were no relationships between wild bird cover and year-on-year density trends. Spring and autumn counts of grey partridge were made at 1031 sites across England as part of the Partridge Count Scheme.

44
A replicated site comparison study between November 2007 and February 2008 of 52 fields in East Anglia and the West Midlands (Field et al. 2010a) (same study as (Field et al. 2010b)) found no difference between

the number of seed-eating birds in fields managed under Higher Level Stewardship of the Environmental Stewardship scheme (fields sown with enhanced wild bird seed mix) than in fields managed under Entry Level Stewardship of the Environmental Stewardship scheme (fields sown with wild bird cover mix). In East Anglia, but not the West Midlands, there were significantly more seed-eating birds on fields planted with wild bird cover under the Environmental Stewardship scheme (59.3 birds/ha) than non-Environmental Stewardship fields planted with a game cover (2.1 birds/ha). Seed-eating birds were surveyed on two visits to each site between 1 November 2007 and 29 February 2008.

45
A replicated site comparison study in winter 2007-2008 on farms in East Anglia and the West Midlands, England (Field et al. 2010b) (same study as (Field et al. 2010a)) found that more seed-eating farmland songbirds (including tree sparrow *Passer montanus* and corn bunting *Emberiza calandra*) were found on Higher Level Stewardship wild bird seed mix sites (6-11 birds/ha) than on non-stewardship game cover crops (<0.5 birds/ha) in East Anglia, but not in the West Midlands (2-4 birds/ha on both types). The survey was carried out on 27 farms with Higher Level Stewardship, 13 farms with Entry Level Stewardship and 14 with no environmental stewardship.

46
A replicated study from April-July in 2006 on four livestock farms in southwest England (Holt et al. 2010) found that dunnock *Prunella modularis*, but not Eurasian blackbird *Turdus merula* or chaffinch *Fringella coelebs*, nested at higher densities in hedges alongside field margins sown with wild bird seed crops, or barley undersown with grass and clover, compared to those next to grassy field edges under various management options (dunnock: approximately 2.5 nests/km for seed crops vs. 0.3/km for grass margins, blackbirds: 1.0 vs. 1.3, chaffinch: 1.5 vs. 1.4). Margins were 10 x 50 m and located adjacent to existing hedgerows. Seed crop margins were sown with barley (undersown with grass/legumes) or a kale *Brassica spp.*/quinoa *Chenopodium quinoa* mix. There were 12 replicates of each treatment, three replicates on each farm. This study was part of the same experimental set-up as (Defra 2007, Pilgrim et al. 2007, Potts et al. 2009).

48
A replicated study on four farms in Gloucestershire and Oxfordshire, England, in 2007 (Rantanen et al. 2010) found that grey partridge *Perdix perdix* released in coveys in the autumn used cover crops more frequently than birds released in pairs in the spring. Four farms were studied. Birds were radio-tagged and their positions marked on a 1:5000 map.

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Leave cultivated, uncropped margins or plots (includes 'lapwing plots')

Background information and definitions

- This intervention can be introduced for ground-nesting birds (sometimes called ‘lapwing plots’), rare arable plants, or both. It may also provide habitat for insects and foraging sites for mammals and seed- and insect-eating birds (Campaign for the Farmed Environment 2011).
- Plots or strips are cultivated, but left undrilled. For ground-nesting birds, the plots are usually at least 2 ha in size. They are different from 'skylark plots', which are much smaller and usually created in groups. If this measure is taken in field margins (6 m strips at the edge of arable fields), no fertilizer is applied, and herbicide applications are minimal, with only spot treatment of particular weeds permitted.
- See also ‘Provide (or retain) set-aside areas’, for rotational or long-term fallow land at the field scale not cultivated or implemented specifically for ground-nesting birds.
- See also ‘Sow rare or declining arable weeds’ for a study of different management options that could also apply to uncropped, cultivated margins.

Key Messages

- Nineteen individual studies looked at the effect of uncropped, cultivated margins or plots on wildlife. Seventeen studies from the UK and northwest Europe (six reviews and seven replicated studies of which two were site comparisons, one a before-and-after trial and one was controlled and randomized) found that leaving uncropped, cultivated margins or plots on farmland provides benefits to some or all target farmland bird species, plants, invertebrates, and mammals. These wildlife benefits included increased species richness of plants, bumblebees, species richness and abundance of spiders, abundance of ground-dwelling invertebrates and ground beetles, increased stone curlew breeding population size, northern lapwing hatching success, Eurasian skylark nesting success and the establishment, abundance or species richness of rare arable plant species. A replicated study found northern lapwing, Eurasian skylark, grey partridge and yellow wagtail bred in lapwing plots.
- Two studies (a replicated study and a review) from the UK found that leaving uncropped, cultivated margins or plots on farmland had no effect on 11 out of 12 farmland bird species or ground beetles. A replicated site comparison study in the UK found fewer seed-eating birds on fallow plots for ground-nesting birds in two out of three regions. One review from the UK found evidence that pernicious weeds were more commonly found on uncropped cultivated margins than conservation or conventional headlands. A replicated site comparison from the UK found the proportion of young grey partridges in the population was lower in areas with a high proportion of uncropped cultivated margins and plots.

Supporting evidence

7

A replicated study in 1999 and 2003 on 256 arable and pastoral fields across 84 farms in East Anglia and the West Midlands, UK (Stevens & Bradbury 2006) found that only one out of 12 farmland bird species, reed bunting *Emberiza schoeniclus*, was strongly and positively associated with uncropped, cultivated strips. No other species showed a strong association (positive or negative) with the strips.

9

A 2007 review of a Countryside Stewardship Scheme in southern England (Evans & Green 2007) found that the population of Eurasian thick-knees (stone curlew) *Burhinus oedicnemus* increased from 71 breeding pairs in 2000 to 103 in 2005, following the creation of 156 stone curlew plots over the study period typically located close (<1 km) to pasture, pig farms or other food sources and away from edges of fields. A further 51 plots were created in 2006 under Higher Level Stewardship. The UK stone curlew population increased from

160 pairs in the 1980s to 300 pairs in 2005. Stone curlew plots consisted of 1-2 ha of arable or set aside land cultivated to create a ‘rough fallow’ in spring.

