CIEEM

UK Bat Mitigation Guidelines

A guide to impact assessment, mitigation and compensation for developments affecting bats

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These mitigation guidelines provide an important update to the previous Bat Mitigation Guidelines (Mitchell-Jones, 2004). They form an invaluable compilation of the current state of knowledge at the time of publication and provide a beneficial tool kit for shaping mitigation plans. Bat mitigation is, however, complex and the Statutory Nature Conservation Bodies (SNCBs) reserve the right to take alternative positions or interpretations which may arise from differing geographies, contexts and legislation in the respective UK countries. Users should refer to the respective SNCB websites for policy updates and issues concerning legislation and licensing.

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AMENDMENTS & CORRECTIONS

Note: Minor typographical revisions and weblink updates will not be shown here but will be incorporated into the PDF version available on the CIEEM website on an ongoing basis.

Section	Paragraph ref.	Change	Date

FOREWORD

These Guidelines reflect the significant changes in our understanding of bat ecology and mitigation practice since the publication of English Nature's (now Natural England's) Bat Mitigation Guidelines (Mitchell-Jones, 2004). They have been produced by synthesising the most up-to-date research evidence available at this time and the expertise of bat ecologists drawing on decades of experience. That they have been almost five years in the drafting reflects both the extensive amount of additional information available and the complexities of delivering successful bat mitigation and compensation. It also highlights the dedication and huge time commitment volunteered by the authors, supported by the steering group and all those who responded in detail during the consultation phase.

Let's also be honest – bat mitigation, and the ecologists who design and oversee its implementation, do not enjoy the best reputation. We can change this by consistently being pragmatic and proportionate in our advice and recommendations, based on an informed assessment of risk and by demonstrating that our work is evidence-based. These Guidelines should help in both regards as well as helping to deliver better conservation outcomes for bats.

It is also important to remember that, like all guidelines, this document provides guidance and not rules. Bat work is complex and these Guidelines should aid professional judgement, not be a substitute for it. There is no magic recipe book or 'one-size-fits-all' solution for any given situation, not least because of the differences in the way that legislation is developing and is applied in each of the four administrations in the UK. Whilst drawing on these Guidelines may assist in achieving any consents and licences necessary to proceed, it is not a guarantee that such applications will succeed.

Of course there is still much to learn about bats and successful bat mitigation and compensation strategies, and we will only achieve more favourable outcomes if we continue to learn through stringent monitoring, recording and using sound professional judgement to innovate where practicable. Innovation can drive step changes in professional practice, but only when it can be shown to be effective. Throughout this document, the authors have highlighted evidence gaps that exist and made suggestions for areas for further research. As practitioners you can help us to develop the evidence base for future editions by monitoring and recording the outcomes of projects you have been involved in and sharing your successes and failures. You can submit your examples of project design, novel approaches and outcomes via the CIEEM website.

The intention is to update these Guidelines every 5-7 years unless there are major changes to the legal protections for bats or other relevant legislative and policy contexts. Minor changes will be made and recorded on the previous page and, where appropriate, the Guidelines will be re-published as an updated version of the first edition.

I would like to extend my personal thanks to Julian Arthur at Tyler Grange LLP for supporting this work and helping to get us started and especially to Paola Reason and Stephanie Wray for the countless voluntary hours they have contributed to authoring this guidance document. We should all be very grateful to them.

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Paola has been an ecological consultant since 1995, joining RSK Biocensus as a Director in 2019. She first encountered bats whilst at the University of Bristol, taking time out to work on Livingstone's flying foxes in the Comoro Islands over several years. She is a Chartered Ecologist and Chartered Environmentalist, a Fellow of CIEEM, and was CIEEM's 'Member of the Year' 2021. She is a member of Natural England's Bat Expert Panel and is on the Technical Review Board for the Bat Conservation Trust's' Bat Survey Guidelines. She joined the Scientific and Expert Committee of Infrastructure & Ecology Network Europe (IENE) in 2022 and, from 2023, co-supervises a PhD on the impacts of noise on bats, generously part-funded by RSK Biocensus and delivered through the Universities of Bath and the West of England.

RSK biocensus EXPERTS IN ECOLOGY

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Steph Wray is an ecologist and sustainability consultant. Although she spends most of her professional life waving her arms around in board rooms saying "But wouldn't it be *even better* if we made lots of money for your shareholders without actually trashing the planet", she secretly still thinks she is a bat consultant. She definitely started out as one, with a post-doc on Livingstone's flying fox in the Comoro Islands. Then, realising that some bats with wingspans of less than a metre were actually quite interesting too, she got a micro-bat licence, dusted off her schoolgirl knowledge of the physics of sound, and started listening. She hasn't had a good night's sleep since.

nature positive

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Note on Coronavirus (COVID-19) in the UK

Consultants and others should always refer to government advice on COVID-19, which differs across the UK.

COVID-19 and working with bats

The IUCN Bat Specialist Group (IUCN BSG) has published its *Recommended Strategy for Researchers to Reduce the Risk of Transmission of SARS-CoV-2 from Humans to Bats – MAP: Minimize, Assess, Protect*. This guidance has been produced by a global panel (including contributors from the UK) with expertise ranging from bat ecology to virology. In preparing the guidance for bat researchers, the panel assessed the available scientific evidence for human-to-bat transmission of SARS-CoV-2 (the virus that causes COVID-19) and the efficacy of risk mitigation strategies.

The IUCN BSG panel found the risk of human-to-bat transmission of SARS-CoV-2 to be credible, especially in countries with high levels of SARS-CoV-2 circulation. However, they also determined that this risk can be reduced using appropriate mitigation strategies. The IUCN recommend that any bat researchers consider three key elements when planning their work: Minimize, Assess, Protect (MAP) to prevent transmission to bats. The full guidance document is available on the IUCN website. To support anyone considering whether it is essential bat activities go ahead, the IUCN BSG have also produced a MAP Decision Tree flow-chart to help with planning and the questions that need to be asked about activities that involve handling or being in close proximity to bats.

This advice is summarised, with links, on the Bat Conservation Trust (BCT) website[1].

Given adverse publicity around this subject, contractors and the public may need to be reassured that they are extremely unlikely to catch Covid-19 from a bat in the UK.

1. https://www.bats.org.uk/news/2020/06/iucn-bat-specialist-group-recommended-strategy-for-bat-researchers-during-covid-19-pandemic

ACRONYMS

BCT	Bat Conservation Trust
CIEEM	Chartered Institute of Ecology and Environmental Management
CIRIA	Construction Industry Research and Information Association
CSZ	Core Sustenance Zone
DAERA	Department of Agriculture, Environment and Rural Affairs
DEFRA	Department for Environment, Food & Rural Affairs
EcIA	Ecological Impact Assessment
EIA	Environmental Impact Assessment
EPS	European Protected Species
FCS	Favourable Conservation Status
GHS	Greater horseshoe bat
HS2	High Speed Two railway
IEF	Important Ecological Feature
IEMA	Institute of Environmental Management and Assessment
ILP	Institution of Lighting Professionals
IROPI	Imperative Reasons of Overriding Public Interest
JNCC	Joint Nature Conservation Committee
LCZ	Landscape Connectivity Zones
LHS	Lesser horseshoe bat
LPA	Local Planning Authority
NE	Natural England
NERC	Natural Environment and Rural Communities
NIEA	Northern Ireland Environment Agency
NPF	National Planning Framework (Scotland)
NRW	Natural Resources Wales
NSA	No satisfactory alternative
PRF	Potential Roost Feature
SAC	Special Area of Conservation
SNCB	Statutory Nature Conservation Body

SNH	Scottish Natural Heritage (now NatureScot)
SPD	Supplementary Planning Document
SSSI	Site of Special Scientific Interest
W&CA	Wildlife and Countryside Act
VWT	Vincent Wildlife Trust
ZoI	Zone of Influence

UK bat species and the abbreviations used in some tables

Species common names	Species scientific names	Abbreviation
Greater horseshoe bat	*Rhinolophus ferrumequinum*	Rfer
Lesser horseshoe bat	*Rhinolophus hipposideros*	Rhip
Daubenton's bat	*Myotis daubentonii*	Mdau
Brandt's bat	*Myotis brandtii*	Mbra
Whiskered bat	*Myotis mystacinus*	Mmys
Alcathoe bat	*Myotis alcathoe*	Malc
Natterer's bat	*Myotis nattereri*	Mnat
Bechstein's bat	*Myotis bechsteinii*	Mbec
Greater mouse-eared bat	*Myotis myotis*	Mmyo
Noctule	*Nyctalus noctula*	Nnoc
Leisler's bat	*Nyctalus leisleri*	Nlei
Common pipistrelle	*Pipistrellus pipistrellus*	Ppip
Soprano pipistrelle	*Pipistrellus pygmaeus*	Ppyg
Nathusius' pipistrelle	*Pipistrellus nathusii*	Pnat
Kuhl's pipistrelle	*Pipistrellus kuhlii*	Pkuh
Serotine	*Eptesicus serotinus*	Eser
Barbastelle	*Barbastella barbastellus*	Bbar
Brown long-eared bat	*Plecotus auritus*	Paur
Grey long-eared bat	*Plecotus austriacus*	Paus

1. Introduction

1.1. Background and objectives

1.1.1. The first version of the *Bat Mitigation Guidelines* was published in 2004 by English Nature (now Natural England) (Mitchell-Jones, 2004). Since its publication, this guidance has been an important resource for bat ecologists involved in development and other land-use change. This update, focused more on development, is designed to address advances in our knowledge of bat ecology, understanding of mitigation requirements, changes to legislation and licensing procedures, and development of best practice in approaches to impact assessment. It is not intended to guide woodland and forestry work[2].

1.1.2. This publication is intended to be a 'live' document, with access freely provided online, to facilitate updates in response to changes in legislative frameworks and policy, new approaches, good practice and newly published research in relation to bats. These guidelines refer specifically to the legislative framework protecting bats within all member countries of the United Kingdom (UK), and examples and case studies refer to those countries. That said, the principles and good practice provided in this document are applicable elsewhere; in such circumstances, the ecological rationale for referring to these guidelines should be explained.

1.2. Scope of the guidelines

1.2.1. This updated mitigation guidance:

- extends the scope of the 2004 guidance to cover not just impacts to roosts but also additional impactsfrom loss of foraging or commuting habitat, and disturbance of bats through, for example, lighting and noise;
- provides a method of valuing bat populations and habitat features used by bats;
- provides specific guidance for assessing impacts on bats as part of an Ecological Impact Assessment (EcIA);
- provides guidance on mitigation in relation to licensable and non-licensable works;
- provides guidance on monitoring the effectiveness of mitigation;
- provides signposts and links to published research and guidance where relevant, including up-to-date evidence of the success of implemented interventions and mitigation strategies; and
- provides guidance to assist bat ecologists in advising how to enhance development sites and achieve net gains for bats.

1.3. Conservation status of bats in the UK

1.3.1. In order to assess the potential impacts of a project and to devise successful mitigation measures to address these impacts, it is necessary to understand the ecology and conservation status of the different species of bats. A useful summary of bat life histories, roosting preferences and foraging preferences is provided in Chapter 3 of the Bat Conservation Trust's (BCT) bat survey guidance for consultants (Collins, 2023) with more detail to be found in *Bats of Britain and Europe* (Dietz & Kiefer, 2016)

1.3.2. Conservation status is defined as "the state of a species ... including, for example, extent, abundance, distribution and their trends" and determined by "the sum of influences acting on the species concerned that

2. BCT highlight a range of resources directed at woodland and forest management at: https://www.bats.org.uk/our-work/landscapes-for-bats/bats-and-woodland

may affect its abundance and distribution within a given geographical area" (CIEEM, 2022). Of the bat species in the UK, some are much rarer and geographically restricted (making them more vulnerable to extinction), and population trends vary. Horseshoe bat populations are increasing whilst others appear stable. For some, there are insufficient data to be certain (Mathews *et al.*, 2018) or the various indicators are contradictory (JNCC & BCT, 2022). Guidance on conservation status, which indicates that it can be applied at various spatial scales, can be found at:

- *Defining Favourable Conservation Status in England* (Mousley & van Vliet, 2021);
- European Commission guidance[3] document on the strict protection of animal species of Community interest under the Habitats Directive 92/43/EEC.

1.3.3. Information with respect to the conservation status of UK bat species can be obtained from the following sources:

- *The State of the UK's Bats 2017: National Bat Monitoring Programme Population Trends* (JNCC & BCT, 2017);
- Habitats Directive Article 17 reporting[4] ;
- *A review of the population and conservation status of British mammals* (Mathews *et al.*, 2018); and
- *IUCN-compliant Red List for Britain's Terrestrial Mammals* (Mathews & Harrower, 2020).

1.3.4. Local data sources may also be available, such as bat group websites, local/county mammal atlases/record centres.

3. https://ec.europa.eu/transparency/documents-register/detail?ref=C(2021)7301&lang=en
4. http://jncc.defra.gov.uk/page-6387

2. Legislation and licensing

2.1. Introduction

2.1.1. All species of bats are protected throughout the UK. However, there are differences in approach to the protection of bats taken by the different devolved administrations. This means that bat mitigation strategies will need to take due account of the relevant legislation and licensing system that apply in each. In this section, the legal framework underpinning these protections is outlined.

International law

2.1.2. The UK is a contracting party to the 1979 Convention on the Conservation of European Wildlife and Natural Habitats (commonly referred to as the **Bern Convention**). The Bern Convention has been described as the "European treaty for the conservation of nature"[5]. Its provisions with regards to bats are transposed into law as follows:

- in England and Wales via the Conservation of Habitats and Species Regulations 2017 (as amended) (the **England and Wales Habitats Regulations**) and the Wildlife and Countryside Act 1981 (as amended) (the **W&CA**);
- in Scotland under the Conservation (Natural Habitats, &c.) Regulations 1994 (as amended) (the **Scottish Habitats Regulations**);
- in Northern Ireland under the Conservation (Natural Habitats, &c.) Regulations (NI) 1995 (as amended) (the **Northern Ireland Habitats Regulations**).

2.1.3. These provisions are more fully described below. More information on the status of European law and the relevance of European Commission Guidance and the potential reform of retained European Union law is set out in **APPENDIX 1**. Species listed within the Habitat Regulations are known as European Protected Species (EPS).

2.1.4. Links to all the legislation listed below are provided in **Section 10.1**. Please note that these links may not contain up-to-date versions of the legislation and it may be misleading to rely upon them. Where there is doubt as to the current legal position, it is best to seek expert legal advice.

2.2. Legislation in England and Wales

2.2.1. All species of bat, their breeding sites and their resting places in England and Wales are protected through a 'dual' system of protection, under the England and Wales Habitats Regulations and W&CA. Because two regimes give legal protection to bats, the implications of both regimes must be fully understood.

2.2.2. Regulation (Reg.) 43 of the England and Wales Habitats Regulations makes it an offence to:

- deliberately capture, injure or kill a bat;
- deliberately disturb bats (which includes any disturbance which is likely to impair their ability to survive, to breed or reproduce, or to rear or nurture their young, or in the case of animals of a hibernating or migratory species, to hibernate or migrate or to affect significantly the local distribution or abundance of the species to which they belong);

5. See: https://edoc.coe.int/en/environment/6802-the-bern-convention-the-european-treaty-for-the-conservation-of-nature.html

- damage or destroy a breeding site or resting place of a bat; or
- possess, control, transport, sell or exchange, or offer for sale or exchange, any live or dead bat or part of a bat or anything derived from a bat or any part of a bat.

2.2.3. Under Section 9 of the W&CA (s.9(4)(b), 9(4)(c) and 9(5) only), it is an offence (in relation to bats) to:

- intentionally or recklessly disturb a bat while it is occupying a structure or place of shelter or protection;
- intentionally or recklessly obstruct access to any structure or place used by a bat for shelter or protection; or
- sell, offer or expose for sale, or have in their possession or transports for the purpose of sale, any live or dead bat or any part of, or anything derived from a bat (or be responsible for adverts suggesting the intention to do this).

2.3. Legislation in Scotland

2.3.1. All bat species their breeding sites and their resting places are afforded full protection in Scotland under the Scottish Habitats Regulations. The legislation in Scotland differs significantly in parts from that in England and Wales. In particular, in Scotland the W&CA is no longer relevant to the legal protection of bats. This neatly side-steps the dual regime which applies in England and Wales.

2.3.2. For any wild bat species (and note where applicable, references to 'a bat' in the singular), it is an offence in Scotland to deliberately or recklessly:

- capture, injure or kill a bat;
- harass a bat or group of bats;
- disturb a bat while it is occupying a structure or place which it uses for shelter or protection;
- disturb a bat while it is rearing or otherwise caring for its young;
- obstruct access to a breeding site or resting place of a bat or otherwise deny an animal use of the breeding site or resting place;
- disturb a bat in a manner or in circumstances likely to significantly affect the local distribution or abundance of the species;
- disturb a bat in a manner or in circumstances likely to impair its ability to survive, breed or reproduce, or rear or otherwise care for its young; or
- disturb a bat while it is migrating or hibernating.

2.3.3. It is also an offence to:

- damage or destroy a breeding site or resting place of such an animal (whether or not deliberately or recklessly);
- keep, transport, sell or exchange, or offer for sale or exchange any wild bat (or any part or derivative of one) obtained after 10 June 1994; or
- for any person on or after 1 May 2007 to possess, control, or transport a live or dead wild bat or any part of a wild bat.

2.3.4. It is worth noting that not all of the offences within the Scottish Habitats Regulations are derived from the Habitats Directive; some were formerly part of the W&CA in Scotland, so are considered 'domestic' (see **2.5.7**). This is of relevance when interpreting case law.

