HS2

Phase One Barn Owl Mitigation Plan

March 2024

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Department for Transport

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List of acronyms

ARS: Active Roost Site

BAP: Biodiversity Action Plan

BOCN: Barn Owl Conservation Network

BOMP: Barn Owl Monitoring Programme

BOMS: Barn Owl Monitoring Scheme

BORN: Barn Owl Recovery Network

BTO: British Trust for Ornithology

CFA: Community Forum Area

EWR: East West Rail

GIS: Geographic Information System HE: Highways England

HS2: High Speed Two

HS2 Ltd: High Speed Two Limited, the company responsible for developing and promoting the UK's new high speed rail network

HSE: Health and Safety Executive

NE: Natural England

OBS: Occupied breeding site

PNS: Potential nest site

SRA: Species Recovery Area

TWAO: Transport and Works Act Order

1 Executive Summary

1.1.1 This Mitigation Plan (the Plan) seeks to ensure that best practice guidelines are followed to minimise any adverse effects of HS2 on barn owls and maximise potential benefits, thereby ensuring legal compliance, the delivery of statutory duties and Government policy.

1.1.2 The construction of Phase One of HS2 and the promotion of the Greatmoor Transport and Works Act Order in relation to the Greatmoor Sidings (the 'Scheme') has the potential to cause a significant reduction in the barn owl Tyto alba population with the loss of up to 80 breeding pairs. During construction, and in the absence of mitigation, barn owls would be subject to significant adverse effects due to the destruction of nest sites, loss of foraging habitat and potential disturbance whilst nesting. Once operational, there is high potential for a further significant adverse effect on breeding barn owls within 1.0-1.5 km of the HS2 route and to adult females within 3 km, due to train strike. The London – West Midlands Environmental Statement identified the residual adverse effects at a national level, and a commitment was therefore made to compensate for these effects.

1.1.3 Compensatory habitat, including key habitat components such as artificial nest sites, will be provided in the wider landscape and outside the main area of collision risk, 3-10 km from the HS2 route and within counties affected by the Scheme. At those locations where significant barn owl movement across the rail line is thought likely, natural screening, which aims to direct barn owls above the height of trains, will be considered during the construction and landscaping phases of the Scheme. The mitigation and compensation measures are summarised in Table 1 below.

1.1.4 Through the successful implementation of the mitigation and compensation measures proposed in this Plan, it is expected that the residual effect on barn owls will be reduced to a level that is not significant.

Table 1: Barn Owl Mitigation Plan: Summary of Aims, Objectives and Actions

Aim	Objective	Action	Effect	Delivery
1. During land clearance and	Prevent damage to barn owls and	**Temporary protective**	Protect barn owls and prevent nest	Prior to and during land- clearance

Aim	Objective	Action	Effect	Delivery
construction avoid nest disturbance	disturbance to their active nests during land clearance and construction	**mitigation** Prior to land clearance and construction, cap/net-off occupied breeding sites and potential nest sites within and 175 m outside construction site boundaries and occupied breeding sites during the non-breeding season (1st October-1st March) and, in advance of this, install replacement nestboxes between 200m and 300 m outside construction site boundaries. Where the set approach cannot be followed, a suitable alternative that still avoids risks of disturbance to barn owls will be identified and followed	disturbance in and within 175 m of construction sites	and/or construction activity. Beginning 2018
2. Maintain size of breeding population	Create a target of 240 artificial nest sites at least 3 km from the Scheme	**Compensation** Suitably experienced ecologist to coordinate installation of artificial nest sites	Following operation, compensate fully for loss of 80 barn owl pairs nesting within 1.5 km of HS2 route	At least three years prior to HS2 operation
3. Facilitate survival during operation by reducing, where possible, collision risk	Consider, and install where practicable, natural screening at high potential collision risk locations	**Averting mortality** Where practicable, install high vegetation screens at high potential collision risk	Attempt to reduce risks of collision	During landscaping phases

Aim	Objective	Action	Effect	Delivery
		locations		
4. Evaluate the success of the Plan	Confirm and improve understanding of the impacts of the Scheme on the local barn owl population and success of the Mitigation Plan	**Monitoring** Suitably experienced ecologist to coordinate nest monitoring/ maintenance activities undertaken by NE barn owl licensees	Provide annual outcomes of nest monitoring in respect of barn owls and non-target species	Annually for 10 years, including at least three years prior to HS2 operational phase and at least five years during operational phase

2 Introduction

2.1.1 The construction of Phase 1 of HS2 and the promotion of the Greatmoor Transport and Works Act Order (TWAO) in relation to the Greatmoor Sidings (hereafter referred to jointly, as the 'Scheme') has the potential to cause a national level adverse effect on the barn owl population. This assessment was based on the UK population of 4,000 breeding pairs as reported in the HS2 Phase 1 Environmental Statement. This effect is due to the destruction of nest sites, loss of foraging habitats and habitat integrity during construction, and mortality due to train strike once the Scheme becomes operational. Collectively this will result in the permanent loss or depletion of barn owl pairs that currently breed within 1.0-1.5 km of the HS2 route. It also has the potential to affect those adults within 3 km of the route, some of which are known to extend their range outside the breeding season.

2.1.2 Due to the likely significant effects of the Scheme, HS2 Ltd. has committed to the development and delivery of a Barn Owl Mitigation Plan (previously referred to as the Action Plan and hereafter as the 'Plan') to detail the mitigation measures that will be undertaken to reduce the effects to a level that is not significant. Relevant assurances are:

- 886 ("...to establish a plan to deploy barn owl nest boxes to support barn owl populations affected by the Proposed Scheme."),
- 2704 ("... the Promoter will reconvene the Barn Owl action group in January 2017 to discuss how to take forward results from an independent report into the dispersal of this species. This will inform mitigation measures both near the line to prevent collisions and in the wider landscape to enhance existing populations."), and
- 2617 ("The Promoter will require the nominated undertaker, where they can be carried out without affecting the safe operation and effective maintenance of the new railway, to use reasonable endeavours to have regard to the measures proposed in the barn owl action plan when developing barn owl mitigation measures during detailed design. These measures will be informed by the independent dispersal study carried out by the British Trust for Ornithology, as recommended by the HS2 barn owl action group.").

2.1.3 The Plan is designed to provide measures which through implementation will both mitigate and compensate for the predicted adverse effects of the Scheme on the barn owl breeding population within 1.5 km of the route. Appendix 1 lists the other key Scheme documents to which this Barn Owl Mitigation Plan is linked. These should be read in conjunction with this document.

2.1.4 Measures aimed at mitigating the effect of damage and disturbance to active nests during land clearance and construction will mainly fall within the Act limits of the High Speed Rail (London - West Midlands) Act 2017, (referred to as the 'Act limits'). However, the measures designed to compensate for the route-wide reduction in the breeding population will, by necessity, take place on private land beyond these Act limits. This has dictated the Plan's strategy and method of implementation and it is expected that the Plan will provide consistency of approach and a best practice model for future phases of HS2.

3 Background

Background information on the ecology of barn owls, relevant to the development and rationale of the Plan is provided in Appendix 2 whilst more general ecology is presented in Appendix 3. To assist the reader the references quoted in these two Appendices are included in the main list of references in section 11 rather than in separate lists. An explanation of the data analysis process used to inform the plan is presented in Appendix 4.

3.1 Potential impacts recorded in the HS2 Phase One Environmental Statement, Volume 3: Route-wide effects

3.1.1 Barn owls will be subject to significant adverse effects due to loss of nesting sites and foraging habitat during construction. In addition, during operation, there is the potential for mortality due to train strike; resulting in further significant adverse effects. Overall, the Environmental Statement reported that, on a precautionary basis, there may be loss of up to 52 pairs of barn owl due to these combined effects. This was reported as equivalent to approximately 1% of the UK population and that route-wide, these losses will result in a permanent residual adverse effect, significant at national level.

3.1.2 To offset the likely loss of barn owls from the vicinity of the Proposed Scheme, the Environmental Statement stated that opportunities to provide artificial barn owl nestboxes in areas greater than 1.5 km from the route will be explored with local landowners. As the availability of nesting sites has, since the mid 1990's, become a limiting factor for this species, the implementation of these measures is likely to increase numbers of barn owl within the wider landscape. If the proposed mitigation measures for barn owls are implemented by barn owl specialists and through liaison with landowners, the residual effect on barn owls will be reduced to a level that is not significant.

3.2 Potential impacts recorded in the Greatmoor Railway Sidings Transport and Works Act Order: Environmental Statement

3.2.1 Due to concerns raised during the passage of the Phase One Hybrid Bill through Parliament, HS2 Ltd has agreed to promote a TWAO under the Transport and Works Act 1992. This will provide railway sidings to the south of Sheephouse Wood at

Greatmoor (approximately 1.8 km from Calvert), north-west of Quainton in Buckinghamshire.

3.2.2 The ES reported that the barn owl population north-west of Quainton comprises two breeding pairs which represents more than 1% of the county population and is therefore of county importance. No barn owl nest sites were confirmed and recorded within the land required for construction of the Proposed Scheme but several mature trees were assessed as having potential to support breeding barn owls.

3.3 Cumulative Impacts of the East West Rail Phase 2 Project

3.3.1 It is anticipated that the Scheme, in combination with that of the East West Rail Phase 2 Project (EWR2) upgrade, will result in a cumulative adverse impact on barn owls within the vicinity where these two schemes interact. The risk of this cumulative impact has been taken into account in the development of this Plan.

3.4 Update on Barn Owl population

3.4.1 In 1987 the Barn Owl Survey of Britain and Ireland recorded a population of 4,450 breeding pairs (Shawyer, 1987). Following implementation of the UK Conservation Strategy (Brazil and Shawyer, 1989) and the UK Barn Owl Species Action Plan (Williams and Galbraith, 1992) concerted efforts to restore this species has led to an estimated population today of between 9,000-12,000 pairs (Shawyer, 2014; Hayhow et al 2017). As a result, in 2016 the barn owl was removed from the 'amber list' of Species of Conservation Concern in the UK and upgraded to the 'green list' (Eaton et al, 2015). Continued survival of the barn owl in Britain today relies on the availability of artificial nest sites such as nestboxes and nest towers and because of the high vulnerability of these sites to loss, damage and deterioration and the barn owl's sensitivity to disturbance whilst breeding, the species remains on Schedule 1 of the WCA 1981 (as amended).

4 Development and Focus of the Plan

4.1 Development

4.1.1 In order to develop this Plan and optimise the mitigation and habitat compensation measures required to achieve a successful outcome, a detailed understanding is required of barn owl ecology together with the factors which currently limit population growth. In particular, a knowledge of barn owl movements, settlement patterns and the size of home range are necessary to determine the distance at which barn owls are at significant risk from collision with rail traffic and the area within which the breeding population will be affected when the Scheme becomes operational. Appendix 2 discusses those aspects of barn owl ecology that can potentially be affected by rail mortality and how in the absence of effective mitigation the size of the breeding population can also be affected.

4.1.2 Between 2013 and 2016, barn owl field surveys and desk studies were undertaken for HS2 Ltd using best practice methods (Shawyer, 2011) within 1.5 km and 5 km of the Scheme respectively. 1.0-1.5 km is considered the distance within which a local breeding population is at greatest risk of being lost or depleted as a result of collision with high speed traffic. Desk studies, on the other hand which extend to 5 km from the HS2 route, have enabled the significance of the impacts of the Scheme to be identified at the local, regional and national levels. Route-wide the locations of known breeding sites are provided within broad measures of confidence (*patchy, partial* or *dedicated*) and provide information of Species Recovery Areas (SRAs) and Barn Owl Recovery Networks (BORNs) associated with the Scheme. Collectively, information derived from both the field surveys and desk studies have been used to formulate the Plan.