11

A replicated, controlled study in the breeding seasons of 1999-2000 on 28 farms in western England (Sheldon et al. 2007) found that 85% of 34 northern lapwing *Vanellus vanellus* nests successfully hatched at least one chick on fields with cultivated ‘lapwing plots’, compared to 64% of 154 nests on all other field types. Nest survival estimates were also significantly higher (99% daily survival vs 95-96% on spring cereals, stubbles and grass habitats), and no nests were lost to agricultural operations, compared to over 50% in other fields.

13

A study in 2003-2005 in Cambridgeshire, UK (Stoate & Moorcroft 2007) found that the nesting success of Eurasian skylark *Alauda arvensis* was significantly higher in a field that was fallowed after harvest, compared to in cereal crop fields (84% success in the fallow field vs 35%), whilst the number of nests in the field increased from two to eight following the fallow. Overwinter counts of yellowhammer *Emberiza citrinella*, reed bunting *E. schoeniclus*, linnet *Carduelis cannabina* and skylark on the fallow field were also far higher than in previous years.

17

A replicated study in 2007 (Chamberlain et al. 2009) found that northern lapwing Vanellus vanellus used 39% of 212 lapwing plots on 180 farms across England, with breeding suspected on 25% of plots. In addition, Eurasian skylark *Alauda arvensis*, grey partridge *Perdix perdix* and yellow wagtail *Motacilla flava* were recorded breeding in 73%, 17% and 6% of plots respectively. There were no significant differences in lapwing occurrence or breeding in plots managed under Higher Level Stewardship compared with those under the Countryside Stewardship Scheme. Lapwing occurrence decreased if there was woodland adjacent, and the probability of breeding increased with the proportion of bare ground present on plots. Skylarks were less likely to be found on plots near hedgerows.

18

A 2009 literature review of agri-environment schemes in England (Natural England 2009) found that spring and summer fallows provided nesting habitats for northern lapwing *Vanellus vanellus*, with 40% of fallow plots used by lapwings and breeding suspected on 25% plots (Chamberlain et al. 2009). In addition, the number of breeding pairs of Eurasian thick-knee (stone curlew) *Burhinus oedicnemus* in southern England increased from 63 in 1997 to 103 in 2005 following the implementation of a Countryside Stewardship Scheme ‘special project’ which included the provision of fallow plots. One study (Walker et al. 2007b) found that 264 plant species typically found in disturbed or arable habitats, including 34 rare and uncommon arable plants, were recorded in three agri-environment scheme options: uncropped cultivated margins (highest diversity), spring fallow, conservation headlands (lowest diversity).

19

A replicated site comparison study from 2004 to 2008 in England (Ewald et al. 2010) found a lower proportion of young grey partridges *Perdix perdix* in the population in 2007 on sites with a high proportion of uncropped cultivated margins and plots. There were no significant relationships with changes in partridge density, brood size or overwinter survival. Spring and autumn counts of grey partridge were made at 1031 sites across England as part of the Partridge Count Scheme.

20

A replicated site comparison study in 2008 and 2009 on farms in three regions in England (Field et al. 2010) found that in two of the three regions, Higher Level Stewardship fallow plots for ground-nesting birds had significantly fewer seed-eating farmland songbirds than conventional crop fields during summer. On farms in East Anglia and the Cotswolds, there were approximately 2.5 birds/ha on crops compared to 1 bird/ha on fallow plots. However, in a third region, the West Midlands, more seed-eating farmland birds were recorded

on fallow plots than in crop fields (1.5 birds/ha on fallow plots compared to <0.5 birds/ha on crops). The group of birds analysed included tree sparrow *Passer montanus* and corn bunting *Emberiza calandra*, but not grey partridge Perdix perdix. Surveys were carried out in the summers of 2008 and 2009, on 69 farms with Higher Level Stewardship in East Anglia, the West Midlands or the Cotswolds and on 31 farms across all three regions with no environmental stewardship.

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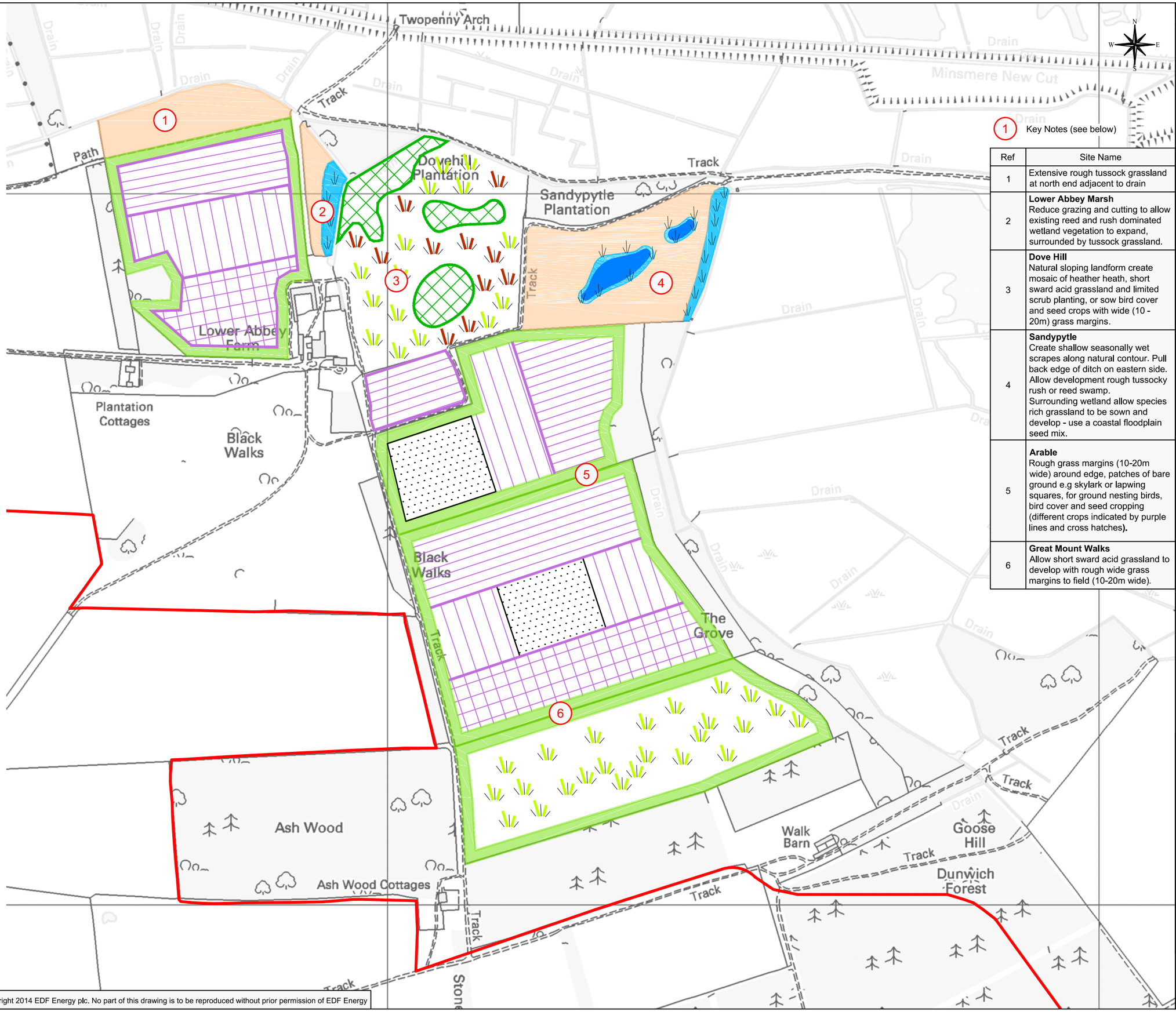