2.4. Legislation in Northern Ireland

2.4.1. The legislation in Northern Ireland is similar to Scotland in that the protection for bats, their breeding sites and their resting places is provided by the Northern Ireland Habitats Regulations. For any wild bat species (and again note, where applicable, references to 'a bat' in the singular), it is an offence to:

- deliberately capture, injure or kill a bat;
- deliberately disturb a bat while it is occupying a structure or place which it uses for shelter or protection;
- deliberately disturb a bat in such a way as to be likely to affect the local distribution or abundance of the species to which it belongs, or impair its ability to breed or reproduce, or rear or care for its young, or impair its ability to hibernate or migrate; or
- deliberately damage, destroy or obstruct access to a breeding site or resting place of a bat.

2.4.2. It is also an offence for any person to:

- have a bat in his possession or control;
- transport a bat;
- sell or exchange a bat;
- offer for sale or exchange a bat; or
- have any dead or live bat, which is taken from the wild or anything derived from such an animal.

2.4.3. It is worth noting that not all of the offences within the Northern Ireland Habitats Regulations are derived from the Habitats Directive; some were formerly part of the Wildlife (Northern Ireland) Order 1985, so are considered 'domestic' (see **2.5.7**). This is of relevance when interpreting case law.

2.4.4. Legislation in force in the Republic of Ireland may be relevant to projects where the impacts extend over its border with Northern Ireland[6]. This legislation, and consideration of trans-border impacts, are outside of the scope of this document.

2.5. Interpretation of offences

2.5.1. The meaning of the offences under the above legislation is not straightforward. Whether or not an offence has occurred will often turn on expert judgment informed by the best available scientific evidence (usually in the form of survey work adopting best practice methodology) as well as legal interpretation of the criminal offences. In these circumstances, it is helpful to have clear guidance on how the law should be interpreted.

Guidance on the offence of damage or destruction of a breeding site or resting place for bats

2.5.2. The criminal offence of "*damage or destruction of a breeding site or resting place*" of a bat derives from Article 12 of the Habitats Directive.

2.5.3. Bats can be found in very transient places (such as behind roller shutter doors, behind temporarily stored building materials, or even within stored vehicles or under a blanket), and it may be difficult to know whether removing or damaging such a place would give rise to this criminal offence. Additional guidance on interpretation is provided in **APPENDIX 1.**

2.5.4. A further key point about this offence is that it is a 'no fault' (or 'strict liability') offence, i.e. the person who commits the offence need not have acted with intention or recklessness or deliberately. In other words, no

6. A summary is provided in bat mitigation guidelines published for Ireland by The National Parks and Wildlife Service (Marnell, Kellerher & Mullen, 2022).

matter how careful the person has been to avoid the offence, if a breeding site or resting place is damaged or destroyed, then the offence has been committed.

Guidance on the bat disturbance offences

2.5.5. Most of the criminal offences protecting bats (as set out above) incorporate the words 'intentional', 'deliberate' or 'reckless'. These terms each have their own legal definitions and there may be situations in which 'intentionally' and 'deliberately' are not synonymous. As a general rule of thumb, of these terms, 'intention' is often the hardest for the prosecution to prove, followed by 'deliberate' and then 'reckless'. More information on how these terms have been defined/treated in law is given in **APPENDIX 1.**

2.5.6. In order to understand disturbance offences, it is necessary to closely examine the statutory language (set out in more detail in **APPENDIX 1**, and summarised below). There are three elements:

- Deliberate disturbance of bats under the England and Wales Habitats Regulations (this derives from Article 12 of the Habitats Directive).
- Intentionally or recklessly disturbing a bat while it is occupying a structure or place which it uses for shelter or protection under the W&CA for England and Wales (this does not derive from Article 12 of the Habitats Directive).
- Deliberately or recklessly disturbing a bat under the Scottish Habitats Regulations (most of these offences derive from Article 12 of the Habitats Directive, although the offence in reg 39(1)(b)(ii) does not); the situation in Northern Ireland is similar (see **APPENDIX 1: Table A1.1)**.
- Deliberately or recklessly disturbing a bat under the Scottish Habitats Regulations (most of these offences derive from Article 12 of the Habitats Directive, although the offence in reg 39(1)(b)(ii) does not); the situation in Northern Ireland is similar (see **APPENDIX 1: Table A1.1**).

2.5.7. The leading Habitats Directive protected species (bat) case, *Morge v Hampshire County Council* [2011] UKSC 2 (19 January 2011)[7], is important for understanding/interpreting disturbance as it applies to bats for legislation which derives from Article 12 of the Habitats Directive. It is not, however, an authority for the disturbance offences that have their root in domestic legislation only, as outlined in **2.5.6** above (see **APPENDIX 1: Table A1.1**).

2.5.8. *Morge* provides clarity on the term 'deliberately', and also on the meaning of the 'disturbance' prohibition in Article 12 of the Habitats Directive. The Supreme Court agreed that this relates to protection of the *species* (not specimens of the species) and that the disturbance does not have to be *significant* to come within the prohibition. While no threshold was set for the minimum threshold for 'deliberate disturbance' of the species, the Supreme Court in *Morge* did provide some guiding principles which are set out in detail in **APPENDIX 1**. In summary, these require each case to be judged on its own merits, taking into account species, conservation status, seasonal factors and so on. It is important to note that *Morge* provides an interpretation of Article 12 of the Habitats *Directive* and, in Scotland and Northern Ireland, the derived *Regulations* refer to 'an animal', so appear to be more strict (see **2.3.2, 2.4.1** and **2.5.6** and see **APPENDIX 1: Table A1.1**).

The meaning of the terms 'intentionally' or 'recklessly'

2.5.9. Unlike the Habitats Regulations (which mainly use the word 'deliberately' in the offences so as to reflect Article 12), the W&CA uses the terms 'intentionally or recklessly' in the offences applying to bats. 'Recklessly' is also used in the Scottish Habitats Regulations. A detailed explanation of these terms is given in **APPENDIX 1,** along with detailed guidance on how to minimise the risk of acting intentionally or recklessly. For practical purposes, adopting a precautionary method of working helps to reduce the likelihood of committing an offence, and would allow practitioners to make the case that they had not acted 'deliberately' or 'intentionally/recklessly'

7. https://www.supremecourt.uk/cases/docs/uksc-2010-0120-judgment.pdf

with regard to the disturbance of bat species. It may therefore reduce the likelihood of an offence being taken to prosecution.

2.5.10. Advice should always be taken from an ecologist to determine whether an offence would be triggered in a particular circumstance. Given the complexities of the law, advice may also need to be sought from a specialist lawyer to determine whether an offence would be triggered in a particular circumstance.

2.6. Licensing

2.6.1. Derogation in the form of protected species licences exists in respect of the offences listed above. The different countries of the UK have slightly different licensing regimes, but the purpose of these regimes is to legitimise activities which would otherwise be unlawful. The licensing regimes can be accessed using the links in **Section 10.1**.

2.6.2. Licensing authorities are frequently asked whether a licence is required for a particular development activity or project. However, this is a decision to be made by the developer, acting on professional advice from a suitably qualified ecological consultant. Developers may also wish to seek legal advice in cases where it is unclear whether proceeding with work without a licence would result in an offence being committed.

2.6.3. If a developer concludes, having sought the relevant ecological/legal advice, that the proposed activity is not reasonably likely to infringe, in England or Wales, the relevant sub-sections of s.9 of the W&CA or Reg. 43 of the England and Wales Habitats Regulations (Reg. 39 of the Scottish Habitats Regulations in Scotland/Reg. 34 of the Northern Ireland Habitats Regulations in NI), the developer is entitled to proceed with the development without a licence, but is at risk of prosecution if that conclusion turns out to have been wrong. Note that the decision on whether or not to obtain a licence may be challenged by a third party alerting the police to any activity which the third party considers should have been licensed. However, ultimately it will be a matter for the police and/or criminal courts to decide.

Derogation tests for bat licences

2.6.4. In order to obtain a bat licence, it is important to understand which derogation tests apply with regards to particular activities. In all countries, the species licensing tests are the three derogation tests derived from Article 16 of the Habitats Directive and outlined below. In England, which (as noted above) has a dual legal regime for bats, licences are (from October 2022) also able to be issued under the W&CA. This is discussed more fully in para 2.6.7 *et seq.*

Bat licences under the Habitats Regulations

2.6.5. For such a licence to be granted, the following three Article 16-derived tests must be met. **APPENDIX 1** explains two of the tests in more detail, as well as the concept of proportionality.

1) Test 1 – the statutory purpose ‘need’ test

- It is necessary to demonstrate that the licence is needed for one of the listed statutory purposes which derive from Article 16. Such purposes include the preserving of public health or public safety or “other imperative reasons of overriding public interest (IROPI), including those of a social or economic nature[8] and beneficial consequences of primary importance for the environment”.

8. The ‘social and economic’ purpose test did not, until very recently, appear in the W&CA, which led to inconsistencies between the W&CA 1981 and the Habitats Regulations licensing regimes in England and Wales. This inconsistency in England has now been addressed (see **2.6.8** et seq.).

2) **Test 2 – no satisfactory alternative (NSA) test**

- In order to obtain a bat licence under the Habitat Regulations, it is also necessary to demonstrate that there is no satisfactory alternative i.e. that there is no feasible way of delivering the 'need' (i.e. the statutory purpose above) which has a better outcome for bats.

3) **Test 3 – the Favourable Conservation Status (FCS) test**[9]

- The third test considers whether the action authorised under the licence (i.e. the action that would otherwise be unlawful) will be detrimental to the maintenance of the population of the species concerned at a FCS in their natural range.
- FCS is described as a situation where a habitat type or species is doing sufficiently well in terms of quality and quantity and has good prospects of continuing to do so in future. The fact that a habitat or species is not threatened (i.e. not faced by any direct extinction risk) does not necessarily mean that it has favourable conservation status. To obtain a licence, it must clearly be demonstrated that the mitigation hierarchy has been followed (see **Figure 5.1)** that all reasonable steps have been taken to minimise/mitigate the impact, and that any remaining damage will be adequately compensated. If it cannot be demonstrated that FCS will be maintained, then a licence cannot be issued. It is important to note that the test applies to 'protected species' and not 'specimens of the protected species'.

2.6.6. In England, EPS Licensing Policies provide additional flexibility in respect of survey data and mitigation required for protected species licensing under the England and Wales Habitats Regulations. They may be applicable to bats in certain circumstances.[10] The Licensing Policies do not apply to the bat offences in s.9(4)(b) and 9(4)(c) of the W&CA.

Licensing under s.16 of the W&CA for s.9(4)(b) and 9(4)(c) bat offences

2.6.7. Under s.16 of the W&CA, licences have not, in the past, been available for development/commercial/economic activities in England and Wales (by contrast this *has* been possible in Scotland for some time). Section 111 of the Environment Act 2021, which came into force on 30 September 2022, amends the wildlife licensing regime under s.16 of the W&CA in England. For the first time, this amendment allows licences to be issued in England (but not in Wales) *for reasons of overriding public interest,* though no licence (for any of the purposes listed under s.16(3) of the W&CA) may be issued unless:

- there is no other satisfactory solution; and
- the grant of the licence is not detrimental to the survival of any population of the species of animal or plant to which the licence relates.

2.6.8. A further change from the Environment Act 2021 to s.10 W&CA means that, in England and Wales, if a person now obtains a Habitats Regulations licence and follows and complies with the licence, then the person is no longer exposed to offences under s.9(4)(b) and s.9(4)(c) of the W&CA (though they would have been previously).

2.6.9. The current requirements of each country's licensing regime should always be checked, and up-to-date versions of application forms downloaded/used (see **Section 10.1** for links).

9. An article explaining FCS can be found here: https://conbio.onlinelibrary.wiley.com/doi/full/10.1111/conl.12200. Natural England have published their approach and principles for defining FCS, and an FCS report for grey long-eared bat here: http://publications.naturalengland.org.uk/category/5415044475256832

10. https://www.gov.uk/guidance/european-protected-species-policies-for-mitigation-licences?msclkid=050bd812c54e11ec900a9e7c5f147b56

The 'incidental result' defence

2.6.10. In England and Wales, there is a defence under s.10(3)(c) of the W&CA which states that any act made unlawful by s.9 of the W&CA is not an offence if it can be shown that *"the act was the incidental result of a lawful operation and could not reasonably have been avoided"*.

2.6.11. However, it is important to remember that there are only two offences in s.9 of the W&CA that are relevant here:

- to "intentionally or recklessly disturb a bat while it is occupying a structure or place of shelter or protection" (s.9(4)(b)); and
- "intentionally or recklessly obstruct access to any structure or place used by a bat for shelter or protection" (s.9(4)(c)).

2.6.12. This defence is therefore potentially useful only in a very limited set of circumstances (and only applies in England or Wales) i.e. it cannot be used as a defence against offences under the Habitats Regulations.

2.6.13. The statutory defence under s.10(3)(c) of the W&CA relies on three things:

- there being a lawful operation;
- ensuring that the 'otherwise unlawful act' (i.e. the activity which contravenes one or more of the two offences above) is the 'incidental result' of that lawful operation; and
- demonstrating that, in carrying out that lawful operation, the incidental result could not reasonably have been avoided.

2.6.14. If the defence is to be invoked and successfully relied upon, it is important that all three of the above elements are met. If relying on this defence, note that there is also a requirement under s.10(5) of the W&CA to notify the relevant Statutory Nature Conservation Body (SNCB). The SNCB must then be given a reasonable time to provide advice as to whether the activity should be carried out and, if so, the method to be used. There is no statutory obligation on the SNCB to provide a response upon receiving a s.10(5) notification. More information on the use of this defence is provided in **APPENDIX 1**[11].

2.6.15. If seeking to use this defence, the precise wording of the law should be carefully reviewed. A court would need to decide whether the defence has been applied properly, and it is recommended that professional legal advice is sought before relying on this defence.

2.6.16. Following changes to the Environment Act (2021), Natural England will introduce (from 2024) a formal process for notifications required under s.10(5) of the W&CA. The incidental result defence is set out under the W&CA and is therefore not available in Scotland or in Northern Ireland for offences relating to bats.

Enforcement

2.6.17. Enforcement of the law in relation to wildlife is primarily the responsibility of the police. Most police forces now have full or part-time Wildlife Crime Officers who take the lead in investigating wildlife crime in their force areas. In addition, there is a Police National Wildlife Crime Unit (NWCU[12]) which has a co-ordinating and investigative support role in relation to wildlife crime across the UK.

11. The requirement under s.10(5) of the W&CA to notify the relevant SNCB if a person wishes to rely on the incidental result defence provided by s.10(3)(c) (as set out in **2.6.14**) does not apply if the offence relates to the dwelling part of a house.

12. www.nwcu.police.uk

2.6.18. At the time of writing, BCT has a Wildlife Crime Project with a Wildlife Crime Officer who is able to provide advice and guidance to the police and also to ecologists. An internal Police Tactical Document is also available to the police on 'Investigating Bat Crime 2022', and it may be helpful to refer crime officers to this.

2.6.19. Where Natural England has issued a licence and conditions have been breached, Natural England has direct investigation and enforcement responsibilities relating to that breach. Natural England also supports the police in any investigation into wildlife offences outside of licensing. Within Wales, Northern Ireland and Scotland, Natural Resources Wales (NRW), Northern Ireland Environment Agency (NIEA) and NatureScot (formerly Scottish Natural Heritage) do not directly investigate; if it is thought likely that an offence has occurred, the case will be referred to the relevant police authority.

Criminal penalties under the W&CA

2.6.20. The maximum penalty in England and Wales for offences under s.9 of the W&CA is an unlimited fine and/or a six-month custodial sentence (outlined in s.21 of the W&CA).

Criminal penalties under the Habitats Regulations

2.6.21. Under the England and Wales Habitats Regulations, Natural England/NRW have a power of enforcement for breach of licence conditions (see Reg. 60), as well as for offences under Reg. 43 (with penalties in line with those of the W&CA).

2.6.22. In Scotland, the Animals & Wildlife (Penalties, Protections & Powers) (Scotland) Act 2020 increased penalties for offences against EPS so that, on summary conviction, there is a fine of up to £40,000 and/or prison up to 12 months. On conviction on indictment, a fine or prison up to five years. In Northern Ireland, the fine is up to £5,000 per offence, but this can be imposed for each animal involved.

2.6.23. Recent prosecutions have used the Proceeds of Crime Act 2002 (as amended) to impose proportionate penalties, as well as relying on the penalties allowed under the legislation cited in the sections above. Under the Proceeds of Crime Act 2002, any profits made as a consequence of not following lawful process can be confiscated, and items used to commit the offences such as vehicles, plant or machinery can be forfeited.

2.6.24. Further details are available at the links in **Section 10.1.**

2.7. Habitats Regulations Assessment (HRA)

2.7.1. Under the Habitats Directive, member states are required to designate areas of their territory containing a representative sample of important habitats and species. These areas are identified under the Habitats Directive as Natura 2000 sites and comprise Special Protection Areas (SPAs) to protect the habitat of wild birds and Special Areas of Conservation (SACs) to protect the habitats of other protected species.

2.7.2. These requirements have been transposed into national legislation (i.e. versions of the Habitats Regulations in each country of the UK). Following the UK's departure from the EU, Natura 2000 sites in the UK are now referred to as the 'national site network'.

2.7.3. SACs may be designated for bats that are listed in Annex II of the Habitats Directive. Accordingly, when determining a consent for a project, a competent authority should check if the project is located within the likely 'Zone of Influence' (ZoI) of any bat SAC (see **Section 3.2** below) and carry out an assessment. The ZoI in each case will depend on the nature and scale of the likely effects and the species concerned (it should not be assumed that only large projects in close proximity to a SAC could be affected).