Informing the Plan

4.1.3 In 2013, dedicated barn owl desk study and field survey were undertaken as far as land access was available and the combined data was used to inform the HS2 Phase 1 Environmental Statement. After 2013, barn owl surveys were extended as far as new land access allowed. This enabled further route-wide data to be obtained and in combination with an updated and extended desk study these data were analysed to inform the Plan (Appendix 4).

4.1.4 A total of 607 precise (six-figure OS Grid) and 19 broader (four-figure OS Grid) barn owl sites were recorded within 1.5 km of the 230 km long route-wide Scheme representing an area of 690 km^2. Of these sites, 88 could be defined as occupied breeding sites or nest sites offering evidence of high breeding potential (OBS) (Figure 1). This suggests an average population density of 0.12 pairs per km^2.

4.1.5 Taking into account the section of line between the M25 and Great Missenden where barn owls will be protected from train strike by a 15 km bored tunnel, it is concluded that a total of 80 barn owl breeding pairs are likely to be affected route-wide by the Scheme.

The highest concentration of occupied nest sites on the Scheme route largely fall within four barn owl Species Recovery Areas (SRAs) (Shawyer, 2011) where intensive conservation effort has been applied during the last 20 years in accordance with regional barn owl conservation programmes and the UK Barn Owl Action Plan (Williams and Galbraith, 1992). The SRA's and highest relative barn owl population densities are centred on the previously defined Community Forum Areas (CFA): CFA9, Central Chilterns; CFA11, Stoke Manderville and Aylesbury; CFA12, Waddesdon and Quainton; CFA13, Calvert, Steeple Claydon and Calvert, Twyford and Chetwode; CFA15, Greatworth to Lower Boddington, CFA16 Ladbroke and Southam; CFA20, Curdworth to Middleton; and CFA21, Drayton Bassett, Hints and Weeford.

4.2 Focus

4.2.1 The Plan should not be considered as an all-embracing barn owl action plan and does not seek to disseminate general information or engage individuals on the wider aspects of barn owl conservation. This advice is freely available elsewhere and has been provided by barn owl practitioners and farm conservation advisers since 1988. However, the delivery of the Plan will include specific advice for relevant landowners concerning habitat creation and the optimal management of rough-grassland along with information on the use, maintenance and monitoring of artificial nest sites. This could be assisted by an illustrated advisory leaflet, specific to the Scheme.

4.2.2 The compensation and mitigation measures recommended in this Plan have been tailored from those used in major road infrastructure schemes where, following implementation of these measures, population monitoring has demonstrated, and continues to demonstrate, high levels of success (Shawyer and Segar, 2013; Shawyer, 2017).

4.2.3 Although the Scheme is an exceptionally large infrastructure project and owl towers would in this instance be considered an appropriate option for mitigation, these structures would be required on private lands outside that governed by the Act. This is likely to place constraints on achieving the necessary agreement for securing the land plots required for their installation. However, owl towers will be considered at locations throughout the route corridor where landowners show a willingness to accommodate them, whilst nestboxes, which rely solely on the availability of existing trees and buildings on private farmland, will offer the greatest scope for the rapid and successful delivery of the Plan.

4.2.4 The Plan is also required to ensure that barn owls are not disturbed during the land clearance and construction phases of the Scheme. This will be implemented through the use of temporary mitigation measures which seek to avoid damage or disturbance to those barn owls which breed within the boundary or in close proximity (175 m) to it.

4.2.5 Nest occupancy is the key nest monitoring parameter for determining population size and is the main parameter used when undertaking local and national barn owl surveys (Shawyer, 1987; Toms et al, 2001) and for evaluating the success of mitigation schemes. For this Scheme, nest monitoring will be used. Success will be determined by the number of breeding pairs which have taken up residence in the artificial nest sites after a period of three full breeding seasons.

5 Aims and Overview of Actions

5.1 Aims and Objectives

Construction Phase

1. Aim: During land clearance and construction avoid nest disturbance

   Objective: Prevent damage to barn owls and disturbance to their active nests during the land clearance and construction phases of the Scheme and enable, where possible, a successful outcome for barn owls breeding within 175m of the construction site.

Operational Phase

2. Aim: As a minimum, maintain barn owl numbers in those counties through which the Scheme will operate by compensating for the loss of breeding pairs and the consequent abandonment of ancestral breeding sites within 1.5km of the rail line.

   Objective: Create a target of 240 artificial nest sites at least 3km from the Scheme.

3. Aim: Facilitate the survival of barn owls during operation of the Scheme by reducing, where possible, collision risk.

   Objective: Consider and install where practicable, natural screening at high collision risk locations.

4. Aim: Evaluate success of the Plan.

   Objective: Confirm and improve understanding of the impacts of the Scheme and the compensatory works undertaken to maintain the current barn owl population.

5.2 Overview of actions

To meet the above aims the following actions will be required.

Temporary Protective Mitigation

5.2.1 Consult HS2 GIS mapped barn owl survey information via gViewer prior to any clearance or construction works and where necessary implement appropriate mitigation measures to avoid damage to active nest sites and breeding disturbance. Details of the methods to be used are provided in Section 6.2 and summarized in the checklist in Appendix 5.

Compensation outside the Act limits

5.2.2 Ground-truth the indicative farmland sites provided by the Plan. This exercise will identify suitable barn owl foraging habitat and artificial nest sites will then be installed as key habitat components approximately 3 km or more from the Scheme and a minimum distance of 1 km from known breeding sites. Detailed methods are provided in Section 6.3.

Averting Mortality

5.2.3 At the potential high collision risk locations identified by the Plan consideration will be given to natural barriers/screens where practicable to reduce mortality. Detail is provided in Section 6.4.

Monitoring

5.2.4 In order to confirm and improve understanding of the impacts of the Scheme on the barn owl population and evaluate the success of the Plan, annual nest monitoring during construction and after the Scheme becomes operational will be undertaken. Nest monitoring will be aimed primarily at determining nest occupancy by barn owls and other non-target species in the new nest sites and will be accompanied by nest maintenance. Detail is provided in Section 7.

6 Mitigation and Compensation

6.1 General approach

6.1.1 Mitigation should be planned by a suitably experienced ecologist. Any aspects of mitigation that could involve disturbance of barn owls (e.g. monitoring) will be undertaken by a NE barn owl licensee. Most of the route-wide barn owl nest sites (mainly nestboxes) recorded during the survey stages of the Scheme, including those that now fall within or adjacent to the construction site boundaries, have been provided by the Barn Owl Conservation Network (BOCN)/British Trust for Ornithology (BTO) county teams and are monitored annually by them under NE licence (for contact details: see Appendix 5). The ecologists planning and coordinating barn owl mitigation should engage with these county teams at an early stage to ensure that the latest information on nesting barn owls is used to inform final details of mitigation. Where possible BOCN county teams should be used to ensure their local knowledge, which includes existing relationships with landowners, is used to develop proposals.

6.2 Temporary Protective Mitigation

6.2.1 General provisions contained in the Phase One Code of Construction Practice, Chapter 9: Ecology, including those for protected and/or notable species, will apply during the construction of the Scheme.

6.2.2 Within the construction site boundary and 175 m beyond this limit (where active breeding sites can be considered at risk from disturbance) and following the route-wide barn owl survey, a total of 88 occupied breeding sites (OBS) and potential nest sites (PNS) have been identified in clusters or as single sites (Figure 2)[1]. To ensure that any active nests are not damaged or disturbed during construction, works are compliant with the legislation, and a potential ecological constraint to the Scheme can be avoided, the suitably experienced ecologist will undertake nest exclusion measures at all OBS and PNS. This will involve capping or netting at these sites outside the breeding season and in advance of works (Shawyer, 2011). At the same time, the suitably experienced ecologist will determine areas where re-survey is

[1] Active roost sites (ARS) have been accounted for within the plan. Where ARS occurred in the HS2 survey records they were upgraded to PNS where applicable.

required. Any additional nest sites identified would also be subject to appropriate mitigation.

6.2.3 To mitigate for their temporary forfeiture, nestboxes (according to Spec: 1004 - Appendix 6) should be installed between 200 m and 300 m from the construction boundary prior to exclusion. Where clusters of OBS and/or PNS occur these may be replaced by a single nestbox[2]. Installation should take place a year in advance of potentially disturbing activities, where practicable. Temporary mitigation should remain in place for the duration of construction and removed (subject to landowner agreement) in the winter prior to commencement of the Scheme's full operational phase. The approach is set out for ease of reference in the checklist in Appendix 5.

6.2.4 Where the set approach cannot be followed, a suitable alternative that still avoids risks of disturbance to barn owls will be identified and followed (e.g. Shawyer, 2011).

6.3 Compensation outside the Act limits

6.3.1 For large infrastructure projects of this type compensatory works are often required to offset the effects of habitat and species loss. In this respect the barn owl presents a unique ecological challenge when attempting to design an effective mitigation strategy. As a result of the high risk of rail mortality and the consequent depletion or loss of established breeding populations within 1-1.5 km of the route, mitigation measures which aim to compensate for these losses are required beyond this distance. This falls outside the limits of the Scheme and hence, outside its area of influence or control.

6.3.2 The main objective of the Plan is, however, to ensure no net loss of barn owl breeding numbers and maintain the existing population at its current level. Mitigation strategies that deal with schemes which involve a high level of collision risk do not seek to eliminate the mortality which is expected to occur but where possible reduce it to a level commensurate with maintaining the population.

6.3.3 Barn owl recovery programmes or species action plans currently operate in the six counties affected by HS2 Phase 1. Integration of the Plan with the county barn owl recovery projects and those who operate them would provide the best opportunity for its successful outcome. This would help to ensure that the existing conservation and research programmes and the landowner support on which these rely, are not

[2] A cluster may occur where two or more OBS and/or PNS are situated within 500m of one another. Professional ecological judgement should be used to determine such sites.

damaged or compromised, duplication of effort is avoided and that continued success for the species conservation in these six counties is maximised.

6.3.4 To reduce the effect of the Scheme on local barn owl populations, compensation will be accomplished by identifying land, mainly private farmland and local nature reserves outside the Act limits, for the installation of nestboxes and / or owl towers.

6.3.5 To compensate for the potential loss of breeding barn owls within the 3-km wide rail corridor, a target of 240 artificial nests will be installed to the approved specifications, (nestboxes, Spec:1004; owl tower, Spec:1006; Method Statement, Spec:2004/Spec:2001 and Installation Statement, Spec:2005) in suitable habitat at approximately 120 sites. If alternative specifications are proposed they will only be used if given prior approval by HS2 Ltd.

6.3.6 Scrutiny of the HS2 barn owl survey data, high definition satellite, Countryside Stewardship, water network and nature reserve maps, together with barn owl suitability map imagery (Barn Owl Trust, 2015) have been used to produce the indicative maps which inform this Plan (Figure 3, with example of detail in Figure 4). The typical size of the land areas within which the artificial nests will be considered, range from 50-350 ha. It is anticipated that this set of search areas will provide sufficient suitable locations.

6.3.7 The indicative sites detailed will, following landowner agreement, be assessed for suitability of habitat, and the availability of trees and built structures for the installation of artificial nest sites and suitable land plots for owl towers.