1 Key Notes (see below)

Ref	Site Name
1	Extensive rough tussock grassland at north end adjacent to drain
2	**Lower Abbey Marsh** Reduce grazing and cutting to allow existing reed and rush dominated wetland vegetation to expand, surrounded by tussock grassland.
3	**Dove Hill** Natural sloping landform create mosaic of heather heath, short sward acid grassland and limited scrub planting, or sow bird cover and seed crops with wide (10 - 20m) grass margins.
4	**Sandypytle** Create shallow seasonally wet scrapes along natural contour. Pull back edge of ditch on eastern side. Allow development rough tussocky rush or reed swamp. Surrounding wetland allow species rich grassland to be sown and develop - use a coastal floodplain seed mix.
5	**Arable** Rough grass margins (10-20m wide) around edge, patches of bare ground e.g skylark or lapwing squares, for ground nesting birds, bird cover and seed cropping (different crops indicated by purple lines and cross hatches**).**
6	**Great Mount Walks** Allow short sward acid grassland to develop with rough wide grass margins to field (10-20m wide).

INTERNAL BUSINESS COLLABORATOR REFERENCE

KEY

- Indicative Sizewell C main development site boundary
- Arable
- Tussock Grassland
- Rough Grass Margins
- Bare Ground
- Wetland - Indicative location
- Water
- Heather Heath
- Short Sward Acid Grassland
- Scrub

REVISION	DATE	DRAWN	CHECKED	REASONS FOR REVISION/ COMMENTS	APPROVED

EDF ENERGY

SIZEWELL C

DOCUMENT:

SIZEWELL C PROJECT

DRAWING TITLE:

MARSH HARRIER HABITAT CREATION

DRAWING NO: Figure 2

REVISION: 1.0

DATE: FEB 2015

DRAWN: P.S

SCALE: 1:5000@A3

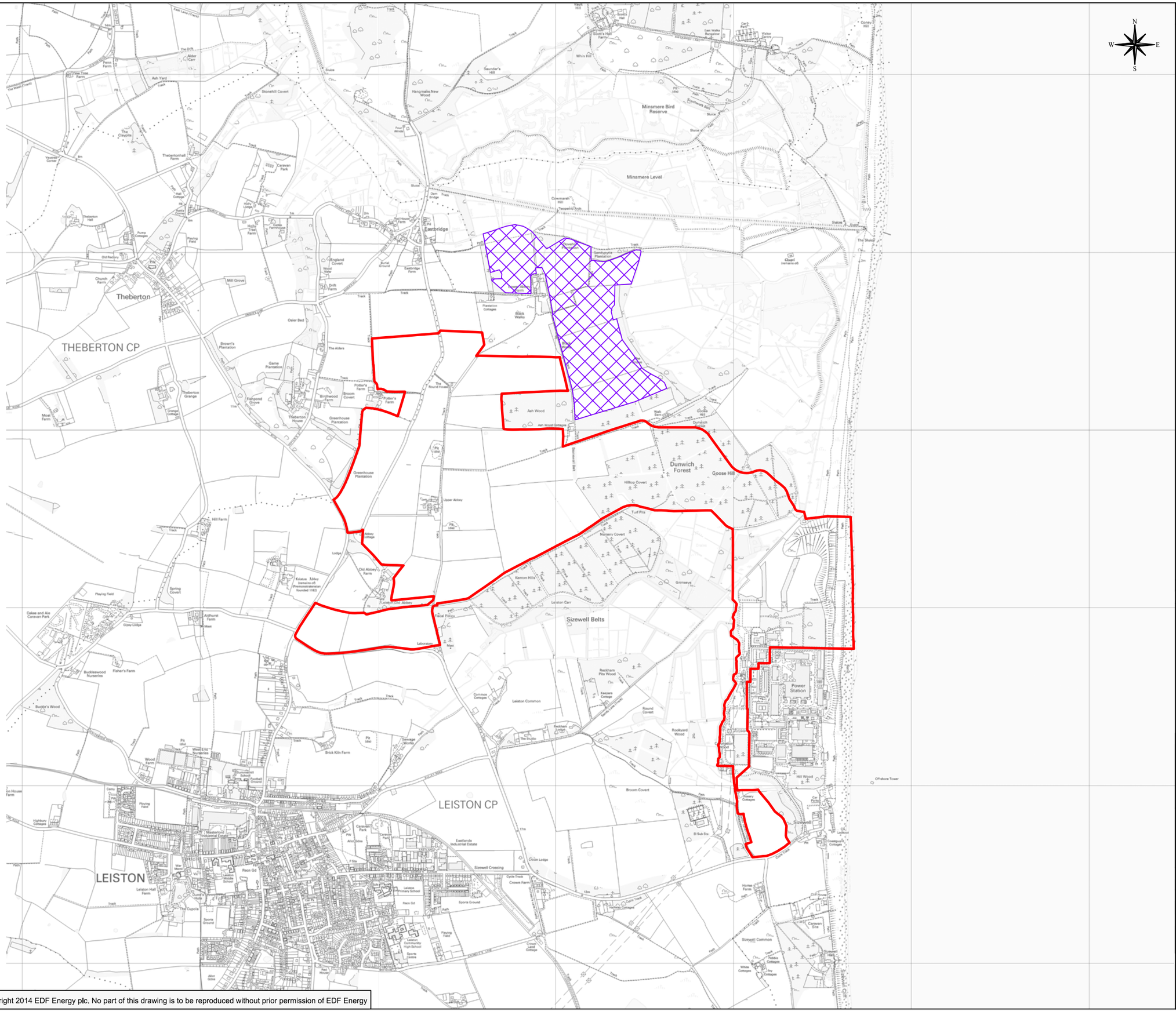
SCALE BAR 0 100 200m

1 : 5000

DRAWING SECURITY CLASSIFICATION

☐ PROTECTIVE MARKING REQUIRED

☒ NOT PROTECTIVELY MARKED



INTERNAL BUSINESS COLLABORATOR REFERENCE

KEY

- Indicative Sizewell C main development site boundary
- Marsh Harrier habitat creation location

REVISION	DATE	DRAWN	CHECKED	REASONS FOR REVISION/ COMMENTS	APPROVED

SIZEWELL C

DOCUMENT:

SIZEWELL C PROJECT

DRAWING TITLE:

MARSH HARRIER HABITAT CREATION LOCATION PLAN

DRAWING NO: Figure 1

REVISION: 1.0

DATE: FEB 2015

DRAWN: P.S

SCALE: 1:20 000@A3

SCALE BAR 0 400 800m

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DRAWING SECURITY CLASSIFICATION

- ☐ PROTECTIVE MARKING REQUIRED
- ☒ NOT PROTECTIVELY MARKED

November 2015
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Appendix B
Review of small mammal and bird densities supported by different habitats and habitat features and justification for inclusion of these in calculations of improvements relative to baseline

The Marsh Harrier Habitat Feasibility report (Amec Foster Wheeler, 2015) presented a summary of data from published sources and work undertaken for EDF Energy at Sizewell on:

- Abundances of rabbits and other small mammals, that would be expected to form part of the marsh harrier diet, recorded in a range of different habitat types;
- Numbers of breeding birds, that would form part of a marsh harrier diet, recorded from the mitigation area in 2007 and 2012;
- Numbers of breeding birds/increase in breeding birds present on an arable farm, managed for the benefit of breeding birds.

A summary is of the information presented in the 2015 report is provided under the 'Background' headings in the following sections, with additional information located since. An assessment of the Baseline situation and also potential abundances in the mitigation area based on the habitats proposed follows the background section.

The baseline is assumed to have been:

- 39.4 ha of intensively farmed arable land.
- 1ha of short grazed grassland.
- 0.71 ha of tussocky grassland at Lower Abbey Farm.
- 1800m of hedgerow (assumed to be 3m wide inc margins) (0.54ha).
- 5.35 ha of wildbird seed/ELS planting.
- Total: 47ha.

Abundance of Rabbits

Background

Harris *et al*. (1995), provides the following summary: '*The most suitable habitats are areas of short grasses, whether these are natural or agricultural. However, they* [rabbits] *are found in a wide variety of habitat types. Densities vary seasonally, with numbers relatively stable over winter (<1 to 15 per ha) followed by highly variable summer peaks (<1 to 40 per ha) (Tittensor 1981). Summer peaks are higher on sandy soils, and over-winter, numbers are higher on sand and chalk than on clay soils (Cowan 1991). The following density estimates were available for over-wintering rabbit populations in specific habitat types:*

- 8.4 animals per ha on chalk grassland, Oxfordshire, based on a capture/mark/recapture study averaged over six winters (Cowan 1984);
- 14-22 per ha on sand dunes, Holy Island, Northumberland, based on marking and population counts (MacDonald 1989);
- 2.1 per ha on sand dunes, East Lothian, using Leslie's trap out method (Kolb 1991a);
- 1.7 per ha on forestry/hill grazing, Borders, using marking and Leslie's trap out method (Kolb 1991b); hill farm/open grazing, Borders, using Leslie's trap out method - (H.H. Kolb pers. comm.); and
- 12.6 per ha on grassland/broom, Strathmore, Tayside, using Petersen/Bailey capture/mark/recapture calculations (H.H. Kolb pers. comm.).'

As another example, whilst Dolman et al (2010) do not state abundances of rabbits present on Breckland grassland, the importance of rabbit grazing to their management is noted and it is reported that '*during*

1855-1862 an average of 28,886 rabbits were harvested annually from Thetford Warren, at a sustainable cropping rate of 24 ha^{-1} yr^{-1}. Clearly, at that time in history there were significantly more rabbits present than 24/ha. However these types of densities are not expected today.

Harris (1995) indicated however that: These figures are for densities that are locally quite high, and if they were typical for all the areas of comparable habitat, they would suggest an over-winter rabbit population approaching 100,000,000. This would be comparable to the estimates of the rabbit population before the introduction of myxomatosis. Whilst the rabbit population is rapidly recovering, it has not reached pre-myxomatosis levels (see below). Thus, for the population estimate, the following density figures were used: 5 per ha for scrub, bracken, sand dunes and sloping coastal cliffs; 2.5 per ha for parkland, lowland heaths, lowland grasslands and arable land; 2 per ha in semi-natural broadleaved, semi-natural coniferous, semi-natural mixed and recently felled woodlands, and broadleaved, coniferous, mixed and young plantations; 0.5 per ha in upland unimproved grassland; and 0.1 per ha in heather moorlands.

Typical rabbit densities in arable fields are not available although arable areas typically do not support extensive cover for rabbits although Harris (1995 made an assumption of 2.5/ha. There are no recorded data on rabbit abundance from the proposed mitigation area or the wider Sizewell Estate. Arcadis however has reported virtually never seeing a rabbit within the proposed mitigation area during site visits. Additionally, the fields were farmed very intensively, such that there was only a narrow grassland margin adjacent to the hedges on site leaving virtually no habitat for them.