2.7.4. The step-wise decision-making (assessment) process required is often referred to as the Habitats Regulations Assessment (HRA) process. The process of screening for 'Likely Significant Effects' is Stage 1 of the HRA, and it must take into account each of the ‘Qualifying Features’ that justified the site being designated. This screening must also consider the proposals alone and in-combination with other plans and projects which are capable of affecting those interest features.

2.7.5. If a project, plan or proposal could have a significant effect on the bat species, alone or in-combination with other plans and projects, then an ‘Appropriate Assessment’ (Stage 2 of HRA) would be required.

2.7.6. The requirement for a HRA remains at the time of writing; however, following the UK’s departure from the EU there is the potential for the HRA process (in England at least) to be reformed by the UK Government. Expert legal advice should be taken as to the consequences of any such reforms.

3. Ecological Impact Assessment (EcIA) 1: Scoping, baseline, and valuation

3.1. Introduction

3.1.1. This section sets out how the importance of bats in a development project can be assessed in an objective and repeatable manner, and at a scale that is relevant to the potential impacts. While the process described below applies to larger schemes (and could be used to generate an EcIA), the *principles* of determining the area over which a project could have an effect, valuing the bats that could be affected, and characterising the likely impacts, also apply to smaller projects. It is important to remember that the cumulative impacts of small schemes could also have significant impacts on the conservation status of bats.

3.2. Zone of Influence

3.2.1. In EcIA, scoping (or 'preliminary ecological appraisal') is the initial stage which considers the potential for impacts to ecological features, to enable the ecologist to decide what baseline information should be obtained – and at what spatial scale – to inform the assessment. Information on scoping can be found in Chapter 2 of the EcIA guidelines (CIEEM, 2022), CIEEM's guidelines on preliminary ecological appraisal (CIEEM, 2017) and Chapter 4 of *Bat Surveys for Professional Ecologists: Good Practice Guidelines* (Collins, 2023).

3.2.2. Establishing the Zone of Influence (ZoI) of the proposed development requires the ecologist to consider the spatial extent within which an impact could occur. As bats are highly mobile species and can use different habitats depending on the time of year, the ZoI for bats must be carefully considered at the start of the assessment to ensure that surveys can be appropriately planned, and relevant data collected. It is rarely acceptable for the consideration of impacts to be limited to the red line boundary, unless these are limited in nature and extent. However, the ZoI should be proportionate to the project's impacts.

3.2.3. Factors to consider when defining the ZoI of a project on bats are:

- the nature of the project and project activities, and the potential for effects at all development stages;
- the nature of the land use and habitats in the vicinity, their connectivity, and how they may be used by bats;
- the assemblage of bat species which may be in the area based on the site location and desk study data; and
- the different habits, behaviours and preferences of different bat species that could be affected, and how these vary both spatially and seasonally.

3.2.4. Infrastructure projects are often of a large scale, potentially extending beyond county boundaries and, sometimes, country boundaries. Consequently, it is necessary to carefully consider the appropriate scale at which to assess impacts on bats (refer to ZoI in **Sections 3.2** and **3.3** in this chapter), which has implications for the baseline data obtained to inform the assessment. Alongside the usual desk-based research and fieldwork to identify roosts and other habitats of value to bats, baseline data collection may necessitate a 'landscape scale' survey method. Examples include remote acoustic monitoring to assess the effect of linear infrastructure or district-wide replacement of street lighting on bats at a population level. Radio-tracking studies, although focused on individuals, can also determine how a population of bats uses different features across large areas of the landscape (useful for linear schemes that may fragment that landscape).

3.2.5. Core Sustenance Zones (CSZ)[13], are defined as "the area surrounding a communal bat roost within which

13. https://www.bats.org.uk/our-work/landscapes-for-bats/core-sustenance-zones

habitat availability and quality will have a significant influence on the resilience and conservation status of the colony using the roost" (Collins, 2023). CSZs are species-specific, e.g. 1 km radius for whiskered/Brandt's bat, to 6 km for barbastelle. Where they are known, CSZs should be used when interpreting the results of background data searches and survey data to help define the ZoI of a project, though they are not known for all UK bat species. Confidence in the calculated CSZ size is also variable, dependent on the quality of the data available. For any given colony, the actual CSZ (and hence the ZoI of a project on bats) will depend on factors such as the spatial configuration of the landscape and the presence of suitable and less suitable habitat (such as marine or urban habitats). CSZs are sometimes specified in supplementary planning guidance where a protected bat site could be affected.

3.2.6. In addition to CSZs for summer activity, setting the ZoI should also consider the relevant distances, seasonality and significance of hibernacula, and spring or autumn swarming sites[14], as these are critical seasonal habitats for a wide range of bat species, and of high significance to populations at a broad landscape scale. Ringing recaptures for a range of species show that such key sites may be around 30 km (Parsons & Jones, 2003; Parsons *et al.,* 2003) and even up to 60km from breeding areas/roosts (Rivers, Butlin & Altringham, 2006) (pers. comm. K. Cohen/Wiltshire Bat Group). Up to 115km has been recorded from DNA studies (Mordue *et al.,* 2021). This would be an especially significant consideration in regard to Annex II species in the catchment of relevant SAC sites.

3.2.7. Sources that can assist further in the identification of the ZoI and survey scope for different development types relating to bats include:

- linear infrastructure (Berthinussen & Altringham, 2017); lighting (Ferguson, Fox & Smith, 2018; Voigt *et al*., 2018);
- onshore wind turbines (NatureScot *et al.,* 2021) which tailors the guidance of Rodrigues *et al*. (2014) to the UK.

3.3. Establishing the baseline

Survey objectives, methods and standards

3.3.1. How important a given site or area is for bats is informed by baseline data from surveys, and available information from public records, local experts and stakeholders (see for, instance, Lintott and Mathews, 2018). For most UK species, there are good general data on range and habitat and, following the precautionary principle, all species that could reasonably be expected in the development area should be considered in the impact assessment; where any are scoped out, this decision should be justified.

3.3.2. Detailed guidance on assessing the baseline with respect to bats through surveys is set out in Chapters 5-9 of Collins (2023) and is not repeated here. Surveys should be interpreted taking into account the likely sampling limitations; for example, Richardson *et al* (2019) demonstrated that most acoustic bat surveys will under-record rarer species. See also Collins (2023, Section 10.2) for a discussion on the limitations of acoustic sampling, noting that these are reducing over time, as software becomes more sophisticated and where good quality recordings are obtained.

3.3.3. Surveys will be required within the 'red line boundary' of a development where likely effects of the development on bats cannot be confidently determined. Surveys outside of the red line boundary may require third-party access to be agreed. This may not always be forthcoming, and hence it may not be possible to fully survey the entire ZoI. In such circumstances, the limitations to the impact assessment (and any measures used to minimise those limitations) should be described within the survey report, and professional judgement used and justified where evidence is missing.

14. In addition to the classic swarming species noted in Table 3.2, there is evidence that common pipistrelle, serotine and lesser horseshoe bats also swarm. For more information see UK Bat Steering Group page on BCT website: https://www.bats.org.uk/our-work/project-collaborations-partnerships/uk-bat-steering-group.

3.3.4. The survey design should:

- set clear survey objectives to assess, as far as is possible, the potential impacts to bats within the defined ZoI of the project;
- refer to, and explain the extent of compliance with, published good practice guidance to identify appropriate survey methods and equipment to gather the required data to satisfy the survey objectives;
- use a suitably experienced team;
- ensure robust data are obtained: this aids analysis, reduces limitations of the survey and assessment, and provides greater confidence in the conclusions;
- consider the requirement for post-works monitoring, and plan an approach that will enable suitable data to be gathered to provide comparable data post-development; and
- consider the type of analysis that is appropriate for the data set obtained through survey, to most clearly achieve and fulfil the survey objectives.

3.3.5. It is important to note that applying 'best practice' does not mean following a 'recipe-book' approach. Rather, it applies methods and effort that allow the potential impacts to bats within the defined ZoI of the project to be adequately determined. Setting survey objectives at the outset is key, and Collins (2023) sets out the types of questions that might need to be answered in different circumstances.

3.4. Assessing importance

3.4.1. Bats (and other protected species) are a material consideration in the determination of any planning application; it is therefore necessary to determine if and how they need to be taken into account during the determination of a specific application. In EcIA, it is only Important Ecological Features (IEFs) that are required to be considered (CIEEM, 2022). Determining the importance of bats that could be affected by a particular project is challenging. Their highly mobile nature, combined with a high level of legal protection and conservation concern, means that roosting, commuting or foraging bats may be present at some time on almost any site, but it does not follow that every site is important for bats.

3.4.2. While bats are nationally or internationally protected species, it does not follow that any ecological feature supporting bats is similarly of national or international importance. The following outlines a method which aims to provide consistency across projects, whilst taking account of regional variations in bat distribution and rarity.

3.4.3. The EcIA guidelines (CIEEM, 2022) recommend describing importance by assigning a feature to a geographic frame of reference, i.e. international and European; UK/national; regional; Metropolitan, County, vice-County, Council area (in Scotland) or other local authority-wide area; and local[15]. This approach has been adopted below, with the caveat that the term 'district' is used to reflect LPA jurisdictions in England; sub-county areas elsewhere; and 'local' has been interpreted to mean the site and relatively close surroundings (such as a parish). Obviously, this term is imprecise, but counties themselves do vary considerably in size. The level of importance chosen for each ecological receptor should be justified.

3.4.4. Importance should be assessed at an appropriate spatial scale, based on species distribution, conservation status, current population trends, functionality of the site and the ZoI of the project in question as it relates to bats. This will include an assessment of whether it supports habitats for roosting, foraging and/or commuting. As data are often incomplete, professional judgement is required to apply the methods described below. However, the rationale behind that judgement should be clearly set out in any ecological appraisal.

3.4.5. Conservation status varies between the different countries of the UK, reflecting current understanding of

15. Various approaches can be adopted for defining local importance, including assessment within a district, borough or parish context or within other locally defined areas (CIEEM, 2022).

abundance and distribution. For example, there are seven priority species[16] in England and Scotland, eight in Wales, and three in Northern Ireland. There are also differences in abundance and distribution within each country boundary. Consultation with statutory bodies and recognised regional experts has resulted in the categorisation of species set out in **Table 3.1**, reflecting the relative abundance of species across the different areas of the UK. Note that the absence of a species from this table does not mean that it never occurs in that region/country; when rarities do occur, their value should be specifically assessed and counted as 'rare' in that region/country[17].

Table 3.1: Rarity category (see para 3.4.5 and associated footnote).

Rarity category	South-west England & S Wales	Southern England	South-eastern/ East Anglia to The Wash	North/mid-Wales	Central England/ Midlands	Northern England	Southern Scotland	Northern Scotland	Northern Ireland
Widespread	*Ppip* *Ppyg* *Paur*	*Ppip* *Ppyg* *Paur*	*Ppip* *Ppyg* *Paur*	*Ppip* *Ppyg* *Paur*	*Ppip* *Ppyg* *Paur*	*Ppip* *Ppyg* *Paur*	*Ppip* *Ppyg*	*Ppip* *Ppyg*	*Ppip* *Ppyg* *Paur*
Widespread in many geographies, but not as abundant in all	*Mmys* *Mbra* *Mdau* *Mnat* *Nnyc*	*Mmys* *Mbra* *Mdau* *Mnat* *Nnyc*	*Mdau* *Mnat* *Nnyc*	*Mmys* *Mbra* *Mdau* *Mnat* *Nnyc*	*Mmys* *Mbra* *Mdau* *Mnat* *Nnyc*	*Mmys* *Mbra* *Mdau* *Mnat* *Nnyc*	*Mdau* *Mnat* *Paur*	*Mdau* *Mnat* *Paur*	*Mdau* *Mnat* *Nlei* *Paur*
Rarer or restricted distribution	*Rhip* *Eser* *Nlei* *Pnat*	*Malc* *Eser* *Nlei* *Pnat*	*Mmys* *Mbra* *Eser* *Nlei* *Pnat*	*Rhip*	*Eser* *Nlei* *Pnat*	*Malc* *Nlei* *Pnat*	*Mmys* *Nnyc* *Nlei* *Pnat*	*Pnat*	*Mmys* *Pnat*
Rarest Annex II species and very rare	*Rfer* *Mbec* *Bbar* *Paus*	*Rfer* *Rhip* *Mbec* *Bbar* *Paus*	*Malc* *Bbar*	*Rfer* *Bbar* *Eser* *Nlei* *Pnat*	*Malc* *Bbar*		Mbra		

3.4.6. The geographical variation set out in **Table 3.1** underpins the subsequent assessment of the importance of roosts **(Table 3.2)**, commuting routes and foraging areas, and of the overall assemblage of bats present on a site (**Table 3.3)**. The boundaries between categories are not absolute and should be treated with caution, particularly where species are at the edge of their range. Climate change and other pressures are already affecting species distributions and the species listed in each category will therefore need to be regularly reviewed (see Sherwin, *et al.*, (2013) and Rebelo, *et al.*, (2010) for an assessment of risk factors by species).

3.4.7. Worked examples are included in **APPENDIX 2.**

Importance of roosts

3.4.8. Bats use many different types of roost, notably for mating, raising young and overwintering, and not all roosts have the same level of importance in supporting a local population of bats. The survey work undertaken should aim to sufficiently characterise each roost through appropriate survey effort (see Section 7.2 of Collins, 2023). This does not mean applying the survey effort set out in Table 7.3 of that document, which is to give 'reasonable confidence' that bats are absent. It means collecting sufficient information, once bats are confirmed to be present, to be able to undertake an informed impact assessment.

16. See https://jncc.gov.uk/our-work/uk-bap/ for lists of priority species in each country. for lists of priority species in each country.

17. A particular example is Kuhl's pipistrelle, recorded on the South Coast, which may visit more frequently than is currently appreciated. A grounded barbastelle was identified in Merseyside in autumn 2022, well away from its currently understood range (source: Tyrer Ecological Consultants, LinkedIn). In January 2023, a second greater mouse-eared bat was recorded by Sussex local Bat Group (only one had previously been recorded, since 2002). In addition, new records of Alcathoe bat are turning up all the time so, for this species in particular, the table is likely to change.

3.4.9. A variety of sources exist to inform an assessment of the importance of roosts, including:

- *Bat Surveys for Professional Ecologists: Good Practice Guidelines*; Chapter 3 (Collins, 2023);
- *The state of UK's Bats 2017* (JNCC and BCT, 2017);
- National Bat Monitoring Programme annual reports (JNCC & BCT, 2022) ;
- *Bats of Britain and Europe* (Dietz & Kiefer, 2016);
- Habitats Directive Article 17 reporting[4];
- NBN Atlas[18]
- County bat atlases;
- Local stakeholders;
- Local record centres and bat groups;
- EPS licensing data (available for England only on DEFRA's MAGIC website[19]);
- *A Review of the Population and Conservation Status of British Mammals* (Mathews *et al.,* 2018);
- *Atlas of the Mammals of Great Britain and Northern Ireland* (Crawley *et al.,* 2020);
- *IUCN-compliant Red List for Britain's Terrestrial Mammals* (Mathews & Harrower, 2020).

3.4.10. Data can also be entered into the Mammal Society's 'Count Bat' app[20], which is designed to give context to roost counts. Data from a roost submitted to Count Bat will be compared to other roosts for that species across the country or more locally, and at various times of the year. Once submitted, a short analysis can be downloaded for use in reports. The more data are submitted, the more reliable the contextualisation will be, so all are encouraged to submit data to the app.

3.4.11. **Table 3.2** below, identifies the importance of different types of roost (see Collins (2023) for one set of definitions). In all cases, the geographic scale set out presents a *likely minimum* and modifying factors may increase but will not usually decrease the importance assigned to roosts. Worked examples are included in **APPENDIX 2.**

3.4.12. Modifying factors include (but are not limited to) the following:

- roosting preferences and typical roost sizes for species/roost types[21];
- species behaviours, such as the tendency to have satellite roosts associated with the main maternity site, for example lesser horseshoe bats (Schofield, 2008), or larger male gatherings, for example Daubenton's bats (Dietz & Kiefer, 2016)[22];
- species at the edge of their range may merit a higher level of importance;
- a species behaviour may differ at the edge of its range, or in what seems to be atypical habitats;
- for tree-roosting bats that move roosts frequently and use several roosts at any one time, or hibernate in small numbers, the importance of the overall roost resource (i.e. the collection of potential roost features (PRFs) which are available to bats) rather than individual trees should be assessed;
- differences in tree-roosting behaviour; for example, Bechstein's bats can return to specific roost trees over many years (Davidson-Watts, pers. comm.), but barbastelles tend to select more fragile features such as lifted bark or hazard beams. As these don't persist as long, specific trees may hold their value for fewer years. These differences need to be reflected in the way the roost resource is valued (and impacts are assessed);
- uncertainty relating to the importance of transitional and mating roosts, particularly for rarer/data-deficient species; and
- caveats/limitations on data collection or interpretation must be taken into account.

18. https://nbnatlas.org/ - but be aware that not all data can be used for commercial purposes (see docs.nbnatlas.org/guidance-for-using-data/)
19. https://magic.defra.gov.uk/
20. https://www.mammal.org.uk/countbat/
21. See para 3.4.10 and associated footnote.
22. See also Bat Roosts in Trees p.21 (BTHK, 2018), though many references are from continental Europe, and the topic has not really been explored in the UK.

3.4.13. In short, **Table 3.2** provides a starting-point for the assessment of the importance of roosts, and not 'answers'. A degree of professional judgement, explicitly supported by sound ecological evidence, will always be needed. That is also the case where a feature supports more than one species or type of roost (e.g. a Natterer's maternity roost and a pipistrelle day roost). In most cases, a feature supporting multiple roosts will be valued at the level of the highest-value element being assessed. Where rarer species or large roosts of more than one species are concerned, a higher value for the building or structure overall may be appropriate.