6.3.8 The Plan recommends that 240 artificial sites are needed to deliver a conservative 33% uptake of barn owls at these nest sites after 3 years of their installation and thereby compensate fully for those breeding barn owls which are likely to be lost to the Scheme. The 33% uptake level falls below that achieved by the author for two major road mitigation schemes in eastern England where in both cases, 100% of the nestboxes provided by way of this mitigation were used by breeding barn owls within 3 years of their installation (Shawyer and Segar, 2013; Shawyer, 2017). This percentage level of uptake is also below that of two major conservation and nest monitoring schemes in Warwickshire and Staffordshire which in 2017 recorded nest occupancy levels of 40 and 45% respectively, but in Northamptonshire this was reported at 32% (Jackson, 2017). A precautionary approach is taken by predicting occupancy based on the results for Northamptonshire.

6.3.9 The target 33% uptake assumes artificial nest sites are sited by a barn owl specialist in currently vacant, optimum or near-optimum habitat and best practice standards for materials, fixings and installation are applied (Appendix 5).

6.3.10 To avoid the cumulative adverse impacts of the Scheme with EWR2, these two schemes will require joint action to mitigate for the breeding barn owls affected within and near to their respective construction site boundaries. However, where the Scheme and EWR2 intercept near Grebe Lake, Calvert, Buckinghamshire, the cumulative effects arising from barn owl mortality and the potential loss of breeding pairs within 1.5 km are largely compensated for by the HS2 Plan itself. This is because the Plan is providing new artificial nest sites 3 km from the Scheme route and along the section between Greatmoor and Twyford Mill, but will, at this location, avoid their installation within the 6 km-wide EWR2 route corridor.

6.3.11 Advice and where possible, actions to bring land into effective conservation management will complement the mitigation measures that are undertaken. Reasonable measures will be undertaken to identify areas, mainly, private farmland and local nature reserves outside the Act limits, for providing advice on the establishment of key barn owl habitat.

6.4 Averting mortality

6.4.1 Research has shown that barn owl mortality 'blackspots' can arise where linear grasslands on the banks of watercourses and other linear features of the landscape, feed onto major roads (Shawyer and Dixon, 1999). For the Scheme, these are considered to be:

Bourne Brook, Hints; Langley and Gallows Brooks, Middleton; River Tame, Water Orton; River Cole, Coleshill; River Blythe, Hampton in Arden; Fincham Brook, Kenilworth; River Avon, Kenilworth; River Leam, Royal Leamington Spar; River Itchin, Deppars Bridge; Oxford Canal, Wormleighton; River Cherwell, Aston le Walls and Edgecot; Turweston and Westbury Mill where the River Ouse and a disused rail line intersect the Scheme; Padbury Brook, Twyford; unnamed stream, Quainton; River Thame, Aylesbury and River Colne, Denham Green.

6.4.2 The widespread removal of potential barn owl foraging habitat along the length of the Scheme and the route-wide planting of high vegetation screens or barriers is neither a practical or proportionate measure for this Scheme. However, the use of 100m long raised earth bunds planted with high vegetation, either side of the track, may be of value where either potential or known barn owl mortality 'blackspots' occur. Their design profile (Spec: 0982 -Appendix 6: Shawyer and Dixon, 1999) allows for barn owls attempting to fly across the rail line to be deflected above the height of traffic whilst providing an open and uninterrupted flight-path behind the earth bunds for those owls which are using these rail-side verges as a foraging resource. The screens, currently prescribed for roads, are usually only practicable where rail verges are of ample width and offer sufficient length (100m) to accommodate them (to reduce the opportunity of barn owls diverting around them).

6.4.3 Barriers or screens are most likely to have greatest potential at strategic locations (see above) on the HS2 route and within the Act limits where prey-rich linear grasslands intersect the Scheme and offer principal flight corridors and dispersal networks for barn owls.

6.4.4 It is considered that the locations identified in 6.4.1 are likely to provide some of the key flight corridors used by barn owls, thus resulting in potential 'blackspots' when the Scheme becomes operational. These 'blackspots' should be re-evaluated during the latter stages of construction and during the landscaping phases of the Scheme when more will be known about the grassland habitats associated with these locations and the relevance and practicality of incorporating vegetated screens into the Scheme. If appropriate, high vegetation planting, potentially on earth bunds depending on local site conditions and constraints, should be added to the landscape design at key locations if the design does not already accommodate this function for other reasons such as screening or noise mitigation.

7 Monitoring and Maintenance

7.1.1 Annual nest monitoring methods, based on those successfully developed and validated for the BTO's 10-year Barn Owl Monitoring Programme (BOMP) and for that of BOMS, will be used. Recording of data conforms to the approved standards of NE and the BTO's Ringing and Nest Recording Schemes and as such is used routinely by the BOCN/BTO nest recorders and ringers in England. The approved standard for nest monitoring, recording and reporting is presented in HS2 Technical Standard – Phase 1 Ecological Monitoring Strategy.

7.1.2 Nest monitoring and general nest maintenance should be undertaken simultaneously on two occasions where practicable (normally between May and August, following the UK protocol of two visits, which is designed to help meet the BTO's nest record scheme) each year for 10 years. Where practicable, monitoring would begin one year after each of the artificial nest sites are installed, and would include at least three years prior to HS2's operational phase and at least five years during the operational phase.

7.1.3 Most of the route-wide barn owl nest sites recorded during the survey stages of the Scheme, including those which now fall within or adjacent to the construction site boundaries, are monitored annually under NE licence by Barn Owl Conservation Network (BOCN)/British Trust for Ornithology (BTO) county teams (for contact details: consult BOCN Coordinator, UK and Ireland). It is desirable that the new artificial nest sites are integrated into their annual nest monitoring and maintenance programmes to provide long term monitoring and maintenance.

Figure 1: Barn Owl Data Overview – HS2 Phase One

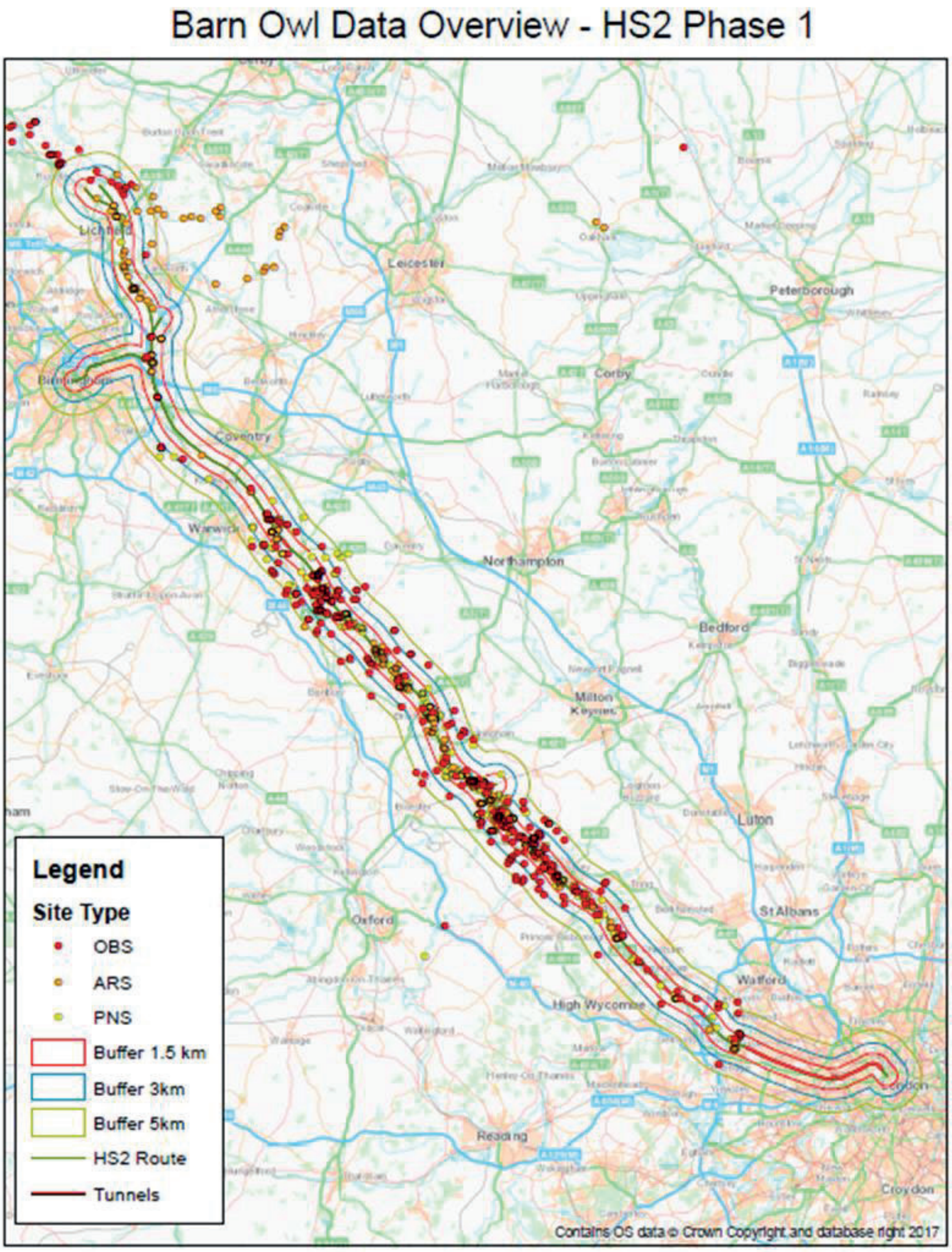


Figure 2: Barn Owl data overview – Sites affected within construction boundary +175m