Reasonable Assessment of Baseline *Condition*

Whilst Harris assumed 2.5 rabbits /ha this is considered to be high for this site which was intensively farmed and, as indicated above, Arcadis has reported virtually never seeing a rabbit within the proposed mitigation area during site visits. However, not all the area was arable originally. Notably there was a small grass field that is horse grazed (and does support some rabbit activity, and also a small grass field at Lower Abbey Farm. Additionally there were grass margins on some of the edge of the area.

As a result it is concluded reasonable to assume an abundance of 0.5-1 rabbit per ha over the whole 47ha mitigation area.

Potential Abundances in the Mitigation Area Based on the Habitats Proposed

Harris reports a wide range of published abundances of rabbits. In assessing an appropriate abundance for the mitigation area, when established, a figure towards the upper end of the ranges stated for grassland habitats would seem appropriate. Particularly as it is known that there are high (albeit unquantified) densities of rabbits on the adjacent Black Walks and other similar areas of grassland on the Sizewell Estate.

It is therefore considered reasonable to assume that densities of 15-20/ha over-wintering (which translates to a higher number in the summer) are likely in the short grassland areas in the mitigation area. Densities would be expected to be lower in the tussocky grassland areas, perhaps in the range 2.5-5/ha, which is neared to Harris estimate.

Therefore it has been assumed that the proposed mitigation will lead to a 15-40 times increase in abundance of rabbits in the areas managed as short grassland and 2.5-10 times increase in areas managed as tussocky grassland. Hedges are considered to support the populations as rabbits have a large (ish) home range and it is not therefore considered appropriate to calculate a different density for this habitat.

Abundance of Other Small Mammals

Background

Published data on the population densities of small mammals in different habitats are limited and difficult to interpret. However, it is well known that small mammal numbers are generally low in intensively managed arable land.

For example Harris *et al.* (1995)[6] reports for field vole that '*Estimating field vole numbers is also complicated by populations being very patchily distributed at the landscape level. This clumped distribution means that they are easily missed by trapping (D.J. Jefferies pers. comm.), and so density estimates for such a patchily distributed species are largely meaningless. Although the species is both widespread and abundant, there are few estimates of population density, and most density estimates are from isolated fragments of suitable habitat, and so are probably atypical. Tapper (1979) calculated a density of 100 per ha for spring populations in suitable grasslands in southern England, with peak densities of 300 per ha. Ferns (1979) recorded 97 per ha in spring in a young larch plantation, reaching a peak of 128 per ha in early winter. Whilst field voles occur in the grassy banks of arable hedgerows, densities are low (Tew 1994). Densities vary from 1 to 15 per ha in mixed farmland in Morayshire (M.L. Gorman pers. comm.).'* Other studies indicate that field vole densities may be 25-45/ha in road verges and 25-250/ha in rough grassland in Kielder Forest, although there are significant uncertainties in the densities quoted (reported in Flowerdew *et al.*, 2004[7]).

Butet and Leroux (2001)[8] studied vole numbers and the relationship between these and the breeding success of Montagu's harrier in western French wetlands. These authors found significant differences in vole densities between arable crops (mean 43 voles/ha) compared to grazed or mown pastures (mean 51/ha) and abandoned pasture land (mean 102/ha). The authors found that mean vole numbers, pooled across the habitat types present in the study area, of less than 100/ha led to reduced breeding success of the harriers.

Other authors have reported that grassland supports more voles than arable land, for example:

- A number of authors have studied diversity and relative abundance of small mammal species in landscapes of varying agricultural intensity, concluding in general that although overall diversity tended not to be that different between the different intensity situations, the number of animals present did vary, with more animals present in less intensively managed situations (e.g. Michel, Burel and Butet (2006[9] and Moro and Gadal (2007)[10]). This is most likely due to the habitat diversity and increased niches available in a more diverse habitat structure;
- Kok's et al. (2007)[11] indicates that their vole index was twice as high in fallow grassland (set-aside) than arable land;
- Brown R.W. (1999)[12] found that small mammal activity was significantly greater in field margins than in open fields in both organic (142 vs 86 mammals respectively) and conventional systems (139 vs 78). There was no difference between systems. The study was undertaken in Essex and Leicestershire;

[6] Harris, S. et al. (1995). A review of British mammals: Population estimates and conservation status of British mammals and other cetaceans. JNCC.
[7] Flowerdew, J.R. et al. (2004). Live trapping to monitor small mammals in Britain. Mammal Rev. 34(1), 31-50.
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[9] Michel, N., Burel, F. and Butet, A. (2006). How does landscape use influence small mammal diversity, abundance and biomass in hedgerow networks of farming landscapes? *ACTA Oecologia.*
[10] Moro, D. and Gadal, S. (2007). Benefits of habitat restoration to small mammal diversity and abundance in a pastoral agricultural landscape in mid-Wales. Biodivers Conservation 16:3543–3557
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[12] Brown R.W. (1999) Margin/field interfaces and small mammals. *Aspects of Applied Biology*, 54, 203-206.

- Broughton et al. (2014)[13] assessed the benefits to four small mammal species (including field vole) of providing 6m wide field margins (sown with a simple grass mix to provide semi-natural habitat for small mammals, invertebrates and birds, typical of ELS options (e.g. option EE3)) compared to the provision of margins typical of conventionally farmed land (2m wide margin measured from the centre of a hedge, or 1m from the top of a ditch). Vole (and other small mammal) numbers increased significantly from year 0 to year 1 relative to the conventional farming approach, and the mean abundance of field voles in autumn continued to significantly exceed those of the conventional farm in years 2-6 (based on analysis of numbers in the autumn);
- Shore et al. (2005)14 found more bank voles Clethrionomys glareolus and common shrews Sorex araneus on sown grass field margins in autumn than on control cropped margins, but no such differences in spring. There were 13-14 and 26-38 bank voles/autumn trapping period on 3 m and 6 m margins respectively, compared to 0-1 voles on control cropped margins. There were 14-15 and 10-13 common shrews/autumn trapping period on 3 m and 6 m margins respectively, compared to 1-4 common shrews on control margins. Wood mice Apodemus sylvaticus were found in similar numbers on all margin types in autumn and spring (0-29 mice/trapping period);
- Arlettaz et al (2010)15, working in Switzerland, found that small mammal density and species richness were higher in wildflower areas than crops. Wildflower areas (two years old, 1 ha) had more small mammal species and individuals (6 species, 458-1285 individuals/ha) compared to crops or meadows (2-5 species, 0-680/ha). In May and July, small mammal densities were significantly higher in wildflower areas (458-1,030 individuals/ha) and winter wheat Triticum aestivum (90-680/ha) than in tobacco Nicotiana tabacum, permanent and intensive meadows and in May maize Zea mays (0-10/ha) (in July the density in maize was 200/ha). In September, density was significantly higher in wildflower areas (1285/ha) than in winter wheat (0), other habitats had intermediate densities (5-60/ha).
- There are no small mammal density data for the proposed mitigation area but some limited data are available for arable margins in areas south of Ashwood (undertaken in April 2015 by Arcadis for EDF Energy). As an example, a mark, release, recapture exercise undertaken in margins comprising a hedge with 2.5m of well-established tussocky grassland either side, has revealed densities of small mammals16 of 0.055 animals/m^2. If pro-rata'd this would equate to a density of 550 animals/ha (i.e. 2000m of similar hedgerow flanked by tussocky grassland) in similar habitat.