3.4.14. It is important to recognise that the term 'roost' is not used in the legislation: what is protected is a *structure or place [used] for shelter or protection*. Recent EU guidance[3], interpreted in a briefing note[23] from which the following is drawn, indicates:

> *"The protection applies all year round if these sites are used on a regular basis" (p. 32). ... "Thus, it follows from Article 12(1)(d) that such breeding sites and resting places also need to be protected when they are used only occasionally or are even abandoned but where there is a reasonably high probability that the species concerned will return to these sites and places. If, for example, a certain cave is used every year by a number of bats for hibernation (because the species has the habit of returning to the same winter roost every year), the functionality of this cave as a hibernating site should be protected in summer as well so that the bats can reuse it in winter" (p. 33).*

3.4.15. The 2021 guidance (p. 33 and p. 35) also states that breeding sites and resting places "that are used regularly either within or between years, must be protected even when not occupied".

3.4.16. In that guidance, there is reference to a place to which a species will return or has a reasonably high probability of doing so, even if used occasionally. Determining whether there is 'a reasonably high probability of return' to some types of roost (e.g. day roosts under external building features) may require more survey effort than is currently recommended or indeed cost-effective, and these should be considered as roosts. However, a common-sense approach is required for 'unusual' locations, particularly where these are transient (see examples in **2.5.3**). There is a lack of UK case-law that could assist, so any such feature (and associated survey results) should be careful assessed to consider the likelihood of bats returning given the potential functionality of the feature[24].

3.4.17. Conversely, 'a reasonably high probability of return' should be applied broadly where a structure clearly merits protection. For example, a lesser horseshoe bat 'roost' may include adjoining cellars, the corridor linking them, an open window above the door providing access to the complex, and a car port outside used for 'light sampling'.

3.4.18. Natural England provide the following guidance within their current licence application forms for *quantifying* roosts for the purpose of licensing:

To be considered the same roost, the locations need to have the same functional and qualitative (e.g. physical) characteristics, be used by the same species for the same purpose (e.g. day roosting) and be within the same building/structure. If the physical characteristics are different (e.g. one roost is in external crevices in the wall and the other is in the roof void against internal timbers) then they should be considered different roosts – because they offer bats different roosting opportunities. If the physical characteristics are similar and provide the same functional characteristics, used by the same species for the same purpose (e.g. transitional roost) but with different individual roosting locations within the overall building/structure, that could be considered

23. The relevance of the EU's 2021 Guidance is explained further in **APPENDIX 1.** For aspects of the 2021 guidance which might have relevance to interpreting the EPS criminal offences in Regulation 43 of the Habitats Regulations (2017) and the associated licensing framework in Regulation 55, a helpful summary and interpretation can be found here: https://www.freeths.co.uk/2021/11/10/key-messages-from-the-european-commissions-revised-european-protected-species-law-bible-dated-12-october-2021/

24. For example, the loss of a possible/probable feeding-roost with limited evidence of use, especially where there are many other similar structures providing the same function, may not meet the definition of a resting-place for licensing purposes.

one transitional roost. If two species are using an area which provides the same characteristics, for the same function, it is still two roosts – as there are two species.

3.4.19. For licensing purposes, current guidance/definitions provided for roosts may change during the lifetime of these guidelines, so definitions issued by the relevant Statutory Nature Conservation Body (SNCB) should be followed. In most circumstances, the aim should be no *net loss* of roosts.

3.4.20. When assessing impacts and determining appropriate levels of compensation (see later chapters), the precautionary principle in relation to the number of roosts may need to be applied. For example, there is limited information on male courtship roosts, but there are indications that multiple features on a building/structure may be used by individual males, and that in such circumstances (i.e. where mating roosts are identified or probable) the number of *features* and not the assumed number of *roosts* should be replicated (K. Cohen, pers. comm.). Multiple features also provide a variety of microclimates, which is likely to be important (see **Section 6.3**).

Table 3.2: Assessing importance of roosts[a]

	Roost category: note this table relates to VALUATION and does not mean that all such sites are 'places of shelter' as referenced in the W&CA or Habitats Regulations. Inclusion in this table does not indicate that a licence would be required; this would be driven by roost status, any impacts and the likelihood of an offence.						
Conservation status/ distribution	Feeding perches; night-roosts; Individual or very small occasional/ transitional/ opportunistic roosts	Non-breeding day roosts (small numbers of species)	Mating sites (excluding individual trees and larger swarming sites); small numbers of hibernating bats	Larger transitional roosts	Hibernation sites[d]	Autumn swarming sites [largely, vesper species which hibernate underground	Maternity sites[c]
Widespread all geographies	Site	Site	Site	Site/Local	District/County [Larger hibernation sites rare in the UK]	District/County [Very large pipistrelle swarming sites as yet unknown in the UK91, but see **Section 6.7**	Unlikely to exceed District importance unless colonies are atypically large; importance increased for assemblages.
Widespread in many geographies, but not as abundant in all	Site	Site	Site, dependent on local distribution [For *Myotis*, see swarming site column]	District	District/County importance dependent on size[b] and number of species	County/Regional importance dependent on size[b]; importance increased for larger sites that serve larger numbers/species	Unlikely to exceed County importance unless colonies are atypically large; importance increased for assemblages.
Rarer or restricted distribution	Site (very well-used night roosts may be of District importance for some species)	Site/Local/District, dependent on local distribution	Site/Local/District, dependent on local distribution	District	District/County importance dependent on size[b] and local distribution; increased value for assemblages.	County/Regional importance on sizeb and local distribution; increased value for assemblages.	County/Regional importance on sizeb and local distribution; increased value for assemblages.
Rarest Annex II species and very rare	Site (very well-used night roosts may be of District importance for some species)	Site/Local/District, dependent on local distribution	Site/Local/District, dependent on local distribution	District	County/Regional importance on size[b] and local distribution; increased value for assemblages	County/Regional importance on sizeb and local distribution; increased value for assemblages.	County/Regional importance on size[b] and local distribution' increased value for assemblages.

a. Sites within or functionally linked to SACs are of International importance for Qualifying Species. Sites that could be functionally linked to SACs may or may not have that level of importance [Example: a small lesser horseshoe bat maternity roost from a multi-component 'bat' SAC may be too far away to be a direct satellite of a maternity roost within the SAC, but may be part of the same population through intermediate unidentified roosts. Sites meeting SSSI guidelines are of National importance (though note that many SSSI citations do not reflect the 'bat' importance of the sites they describe, and not all sites of National importance are designated).

b. In all cases, 'size' needs to be interpreted as 'relative to typical sizes for the species'.

c. Satellite roosts (i.e. alternative roosts found in close proximity to the main nursery colony) should be considered with the associated main colony.

d. For tree-roosting bats that are likely to use multiple trees for breeding and then hibernate in small numbers (which means individual hibernation sites are difficult to detect and many may be missed), the **importance of the roost resource** (i.e. the collection of PRFs which are available to bats) rather than individual confirmed roosts, should be assessed.

Importance of commuting routes and foraging areas

3.4.21. It has not been possible to adopt the same matrix-based approach for valuing commuting routes (flightlines)[25] and foraging areas. It is inherently more difficult to assess them and requires a higher degree of professional judgement. For example, some routes may be used only at certain times of year, and hence show low numbers of bat passes, but they may be critical routes to hibernation sites. As such, the importance of commuting and foraging areas should not be interpreted in isolation and should always be made by an experienced ecologist based on the overall knowledge of bat activity in the area. It is important to explicitly state the rationale for any professional judgement and be aware that any activity recorded will reflect the approach used to collect those data.

3.4.22. Geographical levels of importance are not defined by 'numbers of bats using a feature', because numbers of individuals can be difficult to determine, and colony sizes vary across species and regionally. Care is required to avoid undervaluing common and widespread species; again, the importance chosen should be justified. Assigning a geographical level of importance will be influenced by a number of factors:

- Levels of bat activity indicating reliance (or otherwise) on specific habitats/features as determined by surveys (relative bat activity[110] across the features being surveyed).
- Landscape context: distribution and abundance of suitable foraging habitats, flight-lines and overall connectivity. For example, a 'strategic flyway' narrowed by encroaching development would increase the importance of connecting habitat, compared to a richly connected landscape with many alternatives.
- The species assemblage using a feature, and their conservation status (see **Table 3.1:** Rarity Category).
- Whether any species present are edge-of-range.
- Proximity/connectivity to roosts (species and roost type influence value too)
- A species' habitat preferences and landscape context; for example, a development site without a waterbody may be of lower value to foraging Daubenton's bats than a neighbouring area supporting a large waterbody.
- The importance of roosts is assessed separately (on- and off-site) as set out above. The proximity to roosts should not be over-emphasised when assessing the importance of flightlines, because this should be drawn out by evidence of use. That said, as bats spread out into the landscape from a roost, activity levels along a specific feature can decrease rapidly with increasing distance from a roost.
- Commuting routes may be more obvious at dusk than pre-dawn, as bats often return to roosts well before dawn and/or cross open spaces in darkness (multiple observations from radio-tracking: Davidson-Watts, pers. comm. and authors' own findings).
- Suitable habitat near to hibernation sites or spring/autumn swarming sites, and connections to such habitat, may not be identified through activity surveys and should not be overlooked.
- Where species are difficult to identify by call alone (e.g. *Myotis, Plecotus*), trapping (which may be supported by DNA analysis of droppings from captured bats) may be required to determine the species before assessing importance (though it is important that the project scale and impacts justify this intrusive technique).
- Where trapping is used as a methodology, each species' likelihood of trapping should be taken into account (e.g. high-flying species are less likely to be trapped unless lures are used). Caveats/limitations on data collection or interpretation must be taken into account.
- In all cases, the evidence of a level of foraging or commuting (flight) activity must be based on adequate survey; where surveys are incomplete, a precautionary approach should be adopted.

25. The term 'commuting' is widely used to describe the behaviour of travelling regularly and more-or-less directly from one place to another (and has been widely used throughout these guidelines to describe bats moving through the landscape). In literature, it is often assumed that commuting routes allow bats to reach more productive feeding areas in the shortest possible time. However, there is a continuum of activity between direct fast flight with no foraging to flight time spent predominantly foraging, and behaviour often cannot be neatly categorised into one or the other, nor is foraging always preceded by a period of commuting. In addition, not all flight activity relates to foraging or commuting, but may be social.

Where a commuting route is not strongly evident, the term *flightpath* may be more appropriate. Where a linear feature appears suitable (or has been provided) for bats, but evidence of use has not been collected, the term *flightline* may be more accurate.

3.4.23. Worked examples are included in **APPENDIX 2.**

Identifying the Important Ecological Features (IEF)

3.4.24. Once the receptors have been identified, those which are sufficiently valuable to be considered as IEFs should be subjected to impact assessment. The threshold for doing so is somewhat subjective, but commonly set as 'District value and above'. Professional judgement should be used in deciding the appropriate IEF(s) for bats for a particular scheme. It is almost never appropriate to have a single IEF for 'bat species' as this would mask many differences between species; conversely, it would rarely be helpful or necessary to treat components such as roosts, flight-lines or foraging areas as individual IEFs.

3.4.25. Usually individual species would be considered as individual IEFs, but sometimes groups, such as common and soprano pipistrelles, may be combined where the impacts to each are likely to be very similar and can be considered together. It may also be necessary to treat groups of species which have not been adequately distinguished as a single IEF, for example *Myotis* species, where the likely impacts do not justify trapping. The overall importance of an IEF (species or species group) should correlate to the highest element of importance assigned within the IEF, whether for species, roosts, commuting or foraging.

Assessing the importance of the bat assemblage

3.4.26. Sites of importance to bats often support several species, and it can be helpful to consider the importance of the assemblage as a whole after the individual bat species IEFs have been assessed. This would normally be for larger developments or sites supporting many species; assessing importance of the assemblage is not necessary in all circumstances (and note that multi-species roosts are covered in **Table 3.2**, and also discussed in **3.4.13**). The following provides a standard method for assessing importance of an assemblage, where that is considered useful and/or necessary. Assigning a level of importance to an assemblage provides contextual information only; it is not expected that the assemblage as a whole would be assessed as a single IEF (receptor).

3.4.27. As with the importance of roosts, commuting routes and foraging areas, this approach has been developed to reflect geographic variations in species distributions. To apply this approach, three things need to be determined:

- species present on site (project data);
- local species distributions (desk study); and
- regional species distributions (**Table 3.1**).

3.4.28. To determine the maximum possible score any site could achieve, a score is assigned to each species that could be present (as set out in **Table 3.1**), where:

- widespread in (almost) all geographies [score 1]
- widespread in many geographies, but not as abundant in all [score 2]
- rarer or restricted distribution [score 3]
- rarest Annex II species and very rare [score 4]

3.4.29. Once the score for each has been calculated and summed to determine the maximum theoretical score, the threshold score needed for any assemblage to meet each geographic level of importance, can be calculated:

- Assemblage score meets or exceeds 45% of the maximum score: County importance
- Assemblage score meets or exceeds 55% of the maximum score: Regional importance
- Assemblage score meets or exceeds 70% of the maximum score: National importance

3.4.30. In other words, the percentage score achieved for the site as it relates to the maximum possible determines the importance of the assemblage. As with the assessment of commuting and foraging habitats outlined above, the geographic scale presents a likely minimum and modifying factors may increase the importance assigned. The theoretical maximum score achievable can be modified according to the site's location. For example, few sites are within the distribution of grey long-eared bat, so this species does not always need to be considered when calculating the maximum score; similarly the distribution of horseshoe bats is well known, and again these species could be discounted from sites in many parts of the UK (see Examples 1-5 in **APPENDIX 2**). Any such modification needs to be justified (e.g. using desk-study data of local distributions) and cite sources of distribution data.

3.4.31. Similarly, where one or more *Myotis* are present, the calculation will need modifying to reflect the effort made to separate this genus into species. As in earlier sections, trapping may be required to determine species before assessing importance (though it is important that the project scale and impacts justify this intrusive technique).

Example

3.4.32. A site in the south-west of England could have, as a theoretical maximum: three widespread species (1 point per species - score 3), five less-abundant species (2 points per species - score 10), four rare species (3 point per species - score 12), and four very rare species (score 16) producing a maximum total score of 41 (see **Table 3.3**).

3.4.33. From this starting-point, any site in the south-west of England achieving a score of 18 (45% of the maximum score) would be classed as of at least 'County' importance, a score of 23 (55%) of 'Regional' importance, and a score of 29 (70%), of 'National' importance. Note, this initial assessment is on the basis of presence only, and factors such as higher-status roosts, or large colonies for a species, would increase the importance of any assemblage (up to 'International' importance) and should be used to explain the importance assigned. It is up to the ecologist to justify why that value has been selected, justifying any departure (up or down) from the initial importance suggested by the table. As noted above, **APPENDIX 2** presents additional valuation exercises which illustrate the use of the assemblage scoring approach.

Table 3.3: Assessing the importance of a bat assemblage

[refer to 3.4.26 to 3.4.33 for method and to APPENDIX 2 for worked examples]

Malc (included in **Table 3.1)** is not included here because its distribution is poorly understood.

Rarity category [points/species]	South-west England & South Wales		Southern England		South-eastern/East Anglia to The Wash		North/mid-Wales		Central England/Mid-lands	
Widespread all geographies [score 1]	*Ppip* *Ppyg* *Paur*	Score 3	*Ppip* *Ppyg* *Paur*	Score 3	*Ppip* *Ppyg* *Paur*	Score 3	*Ppip* *Ppyg* *Paur*	Score 3	*Ppip* *Ppyg* *Paur*	Score 3
Widespread in many geographies, but not as abundant in all [score 2]	*Mmys* *Mbra* *Mdau* *Mnat* *Nnyc*	Score 10	*Mmys* *Mbra* *Mdau* *Mnat* *Nnyc*	Score 10	*Mdau* *Mnat* *Nnyc*	Score 10	*Mmys* *Mbra* *Mdau* *Mnat* *Nnyc*	Score 10	*Mmys* *Mbra* *Mdau* *Mnat* *Nnyc*	Score 10
Rarer or restricted distribution [score 3]	*Rhip* *Eser* *Nlei* *Pnat*	Score 12	*Malc* *Eser* *Nlei* *Pnat*	Score 12	*Mmys* *Mbra* *Eser* *Nlei* *Pnat*	Score 15	*Rhip*	Score 3	*Eser* *Nlei* *Pnat*	Score 9
Rarest Annex II species and very rare [score 4]	*Rfer* *Mbec* *Bbar* *Paus*	Score 16	*Rfer* *Rhip* *Mbec* *Bbar* *Paus*	Score 20	*Bbar*	Score 4		Score 20		Score 4
Thresholds	Maximum possible	41	Maximum possible	45	Maximum possible	28	Maximum possible	36	Maximum possible	26
County importance threshold: 45%	County	18	County	20	County	13	County	16	County	12
Regional importance threshold: 55%	Regional	23	Regional	25	Regional	15	Regional	20	Regional	14
National importance threshold: 70%	National	29	National	32	National	20	National	25	National	18

Rarity category [points/species]	Northern England		Southern Scotland		Northern Scotland		Northern Ireland	
Widespreadall geographies [score 1]	*Ppip* *Ppyg* *Paur*	Score 3	*Ppip* *Ppyg*	Score 2	*Ppip* *Ppyg*	Score 2	*Ppip* *Ppyg* *Paur*	Score 3
Widespread in many geographies, but not as abundant in all [score 2]	*Mmys* *Mbra* *Mdau* *Mnat* *Nnyc*	Score 10	*Mdau* *Mnat* *Paur*	Score 6	*Mdau* *Mnat* *Paur*	Score 6	*Mdau* *Mnat* *Nlei* *Paur*	Score 8
Rarer or restricted distribution [score 3]	*Malc* *Nlei* *Pnat*	Score 9	*Mmys* *Nnyc* *Nlei* *Pnat*	Score 12	*Pnat*	3	*Mmys* *Pnat*	Score 6
Rarest Annex II species and very rare [score 4]			*Mbra*	4				
Thresholds	Maximum possible	22	Maximum possible	24	Maximum possible	11	Maximum possible	17
County importance threshold: 45%	County	10	County	11	County	5	County	8
Regional importance threshold: 55%	Regional	12	Regional	13	Regional	6	Regional	9
National importance threshold: 70%	National	15	National	17	National	8	National	12

4. EcIA 2: Predicting the impacts of development on bats

4.1. Introduction

4.1.1. A robust approach to impact assessment is one of the key elements necessary as a baseline from which to design effective and proportionate mitigation. This chapter describes the main ways that impacts arising from developments and other interventions can affect bats, their roosts and their habitats. It then sets out how to assess the significance of impacts on bats in line with CIEEM guidance on EcIA (CIEEM, 2022) which provides a standard approach and structure for ecology reports related to development projects, including those affecting bats. EcIA can be applied to projects of all scales. However, the level of detail required in an EcIA should be proportionate to the scale of the development, and the complexity and severity of its potential impacts.