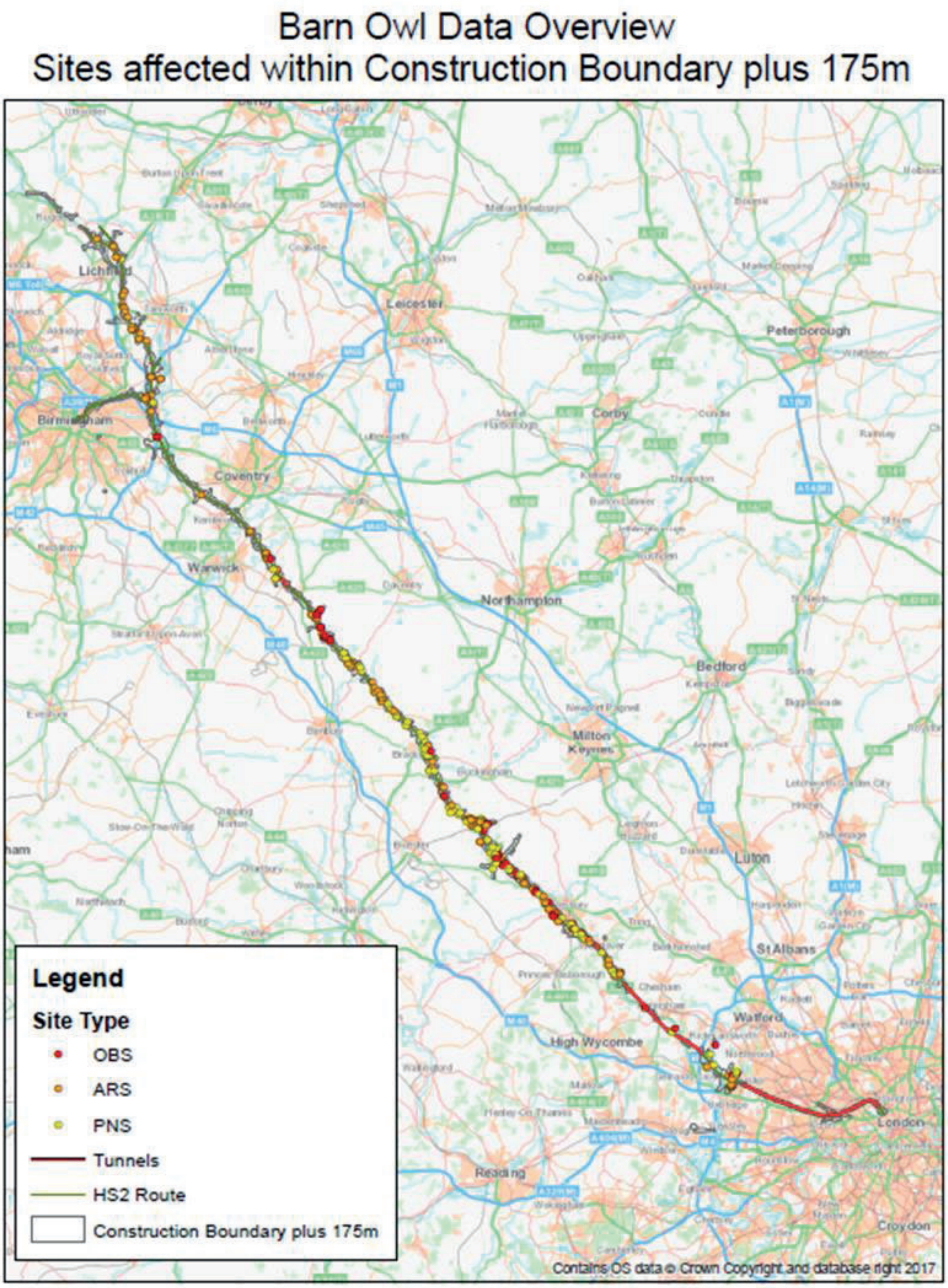


Figure 3: Barn Owl Indicative Mitigation Areas Overview

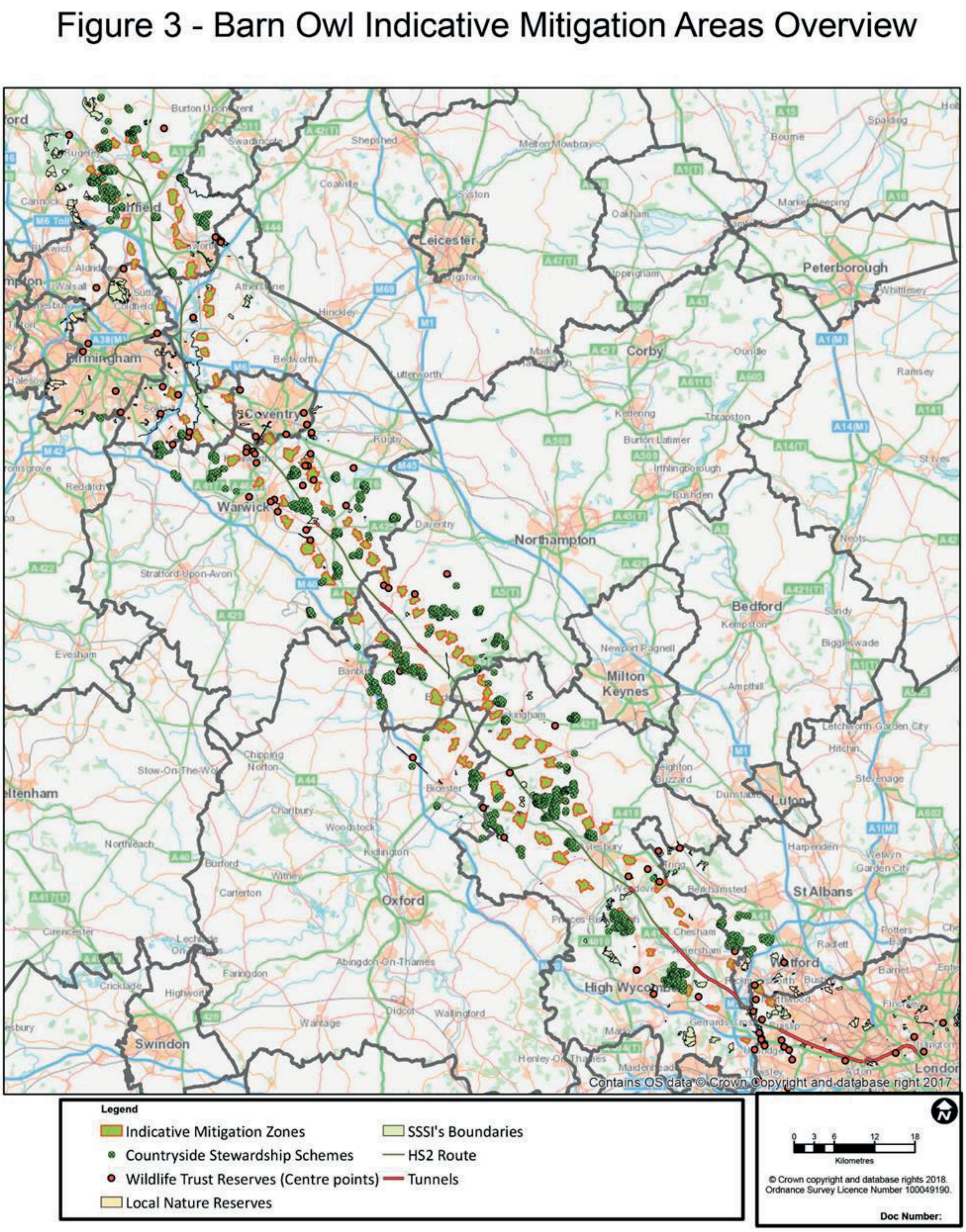
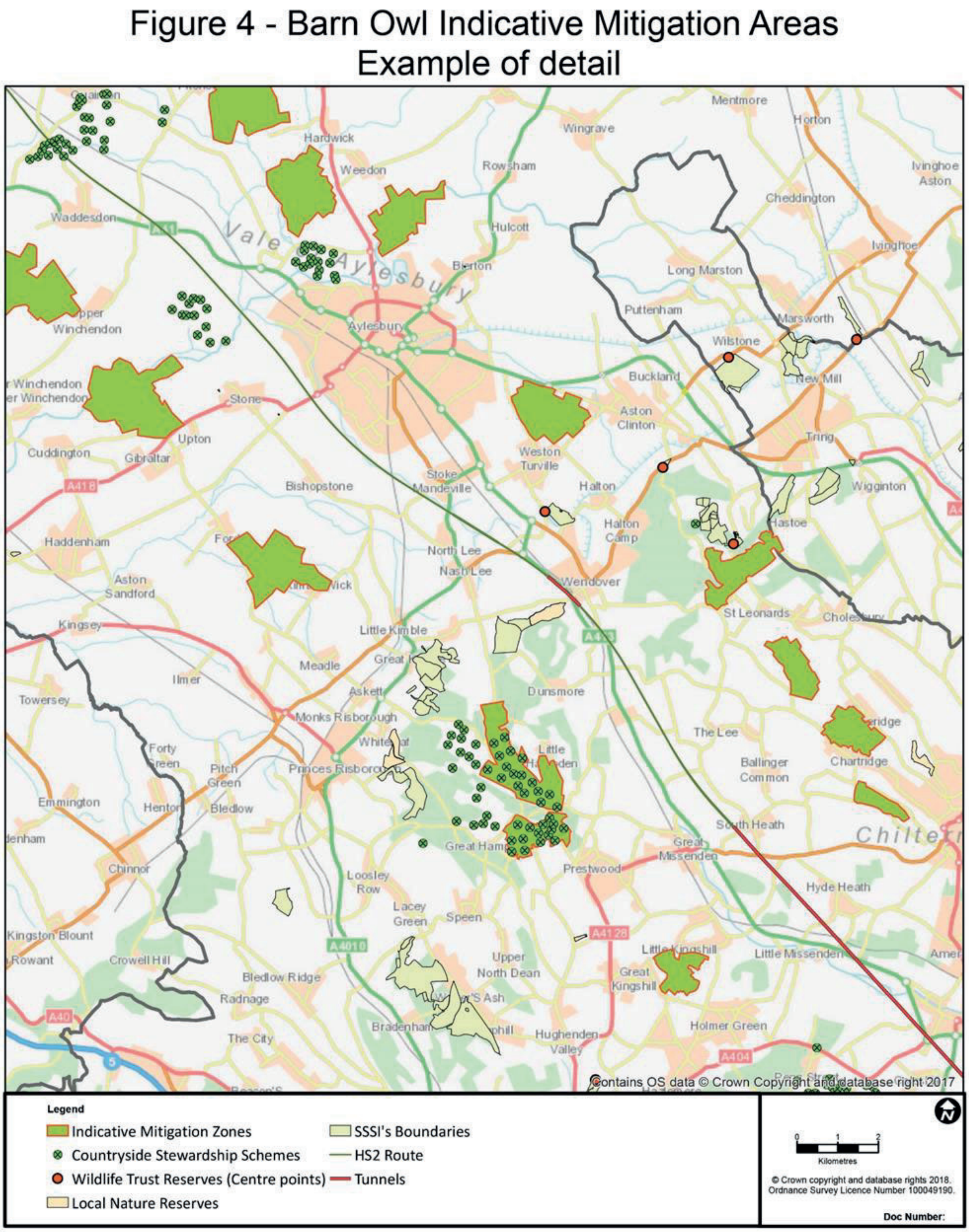


Figure 4: Barn Owl indicative mitigation areas – example of detail



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Appendix 1 – Links to other Scheme documents

Table 2 shows the other key Scheme documents to which this Barn Owl Mitigation Plan is linked and which should be read in conjunction with this document to develop consistent and efficient mitigation management and monitoring programmes.

Table 2: List of HS2 Technical Standards and other key documents relevant to the Barn Owl Mitigation Plan

Title	*Reference*
High Speed Rail (London – West Midlands), Environmental Minimum Requirements Annex 1: Code of Construction Practice	High Speed Two (HS2) Ltd, (2017)
HS2 Technical Standard - Landscape Maintenance, Management and Monitoring Plan	HS2-HS2-EV-STD-000-000023
HS2 Ecology Technical Standards	HS2-HS2-EV-STD-000-000017
HS2 Ecology Technical Note – Ecological Principles of Mitigation	C250-ARP-EV-NOT-000-001010, in: Annex D, Volume 5, Technical Appendices, Scope and methodology report addendum (CT-001-000/2) (November 2013)
HS2 Technical Standard – Phase 1 Ecological Monitoring Strategy	1D108-EDP-EV-STR-000-000001
HS2 Approach Document – Ecological Resilience to Climate Change	1D017-EDP-EV-REP-000-000001
Pringle, H., Siriwardena, G., & Toms, M. (2016). Informing best practice for mitigation and enhancement measures for Barn Owls	BTO Technical Research Report 692, BTO, Thetford, UK.
Shawyer, C. R. (2011). Barn Owl *Tyto alba* Survey Methods and Techniques for use in Ecological Assessment; Developing Best Practice in Survey and	WCP Technical Publication, CIEEM, Winchester, UK.

Title	*Reference*
Reporting.	