Assessment of Baseline Condition

In calculating the national population of field vole Harris (1995) did not use abundances in different habitats, but instead the likely abundance ratio relative to other species for which there was more data. As there are no population data for the mitigation area this is not possible, although the habitats present are known and therefore an assessment of relative abundance of small mammals can be made based on these and assessment of published abundance data for the different habitats as follows.

[13] Broughton, R.K. et al. (2014). Agri-environment scheme enhances small mammal diversity and abundance at the farm-scale. Agriculture, Ecosystems and Environment 192, 122–129.
[14] Shore R.F., Meek W.R., Sparks T.H., Pywell R.F. & Nowakowski M. (2005) Will Environmental Stewardship enhance small mammal abundance on intensively managed farmland? *Mammal Review*, 35, 277-284
[15] Arlettaz R.L., Krähenbühl M., Almasi B., Roulin A. & Schaub M. (2010) Wildflower areas within revitalized agricultural matrices boost small mammal populations but not breeding Barn Owls. *Journal of Ornithology*, 151, 553-564
[16] Combination of wood mouse, bank vole, field vole, yellow necked wood mouse, common shrew, pygmy shrew, water shrew,

- Small mammal numbers in the open field areas of intensively cropped farmland such as was, until recently present, in the mitigation area will be low, perhaps of the order of 0-20/ha.
- Short grazed grassland is expected to support similar abundances to the arable areas above.
- Tussocky grassland can be expected to support 100-300 small mammals/ha.
- Hedges and field margins are the key habitats for small mammals and can support high numbers of small mammals, of the order of 500-1,000 animals/ha, where there suitable margins (e.g. 3-6 m wide grassland margins). The hedges in the mitigation area, when intensively farmed, were 1m wide grassland either side and hence probably supported fewer small mammals.
- Wildbird seed mix areas would be likely to support relatively few mammals (albeit more than the intensive arable areas), probably of the order of 50-100/ha.

Based on the different habitats present in the mitigation area, when under intensive production the approximately baseline number of mammals supported are estimated in the table below.

		Area (ha)		Min/ha	Max/ha	Min total	Max total
Baseline	Arable	39.4		0	20	0	788
	Short grazed grassland	1		0	20	0	20
	Tussocky grassland	0.71		100	300	71	213
	Hedgerow inc margins	0.54		500	1000	270	540
	Wildbird seed	5.35		50	100	267.5	535
					Range	608.5	2096
				Average	Range/ha	13	45

Potential Abundances in the Mitigation Area Based on the Habitats Proposed

The same range assumptions are applied to the different options to generate the comparative ratio of improvement possible.

Abundance of Breeding Birds

Background

Lack (1988)[17] noted that the largest numbers of individuals and of different species of birds in an area of farmland are on farms with the largest variety of farming types and diversity of habitat type, vegetation and other features. In particular mixed farms hold more bird species than farms with only one major agricultural practice. Intensification generally reduces numbers of individuals and species of birds. Lack made the overarching recommendation to retain as much diversity as possible both in fields and surrounding features.

The proposed mitigation area at Sizewell was farmed intensively for arable crops and, when surveyed in 2012, supported 0.4 territories/ha. It would be expected, based on professional judgement, that numbers of territories in lowland rough grassland and Sandlings grassland/heath (two other possible habitats for the site), would not be significantly greater than this. Indeed, a survey of Broom Covert, an area of Sandlings grassland/heath and scrub, on the Sizewell Estate in 2012, yielded a breeding territory density of potential harrier prey species only a little higher than that for the intensive arable land (0.69/ha) based on the numbers of comparable species that would be likely to be accessible to marsh harrier and hence included in their diet.

[17] Lack, P.C. Farmland Habitat Features and Birds. BTO Research Report No. 29.

Arable farming for birds:

It is however possible to considerably increase the number of breeding bird territories present, relative to both the intensive arable management currently employed and also above that for Sandlings grassland/heath and scrub (another potential alternative habitat for the mitigation area but not considered further due to low breeding farmland bird densities), through sensitive management of arable land for birds. For example, the RSPB's Hope Farm is an arable system that has been subject to sensitive management since 2000, for the benefit of birds. Measures undertaken have provided birds with safe places to nest, food in spring and summer for the chicks and food and shelter over the winter. This has resulted in a three-fold increase in the number of breeding bird territories (considering the 19 species on the Farmland Bird Index), from 122 territories (0.67/ha) in 2000 to 291 (1.6/ha) in 2011 around 1.6 territories/ha. Additionally, the number of wintering birds has increased 6-fold over the same period (to 2011). Whilst some of these will be migratory, many will also be resident birds moving into an area optimised for their presence (providing abundant food and shelter). Providing food sources year round for farmland birds is key to maximising the survival of birds through the winter and hence the breeding population the following spring.

Grassland and Hedgerows

The background data reviewed above indicates that grassland itself is unlikely to support significant numbers of breeding birds. It is hedgerows that will provide the habitat that will support the greatest numbers of breeding birds in farmland (Lack, 1988).