4.2. Identifying development impacts on bats

4.2.1. In identifying potential impacts on bats, the entire project life cycle should be considered, including:

- **pre-development impacts** or advance works (e.g. ground investigations involving drilling or digging, asbestos survey, early vegetation clearance, or measures to secure derelict buildings);
- **construction impacts** (not just land take, but scaffolding, piling, building works and construction-related traffic, noise and light);
- **operational impacts** (e.g. the ongoing disturbance from public access, exposure to new predators[26], new lighting, collision mortality from trains or road traffic, or deadwood removal because of increased public access); and
- **decommissioning impacts** (such as removal of structures, disturbance or waste issues).

4.3. Impacts on roosts

Loss or partial loss of a roost feature

4.3.1. Roost loss can occur through, for example, the demolition or partial demolition of a building/structure or through tree felling or tree management. The impact of the loss of roosts on bat populations is poorly understood, though it is believed to be an important factor in the decline of bat populations. The effects of roost loss on bat populations will vary depending on the type of roost, the species and number of bats using it, and the availability of other suitable roost features within their territory. For example, where a single roost of a tree-dwelling species which shows low roost fidelity is lost from a woodland containing many trees supporting similar PRFs, the impact on the local bat population may be limited. In comparison, for a species showing strong roost fidelity, the loss of a single roost may (depending on the type of roost) have an impact on breeding success or recruitment, or overwinter survival, leading to a fall in population numbers or local extinctions. For example, Stone, *et al*., (2015a) found that all soprano pipistrelle bats excluded from their maternity roost found alternative roosts, with no difference in roosting behaviour in the short-term. Conversely, Zeale, *et al*. (2016) found that excluding Natterer's bats is likely to have negative impacts on their welfare and

26. An increase in predation risk may arise from domestic cat ownership (https://www.bats.org.uk/about-bats/threats-to-bats/cat-attacks), but also from alien species increasing their range (e.g. parakeets: (Hernández-Brito *et al*., 2018) or edible dormice (*Glis glis*), both in limited geographies); and potentially from reintroduction programmes which aim to restore the natural components of an ecosystem.

conservation status, as they are more territorial and faithful to their core foraging areas and roosts. That said, even for common species, the cumulative effects of roost loss in terms of long-term survival and species fecundity are unknown, and these are the species most often affected by roost loss through development. Roost loss should therefore be avoided wherever possible.

Modification of a feature containing a roost

4.3.2. This can occur either directly (e.g. the replacement of a roof or a change in insulation materials, roost volume or layout), or through incidental changes to a feature's internal microclimate (temperature, humidity, ventilation or lighting regime, or the stability of any of these). Modification of roost characteristics can lead to roosts becoming unsuitable for bats and ultimately being abandoned. This is particularly important in hibernation roosts, where a constant temperature range is required to maintain torpor and high humidity is required to avoid dehydration, or in maternity roosts where high ambient temperatures tend to be favoured (Dietz & Kiefer, 2016). If the modifications lead to abandonment, the implications for local bat populations would be the same as for roost loss. If the roost is not abandoned, it may support fewer bats, or their winter survival rate, or reproductive success may be reduced. Modification of external attributes (e.g. proximity to cover and favourable habitat) may have similar detrimental effects (Davidson-Watts, 2007), even without direct modifications to the roost itself.

Loss or modification of a roost access point

4.3.3. This can occur either directly (e.g. being blocked by construction works), or indirectly (e.g through the removal or planting of vegetation close to the roost access point). Although bats generally require an uncluttered flight-line to the access point of the roost, species show different preferences for types of access point and the flight-lines leading to them. For some slower-flying species, the flight-line feature leading to the access point can be very important, whilst other species are less reliant on flight-lines. For example, *Pipistrellus* species can use roosts where the flight-path is cluttered or not structurally defined at all, whereas horseshoe bats tend to use larger roost entrances and unobstructed, demarcated flight-lines to allow direct flight into the roost.

4.3.4. There is evidence from laboratory tests (e.g. Neuweiler & Mohres, 1967) that bats have strong and fine-scale spatial fidelity in their navigation, and it is known that mothers find pups in crowded caves (McCracken, 1993), indicating some element of locational memory. This may indicate that bats 'expect' to find a feature such as a roost entrance in its familiar location and experience difficulty in finding access points that have moved. Various reviews of mitigation success (see **Section 6**) show that retaining the same roost access has a higher success rate. Removal or modification of a feature used as a flight-line, including introducing lighting where it was not previously present, could therefore result in abandonment or reduction in the size of a colony, or in delayed emergence leading to reduced foraging success.

Disturbance to bats in their roosts

4.3.5. Disturbance to bats in their roost can be caused, for example, by noise, lighting or direct human interference. Where lighting illuminates a roost access point, it may delay emergence from the roost, resulting in bats missing the period in which peak invertebrate prey is available (at or soon after dusk). This may result in reduced survivorship, fitness or delayed juvenile growth rates (Boldogh, Dobrosi & Samu, 2007). Excessive lighting can prevent bats from exiting their roost (Natterer's bats) or disrupt emergence (affecting timing, numbers and duration – soprano pipistrelles) (Packman *et al.*, 2015) and can even entomb bats in the roost (Zeale *et al.,* 2016). Further information on bats and lighting impacts is available in guidance published by the Institution of Lighting Professionals (ILP) (2023).

4.3.6. Similar effects could be anticipated from direct noise, vibration or human intervention. Reason & Bentley (2020) reviewed studies of bats and noise (measured in decibels, dB) and concluded that most had attempted to correlate bat activity with noise measurements that were 'weighted' to reflect the relative loudness of sounds as perceived by the human ear rather than unweighted noise levels. 'A-weighted' data (represented as dBA) emphasise sounds inaudible to bats whilst under-representing those audible to bats. Many studies fail to measure noise in a standard way or fail to report the methods appropriately to enable comparison or synthesis of the topic. Low-pitched noises, audible to humans but not to bats, are unlikely to cause significant disturbance; conversely ultrasound, which is rarely measured or modelled for developments, could do so (note, there is overlap in the frequencies that are audible to bats and humans). Sudden, loud noises could potentially disturb bats and cause them to abandon roosts (Humphrey & Kunz, 1976; Pearson, Koford & Pearson, 1952; Kunz, 1982; Fenton, 1997a; Ferrara & Leberg, 2005), though there is some evidence to suggest that torpid bats are not as affected by anthropogenic noise (Luo *et al*., 2013). However loud, ultrasonic noise is part of a bat's normal sensory environment and this remains an area where further research is needed.

4.3.7. It has been hypothesised that bats experience some habituation to disturbance caused by chronic noise and vibration, but this is not well evidenced.

- Five common species of bats are known to roost in Wolvercote Tunnel, Oxfordshire, which supports a live railway (Billington, 2013).
- Reason (2017) observed breeding lesser horseshoe bats roosting underneath a noisy hotel bar, but it was not clear whether this represented habituation, or the fact that there was insufficient 'threatening' noise within the frequency range of bats' hearing.
- Schofield (2008) reported the same species reacting 'in an agitated way' to sudden noises such as passing cars (the noise experienced is perhaps not dissimilar to the above, but less predictable).
- F. Mathews (pers. comm.) reports horseshoe bats ignoring regular activity by a forklift truck, but abandoning a roost when a generator was temporarily installed outside.
- R. Green (pers. comm.) has recorded lesser horseshoe bats, brown long-eared bats and serotines roosting in/under motorway/A-road viaducts subject to vehicle 'rumbling' noise. There are other reports of lesser horseshoe bats (also R. Green, pers. comm.) sharing the living spaces of active dwellings, including a breeding roost.
- K. Cohen (pers. comm) reports a comparison of two Bechstein's bat maternity roosts in trees near the same road, the A350 in Wiltshire, which showed markedly differing responses. One tree was set back approximately 20 m where bats emerged, swarmed and re-entered without any reaction to an observer. The other was located at 100 m from the road, and even a twig snapped underfoot in the dark, or a red headlight turned on nearby, 'sent the bats away' for five or ten minutes.
- UK trials of high-frequency broadband acoustic deterrents (two different models) have not detected any sign of habituation in field trials of flying bats, though these have been of relatively short duration (S. Murphy, pers. comm.). However, Packman *et al*. (2015) found some level of tolerance by roosting soprano pipistrelles.
- M. Padfield (pers. comm.) observed Daubenton's bats returning to their maternity roost during pressure-washing of a bridge supporting a busy A-road (described further in **APPENDIX 5**).
- At a construction project in a large urban park, a maternity colony of big brown bats (*Eptesicus fuscus*) tolerated high levels of low frequency sounds [audible to humans, but otherwise frequencies not tested] generated by chainsaws (75–86 dB) and large plant (85–89 dB) within ~30 m of their maternity roost. However, the colony abandoned their roost when workers used a high-frequency (19–28 kHz) laser surveying instrument, inaudible to the human ear (reported in Harvey & Associates, 2019).

4.3.8. Whilst these (and see also **Box 4.1**) are anecdotal (and no measurements were made of the characteristics of the sounds in any of these cases), it seems clear that, when assessing the likelihood of disturbance having a significant effect, baseline levels of noise/disturbance need to be taken into account.

Box 4.1: Roosting in trafficked viaducts and bridges is not unusual; two further examples

Pont Neath Vaughan Viaduct (PNV Viaduct) is a multi-span concrete underbridge in South Wales that carries the A465 over the River Neath. It is located in an area of 'high' suitability foraging habitat along the River Neath and the Afon Hepste Valleys on the southern edge of Brecon Beacons National Park, and well-connected to the wider landscape by a network of river corridors, hedgerows, trees and woodland. The viaduct is a confirmed lesser horseshoe bat maternity roost, with day roosts for greater horseshoe bat, brown long-eared bat, common pipistrelle and soprano pipistrelle within the abutment expansion joints. Monitoring has been undertaken across several years to inform various repairs schemes, with a peak count of 121 lesser horseshoe bats in 2020. Works were programmed for the winter, after the final bat left to hibernate elsewhere in late November.

View of PNV Viaduct, looking east.

The maternity roost location within the PNV east abutment.

LHS roosting within the eastern abutment of PNV Viaduct.

Text and photographs supplied by Mike Padfield, Aecom, with the permission of the Welsh Government.

Skewen Rail Bridge is a multi-span underbridge that carries the A465 dual carriageway over the Vale of Neath railway line. The Vale of Neath railway corridor is bordered by mature and semi-mature trees, creating foraging and commuting opportunities for bats. The Tennant Canal passes 150 m east of the Site with the River Neath further east (260 m), both offering further foraging and commuting opportunities, while the M4 passes 680 m due west. Grassland and woodland habitats associated with the River Neath, Tennant Canal and Junction 42 of the M4 lie to the south and east, while the outskirts of Skewen and Llandarcy lie to the north and west, respectively.

Skewen Rail Bridge was initially surveyed in 2020, with common pipistrelle hibernation (peak count: 2) and day roosts (peak count: 4) confirmed behind delaminated concrete on the crossheads and within bat mitigation boxes. A brown long-eared maternity roost (peak count: 16) was subsequently identified in 2021 roosting within the expansion joint above the east pier, along with soprano pipistrelle day roosts (peak count: 1) behind delaminated concrete and within the expansion joints.

View of the brown long-eared maternity roost within the East Pier expansion joint.

Fresh brown long-eared droppings below expansion joint on East pier.

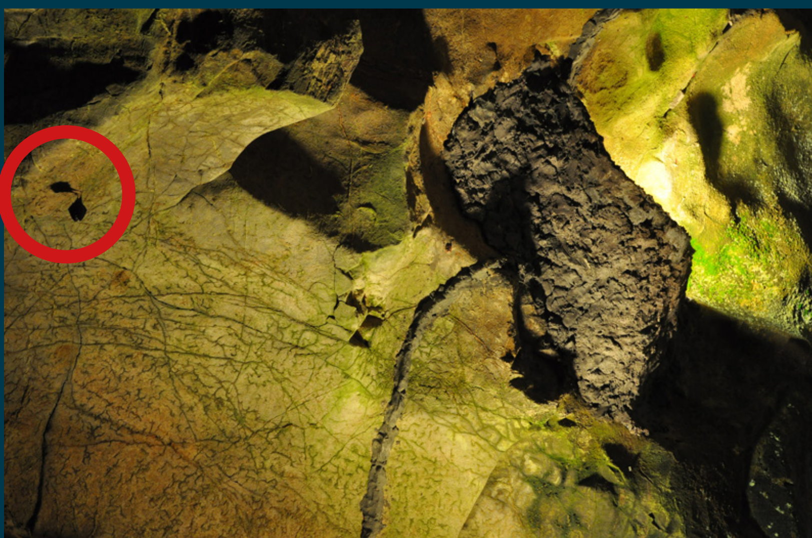
View of the underside of Skewen, looking south with the East Pier on the left.

Text and photographs supplied by Mike Padfield, Aecom, with the permission of the Welsh Government.

4.3.9. There has been even less work on the impacts of vibration. As with noise (examples above), there is anecdotal evidence of tolerance of (habituation to) vibration from bats roosting in bridges under motorways, but there is little published research. A small number of studies have been undertaken on blasting activities in mines looking at impacts on hibernating bats. For example, Summers *et al.* (2022) investigated an active sand mine supporting >50,000 bats of four species in inactive tunnels, which was regularly subjected to blasting activities, and found that blasting did not influence bat activity significantly. They noted, however, that blast details (such as size, proximity) were not made available. A study was also carried out in West Virginia to determine the impacts of surface blasting on two endangered species of hibernating bats (WVDEP/OEB, 2006). These studies provide contextual information, but it is worth noting that vibration effects (the distance over which vibration effects are 'noticeable') are notoriously difficult to predict, being very situation-specific (see **APPENDIX 5**).

4.3.10. Continuing human disturbance may alter bat activity, particularly during the maternity season (Shirley *et al.,* 2001; Mann, Steidl & Dalton, 2002) and disrupt critical torpor cycles of hibernating/overwintering bats, forcing them to overuse essential energy resources, which can affect their survival (Speakman, Webb & Racey, 1991; Thomas, 1995; Fenton, 1997; Johnson, Brack & Rolley, 1998). However, there are circumstances where bats and humans share resources; for example, the hotel bar noted above (**4.3.7**), but also loft spaces or boiler rooms in dwelling houses, storage areas (such as wine cellars), show caves (such as those at Cheddar in Somerset, see **Box 4.2**), and more extensive features such as those at Box Mines in Wiltshire). Again, an element of predictability/habituation may be important. Historic England have published advice on considerations where bats and people may interact[27].

Box 4.2: Bats and humans sharing resources



Lesser horseshoe bat (circled) roosting close to a light fitting, Cheddar caves. Photo: Pat Waring.

27. Managing Properties for Bats and People https://historicengland.org.uk/advice/technical-advice/buildings/building-works-and-bats/managing-properties-for-bats-and-people

4.4. Impacts on foraging or commuting habitats

Loss of foraging habitat or commuting routes

4.4.1. Foraging or commuting habitat can be lost directly through a development's land take or indirectly when habitats are abandoned after being disturbed (e.g. by floodlighting or noise).

4.4.2. Chapter 3 of Collins (2023) summarises the foraging habitat preferences and foraging strategies of different UK species. More detail can be found in Dietz and Keifer (2016) and Kyheroinen *et al.* (2019).

4.4.3. When determining likely impacts on bats as a result of the loss of (or a reduction in access to) suitable foraging habitat, consideration should be given to the:

- bat species that could be affected;
- extent of loss of foraging habitat, and the relative importance of this habitat as indicated by its landscape context (aerial photographs can be useful here) and use by foraging bats;
- location of habitat loss relative to known roosts, e.g. is it within the CSZ and/or juvenile sustenance zone(s)[28] of those roosts (if known);
- proportion of loss in relation to the total area of available foraging habitat for those bats that may be affected, where this can reasonably be estimated;
- timing of loss relative to the life cycle of the species to be affected and their vulnerability to such impacts; and
- length of time between the loss or reduction in foraging resource as a result of the impact and the availability of suitable compensatory foraging habitat as a result of habitat creation, restoration or enhancement.

4.4.4. Most bat species have been recorded commuting along linear features that are dark and sheltered from wind, such as hedgerows, tree lines, woodland edge habitat and waterways (Entwistle *et al.*, 2001). These features also tend to attract or 'trap' (concentrate) invertebrate prey, providing a foraging resource, and the dark conditions render bats less vulnerable to predation (Finch, Schofield & Mathews, 2020a). However, even species strongly associated with linear features can use open landscapes (Finch, Schofield & Mathews, 2020a). This seems more likely when it is dark and predation risk is reduced (Downs *et al.*, 2016), but the degree of use of open landscapes has been less frequently studied.