Appendix 2 – Barn Owl Ecology: Relevant to development of the Mitigation Plan

Introduction

The key objective of a species mitigation strategy is to ensure that the species concerned suffers no net loss in terms of its population size. Unlike most other birds, barn owls are highly susceptible to collision with traffic. For schemes which involve the development of road and rail an understanding of barn owl ecology, particularly where this relates to the patterns of movement and settlement in this bird, is essential for assessing the level of impact likely to arise and to enable the development of an effective mitigation strategy which seeks to mitigate, where possible, mortality risk and compensate for population decline.

Mitigation measures, which have been developed for major infrastructure schemes and which have their focus on preventing disturbance to breeding barn owls during construction and compensating for the loss of nest sites after they become operational, have benefitted greatly from the knowledge gained from the research and conservation work that has been carried out on this species during the last three decades. As a result, this, together with the survey methods and nest monitoring techniques which have been developed to determine the outcome of research and conservation programmes, now form part of many successful 'best practice' mitigation strategies (Shawyer and Holmes, 2009; Shawyer and Segar, 2013; Shawyer, 2017).

This mitigation strategy (Mitigation Plan) directs its attention to ensuring a deliverable and successful outcome and in this Appendix, describes much of the research and rationale which underpins many of the 'best practice' principles on which the Plan is based.

Traffic Collision

Although there have been a few studies in Britain and elsewhere in Europe which have reported the proportion of barn owls that are killed on the rail network, no attempt has been made to understand the number of owls involved and how this might affect the breeding population itself. However, barn owl mortality rates have been reported for roads. Studies which have been conducted in different regions of England show remarkably similar mortality rates, at between 0.7 and 0.8 deaths/km/yr (Law, pers.comm.; Shawyer and Dixon, 1999; Ramsden, 2003) although on one major road in Scotland as many as 2.9 deaths/km/year have been reported (Welch, 2007).

A recent study in Cambridgeshire where barn owls are ringed annually, investigated the effect of a major road improvement on mortality levels and its impact on the local breeding population. Within this relatively small area of 172 km2 the size of the population, prior to the road improvement, was recorded at 45 breeding pairs, representing one of the highest population densities in Britain. The investigation found that after the road improvement and the high traffic speed that resulted, mortality increased four-fold from 1.2 to 5.2 casualties per km per year (Shawyer, in press).

Population effects

After a new major road is built or improved which permits traffic speeds to exceed 80 km/hr, collision risk in some owl species is reported to increase by as much as 20-fold (Illner, 1992). As new or improved roads become operational, barn owls which had once bred within 1.0-1.5 km of the new route are lost or depleted from the local population. It is concluded that as young barn owls attempt to re-settle within these vacant but potentially hazardous territories, most fail to survive long enough to breed leaving ancestral breeding sites permanently abandoned (Shawyer and Dixon, 1999). This was first suspected in the mid 1980's when the findings of a national barn owl survey found less than 0.5% of owlsnesting within 1 km of a major road (Shawyer, 1987). Numerous ecological field surveys conducted since then have confirmed 1.0-1.5 km as being a 'no go' distance for successful breeding in barn owls. In 2011 this led to barn owl field survey buffers being extended to 1.5 km for infrastructure schemes where high levels of collision risk and consequent population decline are considered a likely outcome (Shawyer, 2011).

In the Cambridgeshire study referred to earlier (Shawyer, in press) whilst mortality levels increased 5-fold after the new road became operational and breeding ceased within a distance of 1.0 km, the breeding population beyond this limit and within 3 km of the new road was unaffected and actually increased from 45 to 55 pairs. The implication of this are discussed below in: Estimating the Collision Risks of the Scheme.

Rail mortality

Over a century ago when railways were in their ascendancy, concern over their effect on bird life was already being described (Brotherson in Bolam 1912; Macpherson and Duckworth, 1886) and by the first half of the 20th Century just under 10% of all recorded barn owl deaths were the result of collision with rail traffic. This proportion was similar to that reported for roads at a time when the speed of trains was generally higher than that of vehicles which were rarely exceeding 80 km/hour (Glue, 1971).

Since the 1950's vehicle speeds have increased and road networks have expanded rapidly and although the proportion of road versus rail mortality has changed in favour of the former, the actual number of barn owls killed by rail traffic today is likely to remain high. Although importance of rail mortality in the overall population dynamics of barn owls was not investigated by Glue it is evident that collision with trains remains a substantial hazard to barn owls.

Recent research in Spain using cameras mounted in the forward cabin of high speed trains has investigated the collision risk to birds and estimated mortality levels at 60 birds/km/yr (Malo et al 2016). Although medium-sized raptors constituted 25% of all birds recorded on gantries or flying in front of trains, none of these were seen to have been struck. No attempt was made in these studies, however, to record nocturnal species, such as owls (Garcia de la Morena et al, 2016).

A significant proportion of barn owls recovered dead on roads lack evidence of bone breakage and in some others this can be seen to have occurred post mortem. This suggests that rather than owls being struck directly as they feed on verges alongside traffic or attempt to cross the road, that some are sucked into the slipstream of high-sided vehicles and having been traumatized in this way, die on the roadside soon after. Since most barn owl road mortality occurs during the winter months and at night when temperatures are generally low, it is possible that hypothermia following the initial trauma has an important role to play in the eventual death of these birds (Shawyer and Dixon, 1999).

It is intended that HS2 will offer a high speed, high frequency service with latest figures suggesting an off-peak frequency of 10 trains per hour in each direction with the possibility of 18 trains per hour following the introduction of advanced management procedures. Trains, 400 m long, will run close together on twin tracks at speeds of 250 mph. The effects of high speed rail on barn owls has not been investigated, but from the statistics above it is considered likely that, although the frequency of high-sided road vehicles on many major roads may be greater than that of HS2 trains, the effects of the Scheme on barn owls and their local populations remain significant.

Barn Owl movements

During the breeding season, movement in barn owls is confined to a small home range where nest and roost sites can be found and within which foraging activity is concentrated. Away from the nest, territorial behaviour is unusual in this species and home ranges, which are not actively defended, often overlap with neighbouring pairs. British barn owls are, therefore, described as highly sedentary whilst in other parts of the world some sub-species are more nomadic and dispersal of young can be more wide-ranging (Mikkola, 1983).

Outside the breeding season, however, wider movement can occur in adult barn owls with some extending their home range up to 3 and very occasionally, 5 km (Shawyer, 1987; Cayford, 1992). It is generally thought that this movement is a consequence of the need to seek additional food sources and outlying roost sites at a time of the year when the need to defend nests and provision young is no longer necessary.

To aid this understanding the British Trust for Ornithology (BTO) was commissioned by HS2 Ltd. to undertake a desk study into the movement of barn owls in the region of Britain affected by the Scheme.

This has provided a valuable addition to our understanding of barn owl movement and settlement, from that previously reported in the Migration Atlas (Wernham et al, 2002) and of Cayford (1992) who used radio-tracking methods to identify the inter-seasonal movement of adult male barn owls i.e. during the breeding and non-breeding seasons.

The BTO study reported that movement in barn owls showed no directional pattern but that barriers to this movement can occur when, for example, unsuitable habitat and topography such as coasts, large conurbations and high ground, may restrict this movement.

Adult barn owls were found to travel, on average 2.2 km between years, from breeding place to breeding place and 2.8 km between the breeding and non-breeding seasons. It was considered noteworthy by the authors of this study that the south-east region of England, in which HS2 Phase 1 lies, is the region in which barn owls were found to be the most sedentary. Average post-natal dispersal in chicks of both sexes averaged 7.8 km, agreeing with that recorded in Scotland of 7.4 km for young males and 9.1 km for young females (Taylor, 1988).

Information used to derive the data on which these results were obtained came from the BTO's ring-recovery and re-capture data-set. These records are accurate to within 1 km which meant that the records which fell within 1 km, of which there were many, were by necessity, rejected in these analyses (Pringle et al, 2016). This is, however, unlikely to impose significant constraint when estimating juvenile movement where the distance averages 7.8 km. For adults, which form part of the breeding population and whose movements are far less than those of juvenile owls, accuracy of distance is more important for informing the development of a robust mitigation strategy for this Scheme and indeed, others of its type.

In order to optimise the Mitigation Plan, therefore, data derived from two long-term ringing and recapture studies in Northamptonshire and Cambridgeshire has been used. These studies have been able to track the fine-scale movement in barn owls allowing the inter-yearly movements of adult barn owls to be determined at high precision and with an accuracy of 1 m (Jackson and Shawyer, in prep).

Inter-yearly movements

Results of the study in Northamptonshire has shown that whilst 24% of adult females move greater than 1 km (average of 2.3 km; range, 1.1-3.8 km) between breeding sites, males are highly sedentary with less than 4% exceeding 1 km (range, 1.0-3.0 km; average, 0.4 km).

The same analysis was conducted on a similar-sized sample of ringed adult barn owls in the author's study area in Cambridgeshire. Values were very similar with 32% of females and only 5% of males moving greater than 1 km. This finding provides a high level of confidence in the results obtained from the Northamptonshire study, a county within which the Scheme falls.

In both studies 51% of adult owls of both sexes, ranging between 2-12 years of age, confined their activities to the nest sites originally established in their first year of life. This supports the fact that, throughout their lives, British barn owls maintain a close pair bond and a high level of fidelity to their breeding sites and home ranges in general.

In the small number (26%) of adult females where inter-yearly movement greater than 1 km did occur, it is probable this was in response to the death of or possible divorce from their male partner and their desire to attract a new mate. This confers with the findings of more wide-ranging nest monitoring work by the author where males which have lost their partner almost always remain faithful to the nest site or area they established during their first year of life.

Inter-seasonal movement

During the non-breeding season, adult barn owls usually vacate their breeding sites and re-occupy their favoured winter roost sites, either separately or as a pair, often extending their breeding season range at this time. In our study, inter-seasonal movement could not be determined with any greater accuracy than that of the BTO study. This is because although ringing locations are recorded to a precision of 1 m, recovery of the owls which are normally found dead or injured, relies on members of the public where accuracy is usually recorded to the nearest 1 km.

Nevertheless, the BTO reports a median movement of 2.8 km by adults (both sexes) between their breeding and wintering sites but, unlike that which occurs inter-yearly in females, no inter-seasonal differences were seen between the sexes.

Whilst the average inter-seasonal movement of adults between the summer and winter seasons is a little greater than their inter-yearly movement, neither of these movements exceed 3 km. It is likely, however, that only a proportion of the owls which breed within 3 km of a road or rail line will encounter this hazard. This is because tracking studies, which have been undertaken on male barn owls (Cayford, 1992) and observational research of owls of both sexes (Shrubb 1982), have shown that nest sites are rarely located centrally within the home range but towards one edge and that their movements both in summer and winter are not random but favoured a particular direction. Therefore, a proportion, but not all, of the owls which occupy home ranges within 3 km of a road or rail line are likely to commute toward these whilst others will commute away (see Quantifying Collision Risk below).

Seasonal mortality

The findings of numerous studies on the impact of high speed traffic on barn owl populations have also been used to understand more about the time of the day and time of the year when these events occur and the sex and age structure of the owls that are killed.

In view of the fact that almost all of the movement in adult and juvenile barn owls occurs during the hours of darkness and outside the breeding season, between October and March, it is unsurprising that over 85% of barn owl road and rail deaths occur at this time. An early mortality peak in late autumn is largely due to dispersing juveniles. Adult birds on the other hand are more vulnerable during the winter months at a time when their extended movements can bring them into contact with road or rail traffic, often for the first time in their lives.