There are no data on typical abundances of breeding birds per unit of hedgerow (it is highly variable). However Lack (1988)[18] discusses the value of hedgerows and features that increase their value for breeding birds. Some principles of hedges are provided:

- Hedges of 2m width with a dense ground herb flora are preferred, especially by partridge, pheasant and reed buntings.
- Tall hedges (>2m) are preferred by small passerines – although tall unmanaged hedges with a thin base are often less attractive.
- More specialist farmland birds such as dunnock, whitethroat and yellowhammer seem less fussy, provided they can nest around 0.5m from the edge.
- Hedges with more diversity of species support more birds and hedges dominated by hawthorn hold more birds than other shrub species.
- Trees are valuable.
- Birds appear to use hedge lines as corridors to move.
- **In general the greater the length of edge per unit area the greater the density of breeding birds present. This occurs at least up to a hedge density of 130m per hectare. However within this range the highest number of species on a whole farm occurs at between about 45 and 70m per hectare, as this retains some of the open country birds while providing enough woody vegetation for the majority.**
- **Hedges within 25m of an intersection hold 70% more birds (wren, dunnock, robin, blackbird, blue tit, great tit, chaffinch and yellowhammer) per unit length than straight sections.**

[18] Lack, P.C. Farmland Habitat Features and Birds. BTO Research Report No. 29.

There is not considered to be a robust way to assess how many birds will nest in a given area of habitat and therefore a proxy has been chosen. Therefore a proxy must be used.

The characteristics listed above can be used to assess the attractiveness of hedges for breeding birds and if optimised increase the number using the mitigation area, although it is recognised that trees are probably not desirable in the context of marsh harrier foraging habitat and would not be recommended.

Scrub and hedge support the most birds whilst open field habitats support relatively few. Therefore the assessment of relative value of the area for breeding birds has been based on the length of hedge/scrub belt per hectare on site, taking account of the comments by Lack, above, and also the number of hedge intersections. Between 45 and 70m per hectare would seem optimal in terms of species diversity but up to 130m per hectare would maximise bird numbers. However the assessment must then take account of the character of marsh harrier foraging habitat and apply professional judgement.

Assessment of Baseline Condition

The mitigation area at Sizewell was farmed intensively for arable crops and, when surveyed in 2012, supported 0.4 territories/ha. However there were only 4 birds nesting in the open fields. The rest were in the surrounding habitats.

As indicated above the baseline condition assessment is based on the length of hedge present and the number of intersections.

There are approximately 1,800m of hedge (38m/ha), some of which is degraded, and no hedge intersections on the proposed mitigation site.

Potential Abundances in the Mitigation Area Based on the Habitats Proposed

The relative value of the mitigation areas for birds is assessed relative to this baseline.

Appendix C
Metric Calculations

wood.

Assessment of relative change in harrier prey item abundance

Baseline areas

39.4	of intensively farmed arable land;
1	of short grazed grassland;
0.71	of tussocky grassland at Lower Abbey Farm; and
0.5	1650m of hedgerow (assumed to be 3m wide inc margins) (0.50ha).
5.35	of wildbird seed/ELS planting
Total	**47 ha**

Results

	Mammals				Birds			
Option	Max number	Min number	Relative to baseline high	Relative to baseline low	Hedge/bank per hectare	Hedge/belt (ratio to baseline)	Intersections	Scrub foci
Option 0	2119	603			35		2	0
Option 1	13601	5457	6.4	9.1	83	2.17	7	19
Option 2	13942	5627	6.6	9.3	89	2.35	18	21
Option 2a	14803	6108	7.0	10.1	89	2.35	18	21
Option 2b	15400	6456	7.3	10.7	89	2.35	18	21
Option 3	12970	5136	6.1	8.5	70	1.83	13	19
Option 3a	13831	5617	6.5	9.3	70	1.83	13	19
Option 3b	14227	5815	6.7	9.6	70	1.83	13	19
Option 4	11523	4313	5.4	7.2	35	0.92	2	19
Option 5	6488	2650	3.1	4.4	35	0.92	13	19
Option 6	13378	4925	6.3	8.2	35	0.92	13	19

Note all numbers of mammals can only be treated as indicative
Ranking based on ratios
Option 5 is a sensitivity test — **Grassland area 3:1 short relative to tussocky (28ha short to 9 tussocky)** — Reduced numbers of mammals as short managed grassland supports few rabbits relative to the number of small mammals in tussocky grassland
Option 6 is a sensitivity test — **Grassland area almost entirely tussocky grassland (35ha to 2ha short managed)** — Very high nos small ammals but very few rabbits - unlikely to be deliverable

Supporting Calcs

		Short grassland			Tussocky grassland			Arable			Wildbird seed mix			Hedgerows/belts (assumed area inc margins)							
Mammals	Max range	Area	small mammals	rabbits	Area	small mammals	rabbits	Area	small mammals	rabbits	Area	mall mammal	rabbits	Length	Area (inc margins)	Small mammals	Rabbits	Areas	Nos SM	Nos Rab.	Numbers of mammals (total)
	Option 0	1	20	20	0.71	213	4	39.4	788	39	5.35	535	5.35	1650	0.50	495	See note	47	2051	68	2119
	Option 1	8	160	160	26	7800	130	0	0	0	8	800	8	4130	4.54	4543	See note	47	13303	298	13601
	Option 2	8	160	160	26	7800	130	0	0	0	8	800	8	4440	4.88	4884	See note	47	13644	298	13942
	Option 2a	8	160	160	25	7500	125	0	0	0	8	800	8	5500	6.05	6050	See note	47	14510	293	14803
	Option 2b	8	160	160	24	7200	120	0	0	0	8	800	8	6320	6.95	6952	See note	47	15112	288	15400
	Option 3	9	180	180	26	7800	130	0	0	0	8	800	8	3520	3.87	3872	See note	47	12652	318	12970
	Option 3a	9	180	180	25	7500	125	0	0	0	8	800	8	4580	5.04	5038	See note	47	13518	313	13831
	Option 3b	9	180	180	25	7500	125	0	0	0	8	800	8	4940	5.43	5434	See note	47	13914	313	14227
	Option 4	9	180	180	28	8400	140	0	0	0	8	800	8	1650	1.82	1815	See note	47	11195	328	11523
Sensitivity test	Option 5	28	560	560	9	2700	45	0	0	0	8	800	8	1650	1.82	1815	See note	47	5875	613	6488
Sensitivity test	Option 6	2	40	40	35	10500	175	0	0	0	8	800	8	1650	1.82	1815	See note	47	13155	223	13378