4.4.5. The proliferation of large solar farms is an example where effects such as prey concentration may interact with other factors such as landscape configuration (lack of linear features) to influence the composition of species in an area. A study in Hungary found that bats typically found in urbanized and agricultural habitats were often found at solar farms, while rarer and more specialised species (*Myotis* spp. and barbastelle) were not (Szabadi *et al.*, 2023). This is a complex area which requires more research, but needs to be taken into account in impact assessment.

4.4.6. Fragmentation of bat habitat resulting from removal, obstruction or disturbance of commuting routes can result in bats being isolated from a roost or important foraging grounds, or from seasonal resources such as swarming and hibernation sites. Alternative commuting routes may cover greater distances, requiring the bats to expend more energy and potentially reduce their fitness (Fure, 2012). Increased energetic costs could affect district or regional populations of several species if routes to swarming and wintering sites are fragmented at the landscape level.

28. Refer to **Section 3** of this guidance; also https://www.bats.org.uk/our-work/landscapes-for-bats/core-sustenance-zones

4.4.7. When determining likely impacts on bats as a result of impacts on commuting routes, consideration should be given to the:

- bat species that could be affected. For example, some species tend to closely follow landscape features to aid navigation (Finch, Schofield & Mathews, 2020a);
- importance of the commuting route, informed by survey data, including its seasonal use and the existence of alternative routes (aerial photographs can be useful here);
- quantity, quality and diversity of habitats (and associated prey resources) within the commuting route;
- degree of connectivity between resources, the shelter provided and the extent of any existing disturbance or degradation to the route;
- suitability and value of foraging habitats linked by the commuting feature; and
- proximity of the commuting route to (the) roost(s).

Modification of, or disturbance to bats using, foraging habitats or commuting routes/flight-paths

4.4.8. Foraging habitats and flight-paths (or indeed habitats used on the wing for social behaviours which are less well understood) can be modified either directly (e.g. due to a change in land use or draining of land), indirectly (e.g. through the use of pesticides which may reduce prey availability), or through disturbance (e.g. from artificial lighting or noise which dissuades bats from using them). For example, the brown long-eared bat listens for prey-generated sounds and gleans food items from the ground or other substrates. In a laboratory study of greater mouse-eared bats which use the same foraging strategy, bats chose to avoid foraging in compartments exposed to the playback of road traffic noise. When noise was unavoidable, for example, when traffic noise continued throughout their entire active period, they showed reduced foraging efficiency (Schaub, Ostwald & Siemers, 2008; Siemers & Schaub, 2011; Finch *et al.*, 2020). Lighting may also affect the use of foraging and commuting habitats; see also Voigt, *et al.*, (2018) and specific guidance produced by BCT and the ILP (2023).

4.4.9. Foraging behaviours of bats and their prey (such as moths – see Macgregor *et al.,* 2015) may be affected by artificial lighting. Impacts vary between species in accordance with their relative sensitivity to light. Faster-flying species are less inhibited by light (pipistrelles, noctule, serotine and Leisler's bat), and indeed have been recorded feeding around white metal halide streetlights that attract insects (Blake *et al.*, 1994; Rydell & Racey, 1995); however, bats taking advantage of swarming insects around such lighting may be more prone to collision with traffic (Voigt & Kingston, 2016). Conversely, slower flying species tend to avoid street lights and light generally (i.e. long-eared bats, *Myotis* species, barbastelle and greater and lesser horseshoe bats) (Stone, Jones & Harris, 2009, 2012; Stone *et al*., 2015b; Finch, Schofield & Mathews, 2020b), and consequently are put at a competitive disadvantage, being less able to forage successfully and efficiently. There is evidence that insects attracted from dark areas to well-lit areas can result in a reduction in abundance and a so-called 'vacuum effect' (Eisenbeis, 2006) that may negatively affect more light-sensitive species. Effects on prey may be widespread but hard to detect; for example, van Geffen *et al.* (2015) found some light spectra had effects on caterpillar pupation that could affect not only how much prey is available for bats, but whether it is available at the right time. For larger longer-term developments in particular, impacts on habitat quality (prey biomass), not just habitat loss, may need to be considered.

4.4.10. Degradation of the foraging and commuting habitat resource can also occur through increased disturbance by human activities (e.g. recreation), increased pet density, increased trampling and changes to vegetation, increased light-spill from residential areas or lighting for safety concerns, pollution by dog faeces and other means.

4.4.11. When determining likely impacts on bats as a result of modification to, or disturbance of, bat commuting routes, the aspects identified previously in relation to loss (4.4.6) should be considered. Many of the impacts may have effects beyond the site boundary (e.g. additional street-lighting), so the entire ZoI needs to be considered.

4.5. Direct mortality or injury impacts on bats

4.5.1. Bats may be accidentally killed or injured through roost destruction during construction works, or through collision with road/rail traffic or wind-turbines, and potentially with stationary infrastructure such as tall buildings (Martin, 2017). Bats may also die as a result of barotrauma (sudden changes in air pressure that result in internal bleeding) caused by wind turbines (Baerwald *et al.,* 2008). Some developments, such as new housing schemes, may increase predation risk to bats; cats in particular can be a significant predator of roosting bats (Ancillotto, Serangeli & Russo, 2013).

4.5.2. In recent years there has been a growing literature on road- and rail-related mortality of bats (see for instance the CEDR reports by Grift *et al.* (2018) and O'Brien *et al*. (2018), as well as work by Berthinussen & Altringham (2015)). In general, low-flying species, males, and/or juveniles are more likely to collide with vehicles than are high-flying species, females and/or adults (Fensome & Mathews, 2016). In most cases, vehicle collisions on new infrastructure occur where bats had crossed the line of the route before construction. It is therefore critically important to identify the points where bats cross the proposed infrastructure in order to assess impacts and design appropriate mitigation. The assessment of impact should be precautionary where access has not been available, or if the scheme is within the CSZ of species difficult to detect acoustically.

4.5.3. The identification and assessment of potential effects of onshore wind farms to bats have been widely studied. Comprehensive guides to baseline data collection, assessment of effects and mitigation requirements have been produced for onshore wind farms (NatureScot *et al.,* 2021; Rodrigues *et al*., 2014). There have been few other attempts to calculate mortality in other circumstances[29].

4.5.4. There has been some concern that there may be collision-related fatalities due to bats mistaking the smooth surface of ground-mounted solar panels for that of water, based on a paper by Greif and Siemers (2010); however, this study does not specifically reference solar panels and does not quantify collision risk or any potential ecological impact presented by this behaviour. The fact that bats use echolocation to recognise smooth surfaces, with no collisions reported, suggests that some bat species may be adept at avoiding collision with flat surfaces; however, more recent work has indicated reduced echolocation when bats are flying close to angled mirrors and shiny surfaces (Corcoran & Weller, 2018). Polarotactic insects (those attracted to polarised light, typically that reflected from a surface) are known to be attracted to solar panels (Horváth *et al.*, 2010), which in turn would suggest that insectivorous bats have the potential to be attracted to solar photovoltaic (PV) arrays, but again there is no evidence of collision risk (and most panels include sufficient texture/associated infrastructure to be detectable).

4.5.5. When determining likely impacts on bats as a result of direct mortality risks, consideration should be given to:

- the species of bats affected;
- the numbers of bats which are likely to be affected (such as through probabilistic modelling of collision risk e.g. see NatureScot *et al.,* 2021);
- the proximity of the mortality risk to important roosts or valuable foraging resources, or the importance of the commuting route;
- the sex or life stage of bats likely to be affected; and
- for linear infrastructure, the alternative routes available to bats to avoid collision mortality.

29. One such example, for a proposed airport expansion, is provided in the latest EUROBATS publication (Guidance on the consideration of bats in traffic infrastructure projects), available from EUROBATS Publication Series | UNEP/EUROBATS.

4.6. Characterising impacts on bats

4.6.1. Once a potential impact on bats has been identified, further information is required to characterise what effect, if any, it will have on bats. **Table 4.1** below, is based on the parameters for impact characterisation identified in Chapter 5 of CIEEM's EcIA Guidelines (CIEEM, 2022).

Table 4.1: Characterising impacts on bats

Impact parameter	Considerations	Examples
Is it a positive or negative impact?	Will the impact adversely affect bats?	Loss of or damage to roost sites; loss or degradation of foraging and commuting habitat.
	Will the impact be beneficial? Is it in accordance with nature conservation policy or objectives?	Habitat restoration or creation that increases food availability within the CSZ of a roost. Improving the physical conditions of a roost by, for example, repairing a roof to reduce draughts.
Extent of the impact (the area over which the effect may be experienced) expressed in geographic terms where possible.	Is the development likely to be very local in its effect?	New lighting that might affect a single field used by foraging bats at some times of year, but not affecting the whole of the CSZ or any roosts.
	Will the impact be experienced across a larger area?	Loss (through development land take) of important foraging habitat that attracts bats from several roosts, or represents the majority of the CSZ of a particular roost. Loss of an important swarming site that may attract bats of multiple species from a wide area; disruption of commuting routes to/from swarming or hibernation sites.
Impact magnitude (the size, amount or intensity of the impact). This should be expressed in absolute terms where possible – hectares lost, % of territory affected.	Will it affect a small number of bats?	Loss of a day roost occupied by a single bat.
	Will it affect a large roost/population/a protected site for bats?	Loss of 2 ha of grazed pasture within the CSZ for a known roost; fragmentation of a farmed landscape that prevents bats from accessing foraging habitat.
Impact duration (expressed in relation to the life cycle of the species involved).	Will the impact be short-term?	A few weeks of disturbance as a result of light or noise/vibration during construction.
	Will the impact be medium to long-term?	Construction impacts of major infrastructure spanning 3-5 years and hence potentially affecting more than one generation of bats.
Frequency.	Will the impact occur once?	Felling a tree containing a bat roost; piling the foundations of a new structure
	Is it likely to be repeated?	Regular movements of vehicles adjacent to a bat commuting route resulting in risk of collision and mortality. Additional human disturbance through recreational activities in woodlands.
Timing (in relation to the life cycle of the relevant species).	Will the activity take place at a critical life stage or season of activity?	Disturbance to a mating site during September; obstruction of access to a maternity roost in summer.
Reversibility	Will it be temporary?	Disturbance of a roost from light and vibration that will cease once construction is complete without any other changes to the roost.
	Will it be permanent?	Destruction of a roost as a result of demolition; loss of ancient wood-land habitat
Cumulative, synergistic and in-combination effects.	Will the impact be greater when combined with impacts of other development in the locality?	Loss of habitat at the same time that alternative habitat is disturbed by another construction project.

4.7. Assessing the significance of impacts on bats

4.7.1. Impact significance can be assessed pre-mitigation and post-mitigation; it is common practice in many Environmental Statements to report only the post-mitigation significance (the residual impact). Either is acceptable and in line with CIEEM guidance, but identifying the impact significance before and after mitigation may allow the effectiveness of mitigation to be better described.

4.7.2. Defining impact significance requires the fully characterised potential impact (as set out above) to be assessed against the value of the feature potentially affected (as defined in **Chapter 3.0**).

4.7.3. In EcIA, the significance of an impact on an IEF is expressed using the same geographic scale used to assess the importance of the IEF, but will not necessarily be at the same level. The significance of impacts should be considered on a case-by-case basis. The impact significance cannot be at a level greater than the IEF being assessed and is often at a lower level than that at which the IEF is considered important (excluding consideration of in-combination effects). For example, the maximum significance of an impact to a receptor of 'County' value would be County, but it could be lower.

4.7.4. Where the potential impact relates to the total loss of a feature, (e.g. a roost), or the modification of such a feature to an extent that it will no longer have the same function (e.g. the obstruction of a roost entrance), then the significance of the impact should be the same as the valuation of the feature. For example, the significance of the loss of a roost assessed as being of 'County' value would be County.

4.7.5. In many cases, roosts will not be completely destroyed, and the significance of effects may be more difficult to characterise (particularly effects that are hard to measure or which take time to be manifested, such as breeding success or population viability). Different species of bats will respond in different ways to roost modification. For example, lesser horseshoe bats can show remarkable behavioural plasticity and can adapt to significant modifications to their roost access (see, for example, Reason (2017)), whereas Natterer's bats appear to be much more sensitive to change (C. Packman, pers. comm.). A competent person should make a professional judgement of the likely significance, along with a full rationale. **Table 4.2** sets out some examples of roost modification and disturbance and their potential impact significance before mitigation.

4.7.6. The significance of impacts on foraging habitats and flightlines can be assessed using a similar process (though without relying on a matrix approach to determining a feature's initial value). It is important to note that any surveys will only be a snapshot in time, and may not capture the full importance as determined by records of use. That is particularly true when considering features such as routes between seasonally-used roosts, or habitat close to swarming/hibernation sites. For these reasons, the precautionary principle is important: the potential importance of a habitat to foraging and commuting bats within a changing landscape should also be considered.

4.7.7. The scale of any change will determine its likely impact significance, which cannot be greater than the original value assigned (see **APPENDIX 2** for examples of valuation in practice). For example: for a habitat feature assessed as being of District value, the impact significance may be assessed as also being of District value, if the feature will no longer support foraging or commuting activity after development has taken place (i.e. it will be functionally lost). However, where there is a minimal predicted impact on the functionality of the resource, the impact would be less (potentially negligible/limited to the Site). The nature of the impacts and their landscape context are both important.

Table 4.2: Modification and disturbance impacts to roosts: simple examples

Note that the examples here do not take into account any licensing considerations; it is purely an illustration of likely significance of impact. The outlines and assumptions here should not be directly related to specific circumstances or projects.

These are illustrative examples and the actual level of significance depends on a range of factors, not all of which are stated here, including the local distribution of each species.

The examples are all for individual roosts and do not take into account any cumulative impacts, which could result in higher significance.

Example	Value of roost (from Table 3.2)	Impact	Likely significance before mitigation
Feeding perch of brown long-eared bat, Kent	Site	Shed intermittently used as feeding perch will now experience vehicle movements 24/7	Negligible; unlikely to be the only feeding perch used
Well-used night-roost, lesser horseshoe bat, Gloucestershire	Local	Heater will be decommissioned as gas boiler replaced by ground-source heat pump	Likely to be abandoned or used by fewer bats; Site or Local
Day roost for up to three common pipistrelle bats, anywhere	Site	Re-roofing proposed	Site; unlikely to be the only day roost used
Day roost for up to five serotine bats in Sussex	Local	Access used will be removed in the repairs, but an alternative provided	Local if the replacement is dissimilar (higher risk of not being re-used); Site if similar (higher chance of re-use)
Non-breeding roost of five Bechstein's bats in a tree, Hampshire	District	Tree surgery will reduce canopy of tree outside of period of occupation	Local; very unlikely to be the only day roost used (and canopy will regrow, so importance will be restored over time)
Small hibernation roost in a Gloucestershire tunnel supporting five Daubenton's bats and three Natterer's bats in six crevices	District (>1 species)	Tunnel will be repaired; to maintain structural integrity, access will be retained but three roost cavities will unavoidably be filled.	Local (likely to support same species, but in lower numbers)
Swarming site used by a few thousand Daubenton's and Natterer's bats, anywhere	County importance [Potentially higher if at edge of range in Northern Scotland]	Urgent works to avoid collapse required in November will result in daytime noise and night-time lighting, but for one season only.	Up to County, dependent on availability of other sites (otherwise mating and likely hibernation will be disrupted).
Maternity roost of 20 brown long-eared bats, Northern Scotland	County	Roost void will be divided because of the need to fit fire doors	Up to County (because roost may be abandoned)
Woodland supporting breeding barbastelle and Bechstein's bats, Dorset	National	Woodland edge will be removed to facilitate a waste treatment plant; 5% of the roost resource (i.e. 5% of trees with likely suitable PRFs) will be removed (though no identified roosts) and the plant will be lit, with light spill extending into the edge of the wood.	Depends on proportion of woodland affected by each factor; up to County
Underground hibernation site used by greater and lesser horseshoe bats every year (about 30 bats in total). [Not a swarming site for other species].	National	Woodland surrounding the cave is to be cleared to facilitate an access road.	Up to National, depending on extent (area and proportion) of habitat loss

4.7.8. For developments resulting in direct injury or mortality to bats, the significance of the impact will be directly related to the value of the bat population within the ZoI of the development. So, a population of Regional importance could suffer an impact of Regional significance if mortality was above incidental levels. Unfortunately, it is rare that mortality levels are known or can be estimated in population terms (i.e. percentage affected); nor is the significance of even low levels of mortality well understood. Every effort therefore needs to be made to avoid mortality (or mitigate it where predicted), and to apply remedial measures if the mitigation proves ineffective.

4.7.9. The examples above give an indication of how to assess impact significance on various features such as roosts or habitats, and the effects of mortality. These may then need to be aggregated, depending upon the scale of the development, to describe the impacts on IEFs which may be local populations of individual species or groups of species roosting or otherwise using habitats within the ZoI.

4.8. Residual Impacts

4.8.1. Residual impacts are those that remain after mitigation of impacts on bats has been considered. If an impact has been fully mitigated then there would be no residual impacts; if it is not possible to fully mitigate an impact, a residual impact would remain.

4.8.2. In order to determine whether any residual impacts remain, the following should be considered:

- the nature of the mitigation proposed (e.g. is it intended to eliminate or simply reduce the severity of the impact);
- the effectiveness of the mitigation in the particular circumstances of the impact (i.e. has such a technique been demonstrated as effective for the same species, or a species with, for example, a similar foraging strategy, or is there uncertainty);
- any factors which may affect the success of the mitigation proposed (for example, levels of human interference);
- the likelihood of mitigation and compensation being maintained over a period of time (e.g. working practices, lighting controls, access limitations).