In a study commissioned by the Department of Transport (DoT) and the Highways Agency (HA) (now Highways England (HE), the number of adult barn owls killed by road traffic contributed 33% of the overall death rate (Shawyer and Dixon, 1999). This study together with others have shown that, in late autumn, the proportion of immature barn owls that are killed is about 80% (Baudvin et al, 1991; de Bruijn, 1994; Taylor, 1994) and in America a similar proportion has been reported for eastern screech owls and saw-whet owls (Loos and Kerlinger, 1993).

The high proportion of young barn owls killed is reflected in the large number of immature owls present in the population at this time, most of which are in the process of dispersing out of their natal areas, with many undoubtedly encountering roads and rail lines during this period. Like adults the movement of these young owls is greater in females than in males (Taylor, 1994) and one study reported that in November, four times as many young females were killed than young males (Shawyer and Dixon, 1999).

As the recent BTO study has shown, by late February, most juvenile owls (soon to be classed as adult) have completed their movement, mates have been selected and safe breeding territories established 7.8 km from their natal sites.

Networks for movement

During post-natal dispersal the prey-rich rough-grassland banks of water courses, field margins and other habitats of linear type can offer important dispersal routes for young barn owls (Shawyer, 1987, Wernham et al, 2002). This is manifest by the clusters of road deaths or mortality ‘blackspots’ which can be found at those locations where flight-ways of this type are intersected by major roads (Shawyer and Dixon, 1999).

The importance of these linear grasslands for movement in young barn owls is supported further by evidence of the number of ringed nestlings, subsequently recaptured during their post-natal dispersal on the same habitat corridor (Sheppard and Jackson, pers.com.). In Northamptonshire and Nottinghamshire where barn owls have been studied intensively over many years, the importance of linear grasslands for juvenile movement has also been confirmed from those owls ringed as nestlings that have subsequently been recaptured as breeding adults on the same habitat network.

In Britain, this understanding and that which confirmed a high correlation between the close proximity of barn owl breeding sites and river corridors (Shawyer, 1987) and which in partnership with the Environment Agency and Drainage Boards formed a critical part of the UK conservation strategy in 1988, has led to the significant conservation gain for this species over the last 25 years.

Estimating the collision risk of the Scheme

There is, understandably, considerable public concern for the numbers of barn owls killed on Britain's road and rail networks. It is, therefore, inevitable that popular belief has arisen that road deaths were responsible for the species' decline during the latter part of the last century and that as a consequence of these deaths, the recovery in barn owl numbers has been slowed. There is, however, little evidence for this 'cause and effect' relationship and rather than vehicle collisions adding to the overall mortality, for juvenile birds at least, death from this cause may substitute largely for natural factors, such as starvation. For barn owls, therefore, and for juveniles in particular, collision with traffic might be considered 'substitutive' rather than 'additive' such that the mortality this unnatural cause has little effect on the survival rate of these young birds into adulthood and consequently the size of the breeding population itself (Shawyer 1998).

As a breeding population increases in size, mortality usually increases in a proportionate manner. Indeed, a powerful indicator of population recovery in, for example, otter Lutra lutra and badger Meles meles populations is evidenced, most clearly, by the increasing number of road deaths in these two species. This effect may also be true for barn owls since the study referred to earlier (Shawyer in prep) found that after a 20% increase in a local barn owl population, mortality expressed as a consequence of road death increased four-fold.

Quantifying collision risk

The HS2 Phase 1 Scheme, excluding tunnels, viaducts and the Northolt Corridor in the Greater London Authority, involves approximately 185 km of open track. Assuming 7 km represents the average mean distance of movement in juvenile barn owls (Pringle et al, 2016) the 14 km-wide corridor within which this movement occurs, encompasses an area of 2590 km2. This represents 20% of the land area of the six Vice Counties (13282 km2) through which the Scheme will pass. Taking account of the 850 breeding pairs currently estimated in these six counties and the combined annual mean fledging rate of 2.9 for SE England and the Midlands (Percival, 1990) total annual productivity would average 2,450 young, equivalent to 490 young per year within the 14 km- wide Scheme corridor itself.

The direction of natal dispersal in barn owls is random (all four compass points) so we can assume that about one-quarter, or about 120 of the young produced each year within the Scheme corridor, have the potential to cross the HS2 rail line. Research concerning the movement of ringed barn owls nesting within 3 km of a major road in eastern England indicates that 33% which attempt to cross this road fall victim to RTA's. For the Scheme itself, therefore, we might reasonably expect that up to 40 juvenile barn owls are likely to be killed annually by HS2 rail traffic during its operation, representing, 0.2 barn owl juvenile deaths/km/yr.

During the first few years of operation and prior to the anticipated depletion/loss of the breeding population within 1.5 km, this mortality figure could be swelled by up to 170 adults together with an additional but much smaller number which occupy home ranges beyond this distance, up to 3 km. It is likely, therefore, that the annual barn owl mortality rate during the first few years of operation may approach 0.75-1.0/km/yr, not dissimilar to that reported for juvenile and adult barn owls (0.7-0.8/km/yr) on most major roads in England where these figures have been reported.

In the absence of rail mortality, however, a proportion of the 40 juveniles can be expected to have died from other causes, including starvation during their 20-25 week post-natal dispersal period and before they reach breeding age. Death from starvation, for example, occurs soon after fledging and peaks during the winter months of January and February (Shawyer, 1987) whilst in contrast, about 80%, of all road traffic accidents occur much earlier, between September and November (Shawyer and Dixon, 1999).

Using the reported overall survival rate of 17.5% for first-year barn owls in SE England (Percival, 1990) then we could expect that after the first few years of operation and depletion of the breeding population, the Scheme will continue to contribute annually to the loss of about 7 individuals which would otherwise have survived the risk of collision and be recruited into the breeding population. Whilst any level of juvenile mortality is of concern, the number of young barn owls which fail to be recruited into the breeding population as a result of operation of the Scheme is, therefore, likely to be comparatively small, and this would be the case even if the corridor of risk was considered to be much greater in size.

It is within this context that for this Scheme and any other schemes of this nature, the mitigation measures being considered to reduce mortality along with those which intend to compensate for any decline in population size, must take account of and be proportional to the scale of the impacts they are attempting to address (Shawyer, 2011). For the Scheme therefore, lengthy screening of the line or reducing the attractiveness of rail-side habitat to barn owls in an attempt to reduce collision risk (Pringle et al, 2016; Baudvin 2004; Ramsden, 2003) is unlikely to achieve any significant long-term benefit for barn owls in terms of population stability or growth. It also has the potential to remove an important habitat resource for other flora and fauna which can co-exist alongside roads and rail.

Monitoring nest occupancy and breeding success

It has been suggested by some that breeding success (the number of young which fledge from nests) is the measure by which a conservation or mitigation strategy can be determined. However, measures of breeding success, used, for example, in the BTO's nest monitoring programme (BOMP), whilst valuable to scientists in helping to understand the annual effects of fluctuating prey numbers, weather conditions, or the impact of a potential damaging pollutant, is of little value when attempting to evaluate the success of a conservation or mitigation project. For the Scheme, where the main purpose is to maintain or increase the size of the breeding population, nest occupancy is the parameter of choice when attempting to evaluate success.

For example, the changes that have occurred in the UK barn owl breeding population since the mid 1980's and 1990's and which are reported to have increased by about 5% per annum to just over 200% (Hayhow et al, 2017), have largely been derived from dedicated surveys which record nest occupancy levels in breeding barn owls. However, this population increase is not reflected in the breeding productivity figures recorded during these four decades or indeed since they were first reported in the 1930's which unlike those of nest occupancy, have remained largely static (with a possible dip between 1971 and 1982), averaging 2.9-

3.3 young per successful pair (Blaker 1932, Shawyer, 1987; Percival, 1990, Henderson et al, 1993, Prescott et al, 1996).

Another example of why breeding productivity provides little indication of population size and cannot be used when attempting to measure the success of a conservation or mitigation project, is illustrated by a study on goshawks (Accipiter gentilis). In two British forests, for example, where goshawk numbers have increased substantially over time, breeding productivity has decreased, probably the result of increased competition for habitat and food (Toyne, 1994). Therefore, rather than a fall in breeding success being suggestive of a population decline in a species, quite the opposite can be true.

Barn owl breeding productivity is, in any case, not something that this Plan or others of this type are able to influence and neither is it intended to do so. This is because the primary factors which currently govern annual breeding productivity in barn owls are the short-term but often large annual changes in small mammal abundance and climate, both of which are largely outside human control.

Appropriate mitigation

Artificial nest sites

Where development schemes are concerned it is recommended that the type of artificial nest sites used for mitigation should be proportionate to the scale of the development being undertaken (Shawyer, 2011).

For example, the change of use to a single farm building may simply require a pair of nestboxes installed in suitable habitat nearby, whilst a large barn conversion may best be served by incorporation of an owl loft. For large schemes such as housing or commercial developments Local Planning Authorities are more likely to ‘condition’ a more permanent structure such as a purpose-made owl tower, either on the development site itself or more commonly on land set aside by the developer as a mitigation area (Shawyer and Sheppard, 2006).

For this Plan it is proposed that a target of 240 artificial nest sites will be installed mainly on private farmland and nature reserves and aims to install these at a distance of 3 km or more from the Scheme separated by approximately 2 km intervals or more.

Unlike most infrastructure projects the success of the Plan will by necessity rely on the goodwill of landowners rather than, in this case, on the owners of the Scheme which have no jurisdiction over lands outside the Act limits. For this reason and to help ensure acceptability the use of nestboxes will in the first instance will be the artificial nest site of choice and take priority over owl towers.

Both of these types of artificial nest site have been used successfully for more than 20-25 years and materials trialed and tested to ensure that the nestboxes which are most commonly used on trees the outside of buildings and on poles, will last 20 years in outdoor environments with minimal maintenance. The brick-built barn owl towers which have also been designed to accommodate little owls, kestrels (amber listed), tawny owls (amber listed), stock doves (amber listed), and bat species (European protected) have a minimum lifespan estimated at 150 years

The nestboxes now used widely for conservation and mitigation projects and which will be used to deliver the Plan (Spec: 1004) are manufactured for outdoor use from 12/18 mm Forest Stewardship Council (FSC) phenolic-faced marine birch plywood and constructed using stainless steel screws with brass hinges and draw bolts fitted to large inspection doors (Dewar and Shawyer, 1992). Nestboxes are designed for installation on the main trunk of trees or the outside of buildings and to enable delivery to be made in pack-flat or assembled form. For trees, attachment is made using two 15 mm nylon nuts and bolts to avoid any use of metal fixings and potential H&S risk to future arboricultural operations involving chain-saws. Sacrificial compression pads are fitted between the nestbox and nylon nut to prevent/reduce the pressure of tree growth on the stability of the nestbox, thereby reducing maintenance intervals. Metal coach-screws and rawl-bolts are used for attachment to buildings. Light-fast printed labels, each with a unique number are applied to aid identification during future nest monitoring, maintenance and for the effective recording of contents and identification.

Owl towers (Spec: 1006) materials (bricks, lintels, roof tiles and marine plywood nest chambers with sliding access doors) together with specially designed bricks which accommodate bats, swifts and other small birds can be provided on pallets from a specialist supplier along with architectural construction plans for assembly on site.