		Short grassland			Tussocky grassland			Arable			Wildbird seed mix			Hedgerows/belts (assumed area inc margins)							
Mammals	Min range	Area	small mammals	rabbits	Area	small mammals	rabbits	Area	small mammals	rabbits	Area	mall mammal	rabbits	Length	Area (inc margins)	Small mammals	Rabbits	Areas	Nos SM	Nos Rab.	Numbers of mammals (total)
	Option 0	1	0	15	0.71	71	1.775	39.4	0	0	5.35	267.5	0	1650	0.50	248	See note	47	586	17	603
	Option 1	8	0	120	26	2600	65	0	0	0	8	400	0	4130	4.54	2272	See note	47	5272	185	5457
	Option 2	8	0	120	26	2600	65	0	0	0	8	400	0	4440	4.88	2442	See note	47	5442	185	5627
	Option 2a	8	0	120	25	2500	62.5	0	0	0	8	400	0	5500	6.05	3025	See note	47	5925	183	6108
	Option 2b	8	0	120	24	2400	60	0	0	0	8	400	0	6320	6.95	3476	See note	47	6276	180	6456
	Option 3	9	0	135	26	2600	65	0	0	0	8	400	0	3520	3.87	1936	See note	47	4936	200	5136
	Option 3a	9	0	135	25	2500	62.5	0	0	0	8	400	0	4580	5.04	2519	See note	47	5419	198	5617
	Option 3b	9	0	135	25	2500	62.5	0	0	0	8	400	0	4940	5.43	2717	See note	47	5617	198	5815
	Option 4	9	0	135	28	2800	70	0	0	0	8	400	0	1650	1.82	908	See note	47	4108	205	4313
Sensitivity test	Option 5	28	0	420	9	900	22.5	0	0	0	8	400	0	1650	1.82	908	See note	47	2208	443	2650
Sensitivity test	Option 6	2	0	30	35	3500	88	0	0	0	8	400	0	1650	1.82	908	See note	47	4808	118	4925

Assumptions in mammal calcs

Contribution of scrub foci for rabbits asssumed included in the short grassland calcs.
Abundance assumptions from note:

Short grassland	Small mammals	0-20/ha
Short grassland	Rabbits	10-15/ha
Tussocky grassland	Small mammals	100-300/ha
Tussocky grassland	Rabbits	2.5-5/ha

Hedges in mitigated area assumed to have wide margins (5m either side, 11m in total)
However hedges al;ong footpath have margin on only one side in the calcs above (so 5m total)

Hedge/scrub belts (assumes grass margins present)	Small ammals	500-1000/ha
Hedge/scrub belts (assumes grass margins present)	Rabbits	Within main habitat numbers
Arable/wildbird seed	Small mammals	0-20 arable, 50-100/ha
Arable/wildbird seed	Rabbits	0-1/ha

Birds

Relative Value	Hedge length	New belts (m length)	Hedge/ Belt length per hectare	Intersections	Scrub foci	Hedge/belt (ratio to baseline)
Option 0	1650	0	35	2	0	
Option 1	1650	2230	83	7	19	2.17
Option 2	1650	2540	89	18	21	2.35
Option 2a	1650	2540	89	18	21	2.35
Option 2b	1650	2540	89	18	21	2.35
Option 3	1650	1620	70	13	19	1.83
Option 3a	1650	1620	70	13	19	1.83
Option 3b	1650	1620	70	13	19	1.83
Option 4	1650	0	35	2	19	0.92
Option 5	1650	0	35	13	19	0.92
Option 6	1650	0	35	13	19	0.92

Note that intersections can be increased by having vehicle entrance in middle of hedge rather than at what would otherwise be intersection

Metric of Habitat Provision for Prey Items

Criteria	Tussocky grassland	Score	Short grassland	Score	Scrub foci (no.)	Score	Linear feature (hedge and earth bank) /ha	Score	Hedge intersections	Score
	0-4.9ha	**1**	0-4.9ha	**1**	0	**1**	0-19.9	**1**	0 to 5	**1**
	5-9.9ha	**2**	5-9.9ha	**2**	1 to 5	**2**	20-39.9	**2**	6 to 10	**2**
	10-14.9ha	**3**	10-14.9ha	**3**	6 to 10	**3**	40-59.9	**3**	11 to 15	**3**
	15-19.9ha	**4**	15-19.9ha	**4**	11 to 15	**4**	60-79.9	**4**	16 to 20	**4**
	20-24.9ha	**5**	20-24.9ha	**5**	16 to 20	**5**	80-99.9	**5**	20 to 25	**5**
	25-29.9ha	**6**	25-29.9ha	**6**	20 to 25	**6**	100-119.9	**6**	26 to 30	**6**
	30-34.9ha	**7**	30-34.9ha	**7**	26 to 30	**7**	120-139.9	**7**	31 to 35	**7**
	35-39.9ha	**8**	35-39.9ha	**8**						

	Short grassland	Metric score	Tussocky grassland	Metric score	Linear feature length	Linear feature / ha	Metric score	Intersections	Metric score	Scrub foc	Metric score		Overall metric score	
Relative Value	**Area**		**Area**		**Comprises banks and belts where separate**									**Rank**
Option 0	1	1	0.71	1	1650	35.1	2	2	1	0	0	**Option 0**	**7**	
Option 1	8	2	26	6	4130	87.9	5	7	1	19	4	**Option 1**	**18**	**7**
Option 2	8	2	26	6	4440	94.5	5	18	4	21	5	**Option 2**	**22**	**3**
Option 2a	8	2	25	6	5500	117.0	6	18	4	21	5	**Option 2a**	**23**	**2**
Option 2b	8	2	24	6	6320	134.5	7	18	4	21	5	**Option 2b**	**24**	**1**
Option 3	9	2	26	6	3520	74.9	4	13	3	19	4	**Option 3**	**19**	**6**
Option 3a	9	2	25	6	4580	97.4	5	13	3	19	4	**Option 3a**	**20**	**5**
Option 3b	9	2	25	6	4940	105.1	6	13	3	19	4	**Option 3b**	**21**	**4**
Option 4	9	2	28	6	1650	35.1	2	2	1	19	4	**Option 4**	**15**	**8**
Option 5	28	2	9	6	1650	35.1	2	13	3	19	4	**Option 5**	**17**	
Option 6	1	0	36	0	1650	35.1	2	13	3	19	4	**Option 6**	**9**	