4.8.3. The significance of residual impacts is expressed in exactly the same way as described above, with reference to the geographical level of importance of the bat feature. The assessment of impact significance after mitigation should be conservative. That is, the residual impact should be considered as non-significant only if the mitigation proposed will definitively remove the impact. For example, if the potential impact were light disturbance directly affecting a roost, and the mitigation was to remove lighting from the part of the site close to the bat roost, the impact after mitigation would be non-significant. If, however, the aim of the proposed mitigation was to reduce the lux level of the light or to add a baffle, the residual impacts would be more nuanced. The impact would clearly be reduced from the pre-mitigation levels, but professional judgement, supported by the rationale that led to that judgement, would need to be executed regarding the significance of that impact. The aim of all mitigation strategies should be to reduce impacts to a non-significant level. If this cannot be achieved, appropriate compensation should be proposed.

5. EcIA 3: Mitigation and compensation overview

5.1. Introduction to mitigation

5.1.1. This section sets out the key principles and definitions of mitigation and describes how mitigation should be designed and controlled to maximise the chances of successful implementation and good outcomes for bats. The mitigation hierarchy is defined in **Figure 5.1** below. 'Avoidance' measures considered can include the 'do nothing' option.

Figure 5.1: The mitigation hierarchy

AVOID

Do nothing

Find alternatives to prevent an adverse effect occurring

e.g. time works when bats are absent; design to retain roost or commuting route

↓

MITIGATE

Where options for avoidance have been exhausted and a negative effect remains, incorporate measures or methods to minimise/reduce adverse effects

e.g. timing of works, working methods, lighting design

↓

COMPENSATE/OFF-SET

Where there will be a residual adverse effect after mitigation measures are employed, provide newly created or enhanced alternatives

e.g. replacement roosts or foraging habitat

and

ENHANCE

Provide biodiversity gain

5.1.2. The terms 'mitigation' and 'compensation' are sometimes used interchangeably but have different meanings, as defined in **Figure 5.2.**

Figure 5.2: Mitigation, compensation and enhancement – definitions

Mitigation: measures that *reduce* negative effects, such as changing the timing of works, using different designs, methods or techniques, or making adjustments that reduce the longevity of an effect. Measures may be within a site boundary or extend beyond for mobile species or functionally linked habitats.

Compensation: measures that offset the loss of, or permanent damage to, an IEF where residual effects exist after mitigation. Compensation should only be considered where adverse effects cannot be mitigated. Measures may be located outside the site boundary.

Enhancement: measures that provide net benefits for biodiversity over and above any requirements for avoidance, mitigation or compensation.

5.2. Principles of mitigation and compensation

5.2.1. A strategy for mitigation/compensation should:

- be informed by robust desktop and survey data underpinning an accurate assessment of the predicted effects of a project across its ZoI;
- invoke the precautionary principle in a proportionate manner where there are uncertainties that cannot be resolved, if these are material to decision-making
- ensure continued ecological functionality of colonies by considering roosts, habitats and connectivity at a scale proportionate to the development;
- follow the mitigation hierarchy;
- seek to achieve a positive outcome for biodiversity (see **Section 5.3**);
- provide a clearly established mechanism for delivering the proposed mitigation and associated monitoring required (see **Chapter 9.0**). Normally this would be controlled through planning and licensing.

Mitigation/compensation expectations

5.2.2. Mitigation/compensation should be proportionate to the impacts. In any bat strategy, it should be clear which of the proposed elements are mitigation/compensation and which are enhancement.

5.2.3. Requirements for licensing vary between the different UK countries (as set out in **Chapter 2.0**). The acceptable level of mitigation for a given level of impact will also differ between species. SNCB requirements are not published externally, but reasonable expectations by species and roost type are given in **Table 5.1**. The valuation on which these tables are based is explained in **Chapter 4.0**.

5.2.4. The proposal in **Table 5.1** sets out a proportionate level of mitigation for roosts in different circumstances, based on previous experience of licensing and internal SNCB guidance notes where these have been shared. This table has been devised because a degree of flexibility was considered important. Regional differences in distribution and abundance are accommodated, and it is consistent with CIEEM EcIA methodology, reflecting importance at different spatial scales. However, adhering to this table will not guarantee that the relevant SNCB will approve a mitigation proposal, as a table cannot accommodate all elements of a scheme and each situation is different. Where it is not possible to meet these standards, it may be necessary to negotiate with the relevant SNCB.

5.2.5. For complex sites, and/or where a roost of national importance could be affected, early engagement with the relevant SNCB is recommended.

Check out APPENDIX 4 for Case study 41: Use of a s.106 agreement to secure long-term funding for management of an area close to the South Hams SAC.

5.2.6. For timing requirements for works affecting features, refer to **Table 6.1**; for monitoring effort/duration, refer to **Chapter 9.0.**

Table 5.1: Proposed scale of compensation required

<table>
<tr><th rowspan="2">Value of receptor</th><th colspan="7">Roost category: note this table relates to a feature's original VALUATION and does not mean that all such sites are 'places of shelter' as referenced in the W&CA or Habitats Regulations. Inclusion in this table does not indicate that a licence would be required; this would be driven by any impacts and the likelihood of an offence.</th></tr>
<tr><th>Feeding perches; night-roosts Individual or very small occasional/transitional /opportunistic roosts</th><th>Non-breeding day roosts</th><th>Mating sites (excluding individual trees and larger swarming sites) Small numbers of hibernating bats</th><th>Larger transitional roosts</th><th>Hibernation sites</th><th>Autumn swarming sites (largely, vesper species which hibernate underground (Myotis, long-eared bats and barbastelle)</th><th>Maternity sites</th></tr>
<tr><td>Site</td><td rowspan="2">Flexible (in terms of timing and type)</td><td rowspan="2">Flexible (in terms of timing and type)</td><td rowspan="2">Flexible (type); do not leave bats without a roost</td><td rowspan="2">Flexible (in terms of timing and type)</td><td rowspan="2" colspan="2"></td><td rowspan="2">Flexible (type); do not leave bats without a roost</td></tr>
<tr><td>Local</td></tr>
<tr><td>District</td><td></td><td>Like-for like replacement; no timing constraints</td><td>Like-for like replacement; do not leave bats without a roost</td><td>Like-for like replacement; do not leave bats without a roost</td><td rowspan="2">Like-for like replacement (as close as possible or better); do not leave bats without a roost</td><td rowspan="2">Like-for like replacement (as close as possible or better); do not leave bats without a roost</td><td rowspan="2">Like-for like replacement (as close as possible or better); do not leave bats without a roost</td></tr>
<tr><td>County</td><td rowspan="3" colspan="4"></td></tr>
<tr><td>Regional</td><td>Like-for like replacement (as close as possible, or better); do not leave bats without a roost; erected (if possible) to be available in relevant season before original removed</td><td>Like-for like replacement (as close as possible, or better); do not leave bats without a roost; erected (if possible) to be available in relevant season before original removed</td><td>Like-for like replacement (as close as possible, or better); do not leave bats without a roost; erected (if possible) to be available in relevant season before original removed</td></tr>
<tr><td>National</td><td>As agreed with SNCB</td><td>As agreed with SNCB</td><td>As agreed with SNCB</td></tr>
</table>

In all cases, provision should be suitable for the species, and 'do not leave the bats without a roost' means 'in the season when that roost would be expected to be in use'. Ideally, such compensation would be in place **well in advance,** but it is recognised that this isn't always possible.

5.3. Biodiversity Net Gain (Biodiversity benefits)

5.3.1. Biodiversity Net Gain (and similar terminology such as 'biodiversity benefits') is an approach which aims to leave the natural environment in a measurably better state than beforehand. At the time of writing, the metric produced by Defra (Biodiversity Metric 4.0[30]) for England provides the mechanism of measuring and accounting for biodiversity losses and gains resulting from development or land management change . However, the Defra metric currently only considers habitats as a proxy for biodiversity; it does not take into account requirements of bats and other key species.

5.3.2. In Wales, Section 6 of the Environment (Wales) Act 2016 places a general duty on public authorities to, "seek to maintain and enhance biodiversity in the exercise of functions… and in so doing promote the resilience of ecosystems", which be taken to mandate biodiversity net gain, but the duty does not include specified metrics or a particular target level of enhancement, leaving judgement as to whether proposed developments meet the requirements of local planning authorities on a case-by-case basis. CIEEM has published a briefing paper to inform ecologists and environmental managers of the broad terrestrial planning policy landscape in Wales, the Welsh Government's approach to delivering net benefits for biodiversity and key considerations for ecologists and developers in submitting planning proposals[31].

5.3.3. In Scotland, Section 3A of the Town and Country Planning (Scotland) Act 1997 sets out six outcomes for the National Planning Framework (NPF), including "securing positive effects for biodiversity". The NPF4[32] (2023) includes policies requiring development to enhance biodiversity, with larger development required to leave biodiversity in "a demonstrably better state than without intervention". As in Wales, the policy does not specify a particular metric or level of enhancement required. CIEEM has published a briefing paper which provides Planning Authorities (PAs) in Scotland with an overview of the Biodiversity Net Gain concept and potential implementation mechanisms with reference to Scottish legislation and planning policy (although this pre-dated publication of the NPF4)[33]. A near-final draft of Scotland's Biodiversity Strategy was also published in December 2022[34].

5.3.4. BCT has produced a document detailing how bats and their habitats can be considered within Biodiversity Net Gain proposals[35].

5.4. Ensuring delivery

Consultation and communication

5.4.1. Early consultation with the client and planning authority is required so that:

- the mitigation hierarchy is applied to the design process;
- the requirements and constraints are understood and accommodated, particularly where seasonal constraints and programming implications arise from complex projects with significant impacts;
- the planning authority and, for larger projects, the SNCBs are engaged (early engagement is recommended where the mitigation is particularly complex or novel).

5.4.2. The effective and successful implementation of a mitigation plan will almost always require site supervision and/or employment of a suitably competent and usually licensed Ecological Clerk of Works (ECoW).

30. https://publications.naturalengland.org.uk/publication/6049804846366720 Note the metric used to calculate BNG is constantly evolving, so it is important to check for the latest iteration before use.
31. https://cieem.net/resource/cieem-briefing-welsh-governments-approach-to-net-benefits-for-biodiversity-and-the-decca-framework/
32. https://www.gov.scot/publications/national-planning-framework-4/
33. https://cieem.net/wp-content/uploads/2021/04/Implementing-BNG-in-Scotland-Apr2021-1.pdf
34. https://www.gov.scot/publications/scottish-biodiversity-strategy-2045-tackling-nature-emergency-scotland/
35. https://www.bats.org.uk/our-work/landscapes-for-bats/core-sustenance-zones

5.4.3. The project will always go more smoothly if the project ecologists/ECoWs understand how the bat-related elements fit into the whole, particularly where the progression of certain elements is dependent on the completion of others. This is particularly important for complex, long-running or multi-phased projects.

Planning controls

5.4.4. The British Standard for Biodiversity 42020:2013 defines the requirements for ecological input in the planning process and illustrates how these fit with the Royal Institute of British Architects (RIBA) Plan of Work guidance stages. It also includes suitable wording for planning conditions and other controls.

5.4.5. Suggested controls are set out in **APPENDIX 3**. These and other mechanisms can be used to secure the implementation of mitigation/compensation, as well as management/maintenance and monitoring (**Table A2.1**) and site safeguard (**Table A2.2**). The funding may be used to cover related items such as wardening or interpretation.

5.4.6. For higher-risk/higher-impact cases, an appropriate agreement may need to be in place before a licence can be granted. For exceptional sites, given licensing and longer-term specialist management requirements, it may be advisable for the freehold tenure of dedicated ecology areas (such as a roost constructed for greater horseshoe bats) to be transferred to a responsible body[36].

5.5. Working with clients and contractors

5.5.1. However good a design is on paper, and however detailed the drawings and associated instructions, it is always possible for these to be misinterpreted or mislaid. Bat mitigation is sometimes seen as an obstacle to be dealt with quickly by contractors who have other priorities. Unfortunately, that can lead to costly mistakes that have to be rectified (such as having to remove a new roof to change an unsuitable roofing membrane, despite clear and timely instructions). It is essential to share drawings with contractors at an early stage so that the correct materials and design details are costed and procured in time. It is strongly recommended to hold face-to-face meetings (or conference calls) to explain the objectives, rather than relying on correspondence. Similarly, any restrictions that may apply to working practices (such as seasonal windows affecting programme, limits or bans on night-time lighting) should be fully explained and documented.

5.5.2. The same requirements apply to habitat creation and enhancement measures, which can take longer (several years) to fully establish. It is important that measures are in place and the contractors fully understand the requirements for remedial action in case of failure (see also **Chapter 9.0**).

5.5.3. As noted above, a suitably competent ECoW who works closely with site staff and keeps comprehensive records is often critical to delivery. For larger projects, consistency of supervisory personnel (or good communication between supervising ecologists where continuity not possible) is key. Clear and consistent messaging to contractors and repeat training/engagement (such as toolbox talks) where personnel or contractors change is required. As this requires contractors to inform ecologistS of such change, good relationships and ongoing dialogue are important.

5.5.4. Mitigation implementation should always be checked/recorded as the work progresses, not left to a final compliance check (and labelled photographs are essential). Recording communications and actions as they occur is of paramount importance in case things do not go according to plan. The more complex the mitigation, the more likely it is to deviate from what has been planned (Collins *et al.,* 2020). Clear records may be used by insurers wanting to assess liability for costs, or in legal proceedings, should an offence be

36. One such definition of a responsible body is provided in The Environment Act (2021), S7. Whilst the Act does not apply to all four countries, the definition outlined here of a responsible body may be helpful.

committed or suspected. Even in the absence of formal proceedings, such records (including photographs) establish a clear audit trail of actions, roles, agreements, progress and responsibilities.

5.5.5. Monitoring should be seen as an integral part of the project, and its importance, timescales and costs should be highlighted at the earliest possible stage (see **Chapter 9.0** for specifics). This is particularly important given that, in many cases, monitoring will extend beyond the point at which contractors leave site, and responsibilities for subsequent actions may become less clear if not formalised in advance.

6. Avoidance, mitigation and compensation: roosts

6.1. Introduction

6.1.1. This section describes methods used to mitigate (or compensate for) impacts to bat roosts. Mitigation is not an exact science and the evidence for success, whilst increasing constantly, is incomplete and sometimes contradictory. This is because the factors which drive success are complicated and because there has been inadequate monitoring and reporting of successes and failures. However, it is important that roost loss is mitigated or compensated for, particularly from older buildings, as the materials and techniques used in contemporary buildings can exclude bats or even cause harm, and there is a growing risk that roost sites will become a limiting resource at least for some species and/or in some areas.

6.1.2. Simon *et al.* (2004) go further, and state that not only should existing roosts be preserved where possible, but that it is *essential* to create new roosting opportunities to replace those being lost from the roost resource (e.g. by modern methods of construction/insulation). New opportunities created by ageing/weathering will not be enough to compensate for the likely rate of attrition, and therefore the provision of additional roosts (what might be considered 'enhancement' but is really compensation on a landscape scale) is required, along with landscape-scale habitat improvements (Mackintosh, 2016).

6.1.3. Recent studies[37] examining mitigation success include Lintott & Mathews (2018) and Collins *et al.*, (2020). It's important to note that Lintott and Mathews' study relied on a self-selected sample of consultants' reports, and only included cases where monitoring had been carried out and a report was available. These were of varying quality, meaning that it was only possible to assess the impacts of some aspects of mitigation strategies. Collins *et al*. (2020) included cases from SNCBs where owners agreed to participate in the study (not just those volunteered by consultants) and undertook the monitoring themselves.

6.1.4. These two studies found that the probability of bats returning to a site post-development was dependent on the nature of the changes to the roost structure[38]. If the roost structure was completely destroyed, the likelihood of bats returning was greatly reduced in comparison to where roost structures were retained albeit modified in some way.

6.1.5. The outcomes of the two studies sometimes conflict; this is not surprising given the complexity and variability of bat mitigation and the relatively small sample sizes for the level of variation in each study. It is also important to note that both studies focused on a small sub-set of species so, for these reasons, the outcomes cannot be universally applied, nor taken as confirmation that good quality mitigation fails more often than not in the longer term. This is particularly true when failure in a single critical attribute is likely to result in overall failure (Waring, 2011).

6.1.6. Mackintosh (2016) looked at a series of maternity roost compensation measures in Scotland. This study was relatively small and similarly covered a small range of species and several different compensation types[39]. This again makes it difficult to draw firm conclusions about which factors are critical and which are contributory when determining whether mitigation provision will be used by the same species for the same purpose post-development. The mitigation implemented had only been in place for a maximum of three years, often far less. The before/after colony counts were limited in number and to single years, therefore it is not possible to judge whether any change in roost status/numbers was an accurate reflection of past, or future *long-term,* use.

37. A number of earlier studies are summarised in Mackintosh (2016) and Lintott and Mathews (2018), and those studies are therefore not revisited in these guidelines.
38. Comparing-BCT-and-CIEEM-mitigation-studies-FINAL-16.06.21.pdf (bats.org.uk)
39. Compensation roosts were categorised as being a bat box, heated bat box, retained roost with access points or a bat loft (free standing structure with internal flight space).

6.1.7. Waring (2011) reviewed the compliance of a series of licensed bat mitigation schemes in Snowdonia National Park. This report also outlined approaches to the condition assessment of bat mitigation features, as well as options for determining measures of success for bat mitigation schemes. In terms of mitigation, success was measured by looking at two elements: whether or not the proposed mitigation measures had been implemented as originally specified; and whether or not bats, or signs of occupation by bats (referring to the species for which the mitigation was designed), were present at the time of assessment.