Appendix 3 – Barn Owl ecology: General

Introduction

This Appendix provides a brief insight into the wider aspects of barn owl ecology. Numerous barn owl monographs have been written concerning this species (Bunn et al, 1992; Shawyer, 1994; Taylor, 1994; Shawyer, 1988). It is, therefore, not the intention here to provide more than a brief resume of those aspects of its natural history which, amongst other things, help provide a clue to the popularity of this bird.

Population Status

The barn owl is a globally widespread bird found on all continents except Antarctica. In Britain, it is at the northern limit of its world range. The last UK barn owl survey, carried out between 1994 and 1996 (Toms et al ,2001), estimated the population at almost 4,000 pairs, similar to that reported by the Barn Owl Survey of Britain and Ireland, 12 years earlier (Shawyer, 1987).

In 2014 the UK breeding population was estimated to have increased to about 9,000breeding pairs (Shawyer, 2014) and become more widely distributed, particularly in northern Britain where the barn owl was once considered scarce. This increase was also confirmed in the State of the UK's Birds report (Hayhow et al, 2017) that between 1995 and 2014 the population had increased 227%. This largely resulted in movement of the barn owl from the 'amber list' to 'green list' of Birds of Conservation Concern in the UK (Eaton et al, 2015) and the International Union for the Conservation of Nature now refers to the barn 0wl as a species of 'least concern' at a European and Global level.

Legal and Protective status

Barn owls, like most other wild birds in Britain, are protected by the Wildlife and Countryside Act 1981 (WCA) (as amended) making it an offence at any time of the year to intentionally kill or injure these birds or destroy their occupied nests, eggs and young. Additionally, barn owls are listed on Schedule 1 of the Act making it an offence to intentionally or recklessly disturb them at an active nest site with eggs or young or to disturb the dependent young of these birds. In addition, the barn owl is listed on Schedule 9 of the WCA making it illegal to release barn owls bred in captivity into the wild without a licence (HMSO, 1996).

Natural History

Barn owls are now widespread throughout much of Britain. They are largely nocturnal birds of prey, but during periods of early courtship in February and when provisioning young in mid-summer, they are often seen during daytime. This can also occur if hunting has been suppressed by successive nights of rain, snowfall or high winds, although in some regions of Britain diurnal activity rarely occurs.

British barn owls measure about 34 cm head to tail and unlike many birds of prey their size differs little between the sexes. Outside the breeding season adult males generally weigh on average 320 g, about 20 g less than their female partners. Whilst males maintain a similar body weight throughout the year, females can increase their weight by as much as 50% just prior to breeding. Breeding normally begins during the months of March, April or May although in some years this can occur as late as August and very occasionally, September. In years when field vole abundance reaches its 3-4 year cyclical peak, second clutches are not uncommon and these are usually laid in July with fledging not often occurring until early November and occasionally December.

Barn owls are exclusively a cavity-nesting species which, before barns and other agricultural buildings became part of Britain’s landscape, bred in the cavities of trees and cliffs (Bunn et al, 1982). Whilst a small proportion of these natural nest sites are still used by barn owls, artificial nest sites such as nestboxes and owl towers are now considered to comprise, 75% of the breeding sites occupied by this owl (Shawyer, 2014).

Breeding sites are normally selected by the male four to eight months after fledging at which time pair bonds are established and breeding begins. Before and during egg-laying, male barn owls normally roost alongside their partners but at the time of hatching most move out of the nest chamber but continue to roost nearby.

Barn owls are believed to maintain their partners throughout their lives, only selecting a new one after one has died. However, divorce of male partners is believed to occur, for example, between the laying of first and second clutches in those years when double brooding occurs (Taylor, 1988; Jackson et al, 2017). Polygyny also occurs in British barn owls with two females served by a single male sometimes breeding in the same nest chamber or at a vacant one nearby (Shawyer, 2013).

Typical average life expectancy for juveniles is less than 1 year and 3-4 years for those which survive into adulthood. However, these survival figures may be influenced by premature mortality, associated with the large proportion of road casualties which make up the samples from which some of the data has been analysed.

In the breeding season foraging techniques normally involve the low-level quartering of rough grassland whereas 'perch hunting' occurs more commonly in winter when energy conservation is often of greater importance.

In Britain, barn owls feed on small mammals, primarily rodents, with field voles Microtus agrestis contributing between 50-65% of the prey taken (Taylor, 1994; Love et al, 2000). Barn owls are able to adapt their diet, replacing the field vole with the less habitat-specific wood mouse Apodemus sylvaticus (Meek et al, 2003) although this small mammal rarely assumes sufficient abundance on its own to enable barn owls to breed successfully (Shawyer, 1987). As hunters of small mammals, any temporal change in prey availability can have a significant impact on breeding success. However, the short-lived changes in annual breeding success provides no measure of the size of the breeding population, which over the last 20-25 years is, as previously described, has grown at an estimated average rate of about 5% per annum (Shawyer, 2014).

Barn owls prefer low-lying farmland below 150 m above sea level and in 1987 95% 0f the British population was recorded breeding below this level. Winter snowfall which increases with both latitude and altitude inhibits hunting and has been the main factor governing the species' distribution in Britain. Since the turn of the last century, winters have become milder and barn owls have responded, with some pairs establishing home ranges at altitudes in excess of 150 m and in the higher latitudes of northern Scotland. Nevertheless, owls which occupy these more marginal areas suffer greatly from starvation during harsh winters and this is often evidenced by significant losses, locally and a protracted recovery in numbers.

Barn owls will utilise a wide range of habitat types, providing these habitats offer a plentiful supply of small mammals, in particular field voles. Optimal habitats are those that are found in low-lying areas of Britain which contain a sufficient area of rough-tussocky grassland with a well-developed sward structure and a dead thatch or litter layer of straw at the base (Shawyer, 1990; 1998). These grasslands are most commonly found on the banks of watercourses, field, road and track-side margins, unimproved or semi-improved open grasslands, orchards, newly-planted coniferous plantations and recently-felled woodland (Bunn et al, 1982; Shawyer, 1987; Taylor, 1994).

Changes in agricultural and watercourse management practices during the last century, including those which were instigated in 1988 as part of the UK Conservation Strategy and which later included the linear grasslands associated with agri-environment schemes, have been central to the successful recovery of the barn owl population in Britain in recent years (Shawyer, 1987; Meek et al, 2003).

During the breeding season, barn owls will typically occupy a home range of 3-7 km2 (300-700 ha) rarely moving more than 1-1.5 km from their breeding sites (Shrubb, 1984; Shawyer 1994). Within this home range they normally require 30-50 ha of rough-grassland when comprised largely of whole fields within which small mammals are often quite widely dispersed. (Askew, 2006). In arable areas, linear habitats where small mammal density can be especially high, are commonly utilised. In these linear habitats, 7.5-12.5 km (4.5-7.5 ha) is normally required by breeding barn owls (Shawyer 2011). In parts of south-west Scotland where rough-grassland habitat is largely confined to commercial forest edge, 9-11 km of grass margin is considered necessary for achieving breeding success and maintaining a stable population (Taylor, 1994). As well as providing rich feeding grounds, establishment of these linear habitats has been valuable for restoring habitat connectivity at both a local and landscape level, thereby overcoming the habitat fragmentation identified in the latter half of the last century as a major cause of population decline in British barn owls (Shawyer, 1987; Brazil and Shawyer, 1989).

Threats

The ultimate causes of historical barn 0wl decline are well-documented and are generally thought to be attributed to the following principle factors. These are land-use changes with the ploughing-up of natural and semi-natural habitats for large-scale agricultural systems, disappearance of nest and roosting sites due to the loss and conversion of agricultural buildings and the felling of old trees along with urbanisation, and the expansion of major road networks (Shawyer ,1987; Hindmarch et al, 2013). In spite of the barn owl's general scarcity in the mid 1990's, more were recorded dead on British roads than any other wild bird. The extreme vulnerability of this species is undoubtedly due to its nocturnal nature and low altitude flight characteristic whilst moving about its home range and hunting road and rail verges (Shawyer, 1987; Shawyer and Dixon, 1999; Ramsden, 2003).

Before the construction of dual carriageways and modern vehicle development, traffic speeds were far below those seen today. During the early to middle part of the 20th Century barn owl road deaths in Britain were relatively low, accounting for 12% of all mortality, whilst trains, which generally far exceeded the speed of most road vehicles at this time, accounted for 11% (Glue, 1971). Since then the number of vehicles on Britain's roads has increased by over ten-fold with most vehicles able to attain speeds double those of the 1970's, one reason why the relative proportions of barn owl road and rail deaths have changed so dramatically. Also, because the public today has largely unrestricted access to roads and visual access to the soft estate of HE, barn owl road deaths are undoubtedly reported in far greater numbers than those killed on the rail network where public access is highly restricted. Of the rail deaths reported today, most are by train drivers. Although the proportion of road versus train casualties has changed significantly since the last century it is likely that the absolute number of barn owls killed by trains, remains relatively high and that collision with rail traffic continues to represent a substantial hazard to barn owls.

Conservation

Recovery in the barn owl population began following publication of the UK Conservation Strategy and introduction of its Farmland, Forestry and Riverside Link Initiative (Shawyer, 1990). The Strategy was subsequently included in the Joint Nature Conservation Committee and RSPB UK Barn Owl Species Action Plan 0735 (Williams and Galbraith, 1992). The UK Conservation Strategy led to the establishment of the Barn Owl Conservation Network (BOCN) project (Brazil and Shawyer, 1989). In 1988, a Coordinator for the UK and Ireland was appointed to develop a countrywide team of conservation practitioners and specialist barn owl advisors. Their actions are largely responsible for the species' significant recovery in Britain over the last 25 years.

Dedicated work undertaken by conservationists and researchers as part of the BOCN project has also resulted in the establishment of barn owl Species Recovery Areas (SRA's) in most counties of England. Extensive linear rough-grassland habitats along Britain's rivers and streams which provide habitat links between the once isolated local barn owl populations, are known as Barn Owl Recovery Networks (BORN's). These have also been created in partnership with the Environment Agency, Drainage

Boards and other like-minded organisations and now provide essential connectivity of habitat for this otherwise sedentary owl.

Prior to the mid 1990's foraging habitat was the main factor limiting the numbers of barn owls in Britain but following their restoration and creation the lack of natural nest sites has assumed far greater significance. Since that time artificial nest sites have, therefore, become a key habitat component in conservation and mitigation strategies involving this species. Thousands of these sites, which include nestboxes and owl towers and which have been installed by the BOCN and others as part of the UK'S Barn Owl Conservation Strategy, now represent about 75% of the nest sites used by barn owls in Britain today. These artificial nest sites have not only contributed to the population recovery in this species but for researchers have become a valuable asset when auditing the value of conservation and mitigation schemes.

The SRA's and BORN's which comprise an estimated 10,000 artificial nest sites, now collectively hold a significant proportion of the barn owl population in Britain and are increasingly being given high priority by local planning authorities under their remit to 'promote the preservation, restoration and re-creation of priority habitats, ecological networks and the protection and recovery of priority species populations, linked to national and local targets' (NPPF, 2012). Important mechanisms for achieving this remit are to protect and enhance the integrity of these SRA's and BORN's as areas of conservation importance (Shawyer, 2011).

Appendix 4 – Data analysis process

Data layers

High precision desk study and field survey data were collated and converted into a GIS compatible format. Point data was geocoded into the OSGB36 co-ordinate system of notation and existing shape file or GIS data was projected into this format. Data at the tetrad or 1-km level was geocoded based on the centre-point of the enclosing grid square of the appropriate size drawn from the OS coordinate system.

Barn owl data layers were then harmonised into a single notation of OBS, ARS, and TRS. Datasets collected involving other survey categories were converted into the single system of notation, based on appropriate criteria. All datasets were then concatenated into a single dataset to allow simultaneous analysis.

Barn Owl Impacts

Impact was assessed by creating buffers around the consolidated construction boundary provided by HS2, plus 175 m (maximum recommended buffered distance for barn owl nest disturbance) and at set distances of 1.5km, 3km and 5km to allow the GIS to select barn owl records falling within the relevant zones of potential impact.

Where barn owl records were received, for example, from multiple sources and were closely grouped within an OS 1-km square, these were consolidated at a 1-km square level and accounted for during GIS analysis, as a single barn owl site.

Sites for Mitigation

In order to determine the number of barn owl sites affected during the land clearance and construction phases of works, the GIS barn owl data was overlaid onto the construction boundary layer provided for this analysis by HS2. The buffer layer finally used in the GIS interpretation was increased by 175 m beyond the construction boundary to allow for potential disturbance to those barn owls nesting just outside the construction site boundary.

Sites for Compensation

Based on the barn owl sites affected by the Scheme, the number and distribution of potential compensation areas (indicative) were identified. These were selected between 3 km and 3.75 km from the HS2 route line and be of a size and type which offer habitat and other features suited to barn owls. Detailed satellite maps were carefully overlaid with relevant barn owl suitability GIS layers for habitat, waterways, SSSIs and conservation areas, including SRA's, BORN's and local nature reserves. By necessity some of the indicative compensation sites fell outside the ideal selection criteria but where possible these were separated from potential hazards such as major roads and EWR2, by a suitable distance or buffer feature, such as woodland.

Appendix 5 – Temporary mitigation – quick start checklist

Temporary barn owl mitigation prior to land clearance, habitat creation and construction

A quick-start checklist

Background

The barn owl is specially protected on Schedule 1 of the Wildlife and Countryside Act 1981 from intentional or reckless actions that causes disturbance to this species whilst breeding. The barn owl breeding season normally occurs between the months of March and September but can extend into November in years of high prey availability and the production of second broods. This checklist just covers the initial temporary measures.

Mitigation

Step 1

Consult barn owl data to confirm the locations of any barn owl nest sites (potential and confirmed) within and 175 m outside construction site boundaries.

Step 2

The suitably experienced ecologist will determine areas where re-survey is required. Any additional nest sites identified would also be subject to appropriate mitigation.

Step 3

In agreement with landowners, install new barn owl nestboxes in accordance with: spec 1004 and Method Statement spec 2004 (See: Appendix 5 Barn Owl Mitigation Plan) between 200 and 300m from the construction site boundary.

This is to provide temporary mitigation for those barn owl nest sites that will be lost or disturbed during construction works and until the Scheme becomes operational.

Step 4

Outside the breeding season, cap off/net all existing potential and confirmed barn owl nest sites within and up to 175m outside the construction boundary (See: Appendix 5 Barn Owl Mitigation Plan).

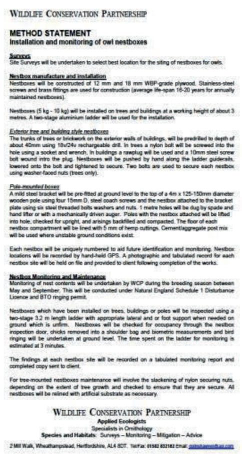
All nestboxes/tree cavities/building chambers to be inspected at the time of capping to ensure no other wildlife is present and could be trapped during these nest exclusion procedures.

NOTE: The BOCN/BTO barn owl specialists who monitor the nest sites affected by the Scheme have a close association with landowners where their nestboxes have been installed (Shawyer 2011, p. 9 & 19).

* Contact details for the county BOCN/BTO barn owl specialists and NE licensees for Herts, Bucks, Oxon, Northants, Warwick and Staffs can be obtained directly from: Barn Owl Conservation Network Co-ordinator, UK and Ireland on 07774 899344 or bocnenquiries@aol.com.

Appendix 6 – Best practice standards for Barn Owl mitigation (Shawyer, 2011)

Nestbox Spec: 1004 (tree mounted) (building mounted)



WILDLIFE CONSERVATION PARTNERSHIP

METHOD STATEMENT
Installation and monitoring of owl nestboxes

Surveys
Site Surveys will be undertaken to select best location for the siting of nestboxes for owls.

Nestbox manufacture and installation
Nestboxes will be constructed of 12 mm and 18 mm WBP-grade plywood. Stainless-steel screws and brass fittings are used for construction (average life-span 16-20 years for annually maintained nestboxes).

Nestboxes (5 kg – 10 kg) will be installed on trees and buildings at a working height of about 3 metres. A two-stage aluminium ladder will be used for the installation.

Exterior tree and building style nestboxes
The trunks of trees or brickwork on the exterior walls of buildings, will be predrilled to depth of about 40mm using 18v/24v rechargeable drill. In trees a nylon bolt will be screwed into the hole using a socket and wrench. In buildings a rawplug will be used and a 10mm steel screw bolt wound intro the plug. Nestboxes will be pushed by hand along the ladder guiderails, lowered onto the bolt and tightened to secure. Two bolts are used to secure each nestbox using washer-faced nuts (trees only).

Pole-mounted boxes
A mild steel bracket will be pre-fitted at ground level to the top of a 4m x 125-150mm diameter wooden pole using four 15mm D. steel coach screws and the nestbox attached to the bracket plate using six steel threaded bolts washers and nuts. 1 metre holes will be dug by spade and hand lifter or with a mechanically driven auger. Poles with the nestbox attached will be lifted into hole, checked for upright, and arisings backfilled and compacted. The floor of each nestbox compartment will be lined with 5 mm of hemp cuttings. Cement/aggregate post mix will be used where unstable ground conditions exist.

Each nestbox will be uniquely numbered to aid future identification and monitoring. Nestbox locations will be recorded by hand-held GPS. A photographic and tabulated record for each nestbox site will be held on file and provided to client following completion of the works.

Nestbox Monitoring and Maintenance
Monitoring of nest contents will be undertaken by WCP during the breeding season between May and September. This will be conducted under Natural England Schedule 1 Disturbance Licence and BTO ringing permit.

Nestboxes which have been installed on trees, buildings or poles will be inspected using a two-stage 3.2 m length ladder with appropriate lateral and or foot support when needed on ground which is unfirm. Nestboxes will be checked for occupancy through the nestbox inspection door, chicks removed into a shoulder bag and biometric measurements and bird ringing will be undertaken at ground level. The time spent on the ladder for monitoring is estimated at 3 minutes.

The findings at each nestbox site will be recorded on a tabulated monitoring report and completed copy sent to client.

For tree-mounted nestboxes maintenance will involve the slackening of nylon securing nuts, depending on the extent of tree growth and checked to ensure that they are secure. All nestboxes will be relined with artificial substrate as necessary.

WILDLIFE CONSERVATION PARTNERSHIP
Applied Ecologists
Specialists in Ornithology
Species and Habitats: Surveys – Monitoring – Mitigation – Advice

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Barn Owl Nestboxes
The 'A Frame'

About the Barn Owl

Fixing methods: Spec: 2001
(nylon bolts/compression discs)

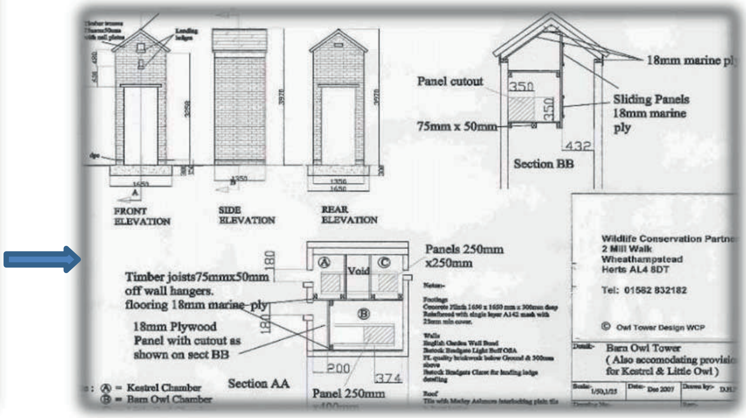
Method Statement

Spec: 2004

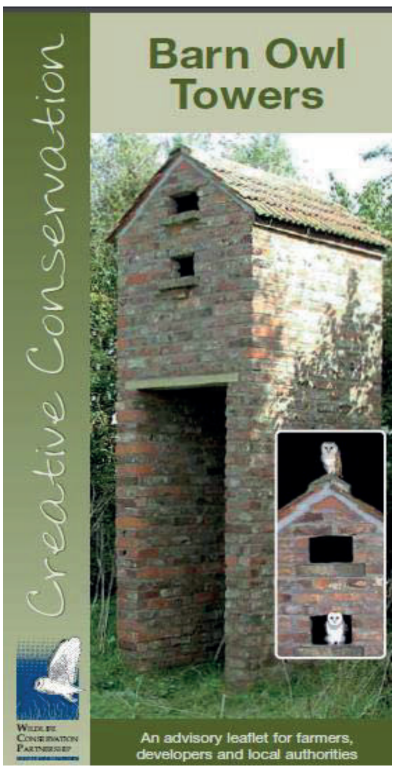
Installation Advice

Spec: 2005

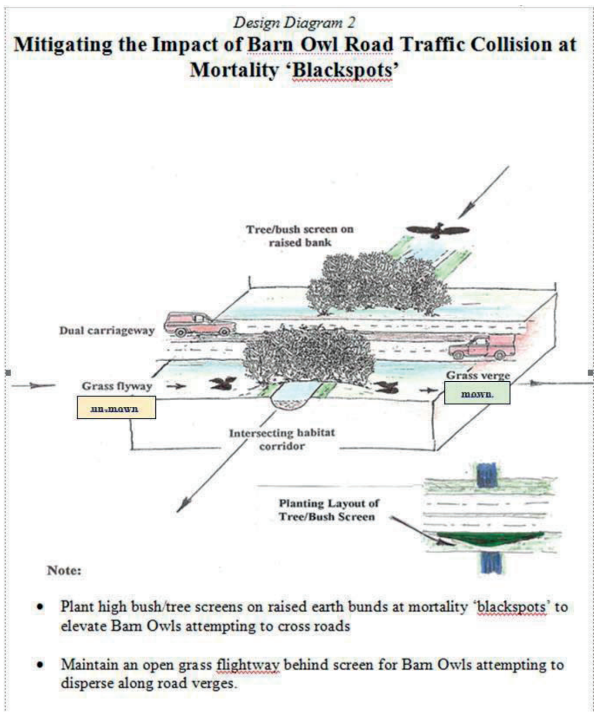
(Brazil and Shawyer, 1989) (Shawyer, 2005)



Owl Tower: Spec 1006



Owl Tower leaflet (Shawyer and Shephard, 2006)


Design Diagram 2

Mitigating the Impact of Barn Owl Road Traffic Collision at Mortality 'Blackspots'

Note:

- Plant high bush/tree screens on raised earth bunds at mortality 'blackspots' to elevate Barn Owls attempting to cross roads
- Maintain an open grass flightway behind screen for Barn Owls attempting to disperse along road verges.

Vegetative 100m wide dual barrier/screen (Shawyer & Dixon, 1995)

Mobile off-road work station –pack flat nest boxes **Tree cavity caps**

Nest sites – netted and or capped prior to construction works

Artificial nest sites – capped prior to construction works

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