6.1.8. Mitigation success may vary between species and roost types. Lintott and Mathews (2018) found that large pre-development pipistrelle roosts (> 100 individuals) retained similar numbers of bats following mitigation. There are numerous examples of lesser horseshoe bats successfully adopting new roost provision (see, for example, Schofield, 2008). However, rarer species (other than lesser horseshoe bats) are less often found in situations where their roost might be lost (at least, they represent a very small proportion of licence applications), so there are fewer examples to test effectiveness. This suggests that licensing is protecting those rarer species by the implementation of the mitigation hierarchy, i.e. through avoidance of impact and thereby avoiding a need for licensing.

6.1.9. For brown long-eared bats, roost sites which were retained (with existing access points), and of a similar size (i.e. where impacts were avoided), unsurprisingly tended to be the most successful in retaining roosts (Shepherd & Stroud, 2010). Creating a bat loft in an existing building on a site, presumably known to the colony, has a good chance of success (Shepherd & Stroud, 2010). Collins *et al.* (2020) found adapted buildings were used more than retained roosts, although the retained roosts in that study were typically lower status day roosts, whereas the adapted buildings supported larger roosts. The success of new lofts in new builds varied. Whilst Shepherd and Stroud (2010) found them little-used, and Collins *et al.* (2020) found them unused, Lintott & Mathews (2018) recorded brown long-eared bats in around 20% of new lofts, with at least some likely to represent maternity colonies which can comprise as few as five individuals (Dietz & Kiefer, 2016). For this species, even in ideal habitat, time may be a critical factor. This may be because a small number of individuals takes longer to find new roosts[40], or because new construction materials are (at least initially) unattractive.

Check out the following case studies in APPENDIX 3 for examples of successful brown long-eared bat roost creation:

- *Case study 1: Fron Haul, Flintshire, North Wales;*
- *Case study 2: Sherwood Hideaway, Ollerton, Nottinghamshire.*

6.1.10. In compiling these guidelines, monitored examples that have resulted in use by bats have been included, even where there is uncertainty as to what made the mitigation successful, or which factors were critical. Where measures have little or no supporting evidence, this has been made clear.

6.1.11. In addition to the examples included in this document, case studies are available at the locations listed below. Some of these are 'live' sites, and consultants are strongly urged to contribute studies to these sites, and to consult them for updates and examples.

- BCT's Mitigation Case Studies Forum 2017 (Bat Conservation Trust, 2017)[41];
- BCT's Roost website[42], which promotes good practice through the sharing of bat roost mitigation and enhancement case studies;
- EUROBATS Report of the Intersessional Working Group on Purpose-built Roosts[43]

40. *The Bat Mitigation Guidelines* (Mitchell-Jones, 2004) reports a case study (No. 4) where a new roost was built for a maternity roost of 30-40 brown long-eared bats. The first signs of bats were recorded within two months of completion of construction, and bats bred there in the first year, with a similar colony size (35-45).
41. Forum proceedings available from this webpage: Bat Roost Mitigation Project - Bearing Witness for Wildlife - Bat Conservation Trust (bats.org.uk)
42. https://www.bats.org.uk/our-work/buildings-planning-and-development/roost-replacement-and-enhancement
43. https://www.eurobats.org/sites/default/files/documents/pdf/Advisory_Committee/Doc.StC14-AC23.31-Report_Purpose-built_Roosts.pdf

6.1.12. A recurring theme of the EUROBATS review cited above[43] *(inter alia)* is that the uptake of purpose-built (i.e. artificial replacement) roost structures can be slow. This is an extremely important point. It may be many years before bats adopt them, as demonstrated by a number of specific examples in that review. Designs for new roosts may be adequate in terms of the roosting ecology of the target species, but other factors, such as the social structure of colonies, or the existence of other known roost sites, may influence their uptake. In addition, it is not yet known *how* bats find new roosts (this may differ between species). This means both that there may be a short-term impact on the local population, and that long-term monitoring may be necessary to fully appreciate the beneficial impacts on bats of adding to the local roost resource.

6.1.13. Conservation Evidence is another free information resource that summarises global evidence about the effects of conservation interventions. The site collates and examines scientific studies of specific interventions designed to benefit wildlife or ecosystems in order to determine if there is any evidence of effectiveness. 'Key messages' for each intervention show the extent and main conclusions of the available evidence over the last few decades. The supporting detail allows an assessment of the quality of the evidence and how relevant it is to a particular situation. To be included as evidence, there must have been an active intervention, and monitoring must include an appropriate comparison (control). In many cases where mitigation is applied for a development, there is no control and therefore such examples cannot be submitted. Many interventions, even those commonly used, are said to have 'no evidence' for this reason; i.e. effectiveness has not been adequately tested. As for the other resources noted, consultants are strongly urged to contribute studies, and to consult Conservation Evidence for updates and examples.

6.1.14. As sites vary in their characteristics and the species they support, and developments differ in their impacts, consultants may make a case for different techniques and levels of effort. Importantly, all interventions must be monitored (see **Chapter 9.0**) for an adequate period of time, and the results reported, so effectiveness (or otherwise) can be improved.

6.1.15. There is a responsibility to make sure that any proposed mitigation meets other 'non-wildlife' legal requirements. For example, the incorporation of bat access points into new or refurbished buildings may need to comply with planning requirements and Building Regulations. Older buildings may require listed building consent[44], and there is a separate consent for scheduled monuments[45]. Separate rules apply to churches. Who is responsible will vary depending on the nature of the project and whether a licence is needed or not, e.g. consultant, client, architect, or building contractor. Insurance or warranty organisations, such as the National House-Building Council, may also impose additional requirements. Adopting the options in this document does not indicate or ensure compliance with any such requirements.

6.2. Avoiding and minimising disturbance to bats

Timing

6.2.1. The great majority of roosts are used seasonally, so there is usually some period when bats are not present, or are present in much lower numbers. Consequently, the most common and effective method of avoiding disturbance is to carry out work at the time of year when bats will be absent.

6.2.2. Bats are most vulnerable during the maternity season (when heavily pregnant females or non-flying pups may be present) and the hibernation period (when untimely arousal from hibernation may affect fitness and even survival).

6.2.3. Although there are differences between species, maternity sites are generally occupied between May and August (some into September) and hibernation sites between October/November and March, depending on the weather. Note that bats are unlikely to be fully hibernating in October in most areas of the UK, given that

44. https://historicengland.org.uk/advice/planning/consents/lbc

45. https://historicengland.org.uk/advice/planning/consents/smc

46. Figures based on the normal maximum and minimum daily temperatures based on weather data collected from 1981 to 2010 https://www.currentresults.com/Weather/United-Kingdom/temperature-october.php (website uses Met Office data).

mean temperatures average a daily high of 14 °C and a low of 7 °C[46] and, with climate change, the periods when bats are not hibernating may begin to extend.

6.2.4. In principle, the optimum time for works of all types is likely to lie outside the maternity and hibernation seasons. Spring and autumn therefore represent the periods when bats are least vulnerable to disturbance. The recommended times shown in **Table 6.1** below should be modified in the light of site-specific species information, latitude and ambient conditions.

Table 6.1: Optimum season for works in different types of roosts

The period of works may be extended if the way in which the bats use the site is well understood.

Roost type	Months to avoid	Optimum period for carrying out works (some variation between species and weather-dependent)[a]
Maternity	May-August (potentially September)	September to end April
Hibernation (not used for swarming)	November to March	April to end October [see also **6.2.14** et seq]
Hibernation and swarming site	August to March (key); potentially July until April	April to July (potentially later, depending on site and nature of works)
Mating/swarming: not used for hibernation	August to October (key); potentially July until mid-November Also April-early May in at least some species[b]	Mid-November – end March (potentially later, maybe species-specific) Broader restrictions if site also used for hibernation: see above
Non-breeding summer roost	None	No restrictions – assuming bats can be excluded if present in small numbers or otherwise safely managed

a. See **Section 6.9** for the timing of bat exclusions

b. Furmankiewicz *et al*., 2013

6.2.5. Annual (and regional) variations in temperature affect bat behaviour, and assumptions of how bats will behave in any month are likely to be increasingly challenged by climate change, bringing warmer but also more unpredictable weather (Sherwin, Montgomery & Lundy, 2013). **Table 6.1 therefore needs to be interpreted with caution** rather than rigidly, and supported by evidence (demonstrating, for example, that bats have departed a roost or are active earlier than anticipated). It should be used as a planning tool, in combination with inspections/surveys to confirm absence as appropriate.

6.2.6. Adequate surveys and a good understanding of the seasonal activity patterns of the species involved will help in determining the optimum time to carry out the proposed work. For instance, Davidson-Watts, *et al.* (2006) recorded common pipistrelles moving roosts between pregnancy and lactation, which could provide a window within the breeding season to get works completed; equally, a maternity colony with non-volant young may arrive unexpectedly, perhaps in response to changing weather conditions. Nathusius' pipistrelle, a species that may become more widespread with climate change, may occupy maternity sites early, in April (Dietz & Kiefer, 2016), but also leave as early as July (Dietz & Kiefer, 2016). Conversely, some species – notably long-eared bats, serotines and lesser horseshoe bats – tend to use summer sites until well into autumn, or even winter in some sites. Species may also share a structure, so care is needed when drawing up works timetables. These examples illustrate that planning the work in advance is important, but **evidence rather than doctrine should be used to determine when it is safe to undertake works.**

6.2.7. Activities which could cause temporary roost disturbance but leave roosts and access points unaffected (e.g. works resulting in short-term noise or lighting) are good examples of where a licence could be avoided through appropriate timing and the use of a Method Statement. Where the same structure is used throughout the year, it may not be possible to avoid licensing. If the roost site will be materially affected (or destroyed), a licence will be needed.

6.2.8. When determining whether a licence could be avoided by timing the works at an appropriate time of year, the likelihood of discovering bats outside of the anticipated season of occupation, and potential for programme slippage, should both be considered.

6.2.9. As a starting point, the best times for building or re-roofing operations are spring (though nesting birds may be a constraint) and autumn, when bats are active and least vulnerable. However, where buildings are only used opportunistically by individual or very small numbers of non-breeding bats for (likely) short periods of time, it should be possible to undertake such operations with care during the summer.

6.2.10. Similarly, whilst **Table 6.1** sets out the 'optimum season' for works affecting winter roosts, this applies most usefully to what might be called 'classic' hibernation sites, i.e. sites providing cool stable conditions which tend to support larger numbers of hibernating bats (or possibly smaller numbers, but over several years). However, many bats do not use such sites during the winter months, instead roosting individually or in small numbers in buildings (particularly pipistrelles) or in trees. In addition, when prevailing conditions are favourable, many bats are frequently found in thermally unstable roost sites and not necessarily in hibernation torpor.

6.2.11. It would therefore not be appropriate to avoid all work to any building or trees which could support a bat during the winter months as, whilst bats may be found almost *anywhere* (e.g. under roof tiles, soffits, wall-plates, or cladding that provide PRFs), they are not *everywhere*. Preventing all works to structures and trees for the entirety of the period November to March in case a winter-roosting bat could be present, however low the risk, is therefore impractical and disproportionate. For instance, for large-scale Local Authority roofing projects (thousands of properties in any year), it is simply not possible for all roof-strips to be carried out only in spring and autumn. For trees, the winter period is the most common for forestry operations (Davidson-Watts, pers. comm.).

6.2.12. Repeated disturbance to hibernating bats can seriously deplete their food reserves but, as noted by Mitchell-Jones (2004), unless significant numbers of hibernating bats are known to be present, there is no advantage in requesting a deferment of scheduled building works. It is therefore important to assess hibernation potential when determining whether works can safely continue during colder weather. This assessment (and the supporting rationale) should be fully documented, and updated whenever new information comes to light (i.e. survey data).

6.2.13. For working on trees in winter, particularly in woodland, an understanding of the likely value of the roost resource in all seasons would be part of the approach to survey and assessment, and is covered in revisions to published UK bat survey guidance (Collins, 2023). However, the SNCBs' current position is that an identified tree roost cannot be removed in winter, even when it can be demonstrated that bats are absent from a roost (see para 6.5.19).

Assessment of winter potential of 'non-classic' features within buildings

6.2.14. An assessment of 'non-classic' winter potential is not always undertaken for the purposes of planning. In addition, the vast majority of re-roofing works (by far the largest category of works affecting such 'non-classic' hibernation sites) do not require planning consent. This section is therefore included to guide such an assessment, prior to winter working on any type of site where 'non-classic' features may be present (i.e. most types of building).

Box 6.1: There is more to understand about winter-roosting bats and the conditions they will tolerate.

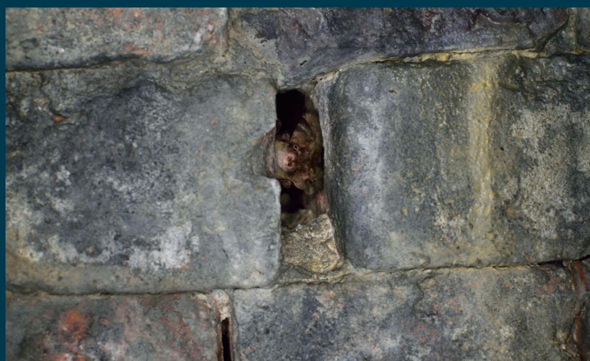
Left and centre: Six pipistrelles were spotted in this slim, exposed tree February 2021; four at 3m and two at 1.8m, just 5cm in, and clearly visible. Photos/data: Brady Roberts, Aether Ecology (L); Adam Young, Origin Arb (R). Right-hand photo: a slim dead sycamore supporting a pipistrelle in 12 January 2022; daytime temperature 10 °C. The bat had moved on within a week.

Photo/data: Nick Carter.

Below left: an active Natterer's bat on the external facade of Ashby Tunnel. Although it was -5 °C, it groomed for c.15 mins and then entered the tunnel, settling about 50 m from the entrance. Night-time temperatures had fallen to -10 in the preceding week and there was a heavy covering of snow. Two other Natterer's bats were torpid and within 1 m of the entrance at a height of c.4 m.

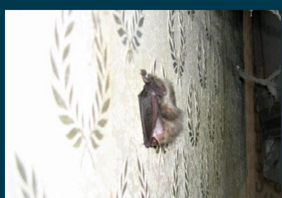
Below right: The brown long eared bat is within the roof (height of 2m) of the tramway tunnel at the National Trust's Calke Abbey.The bat is awake and looking down onto a footpath used by hundreds of people a day. The bat is known to use the same roost during the colder months and had used the site for several years.

Photos: Garry Gray



Torpid bat behind a painting in a vicarage, West Wales, December. Outside temp 6 °C.

Photos: Glyn Lloyd-Jones



Two brown long-eared bats, January 2023; outdoor temperature 6 °C in a pocket of ironstone open at the top and bottom in the pinnacle of an arch.

Photo: Claire Andrews.

At first glance, this agricultural barn appears to be rather unsuitable for bats, comprising an asbestos roof, with permanently open doors. However, despite the light and draughty conditions, and lack of recognised 'typical' internal roosting features, this brown long-eared bat was found roosting out in the open (4 January 2023, Wiltshire) during a mild spell. No other evidence of bats was present.

Photos: Jon Byrd.

Left: two common pipistrelles bats tucked behind a wooden fascia board of a flat roof on the north side of a school in Fort William (12 January 2023). The weather was c.6 °C, raining heavily with light winds.

Photo K. Martin.

Right: hibernating brown long-eared bat in a mortar gap on the pier of a railway bridge crossing a very small stream. Weather: mild, sunny, limited cloud cover.

Photo: Steph Cooling-Green.

Right: these pictures of bats –brown long-eared bat and pipistrelle - were taken on 13 December 2022, in a very open wind-exposed barn after snow fall. Not fully torpid, both were roosting in folds of hanging hessian sacks (also pictured). They had moved before the January count, illustrating that these species are active during much of our British winters.

Photos/text: James Booty.

6.2.15. For 'non-classic' hibernation sites, particularly those within/behind external features of buildings or cavity walls, the extent to which they can be surveyed is limited. Often only a destructive search would be definitive, and therefore counter-productive. A static detector placed outside a structure might pick up bats flying past on warmer nights rather than confirm winter use. This may give a useful understanding of winter bat activity if a number of buildings are being affected, but is unlikely to be helpful in relation to a specific building.

6.2.16. For void-dwelling species which can linger into winter (notably brown long-eared bat, serotine) but not always visibly so (e.g. where there is deep insulation obscuring joists or the peak of the void is well above head height, preventing close inspection), visual inspections supported by static detectors within the void, during conditions which include periods suitable for bats to be active (Park, Jones & Ransome, 2000)[47], (Hope & Jones, 2013), can indicate continued presence or almost-certain absence. It is important that the detectors are there for a sufficiently long period, to be judged by the prevailing conditions, but not fewer than five suitable days. Daily temperatures within the void and ambient external temperatures should be monitored.

6.2.17. A rationale for undertaking a winter assessment is shown below in **Figure 6.1** (with thanks to Neil Middleton, BatAbility Courses & Tuition). The results of this assessment should guide the approach to mitigation, notably timing restrictions. The assessment should consider:

- the suitability of features to support roosting bats or to allow access for roosting bats;
- the temperature and humidity conditions likely to be present within the structure during the winter period and the suitability in this respect for it to be used by hibernating bats;
- the surrounding habitat, in terms of its potential for use by bats outside of the hibernation period for commuting and/or foraging purposes (i.e. is it reasonable that bats are familiar with the area and therefore may be aware of suitable roosting locations within the site); and
- the presence of known roosts within the structure, or adjacent structures, or surrounding area during the active season.

6.2.18. The last point should be informed by surveys undertaken at other times of the year, where possible.

6.2.19. If works are required that could in principle affect bats, a risk-based approach is required, dependent on the likelihood of encountering bats, the status of the work, and weather/temperatures experienced. The likelihood of species other than pipistrelles should be considered (brown long-eared bats and whiskered bats are the next most commonly found under external features). The rationale for continuing in adverse conditions should be recorded.

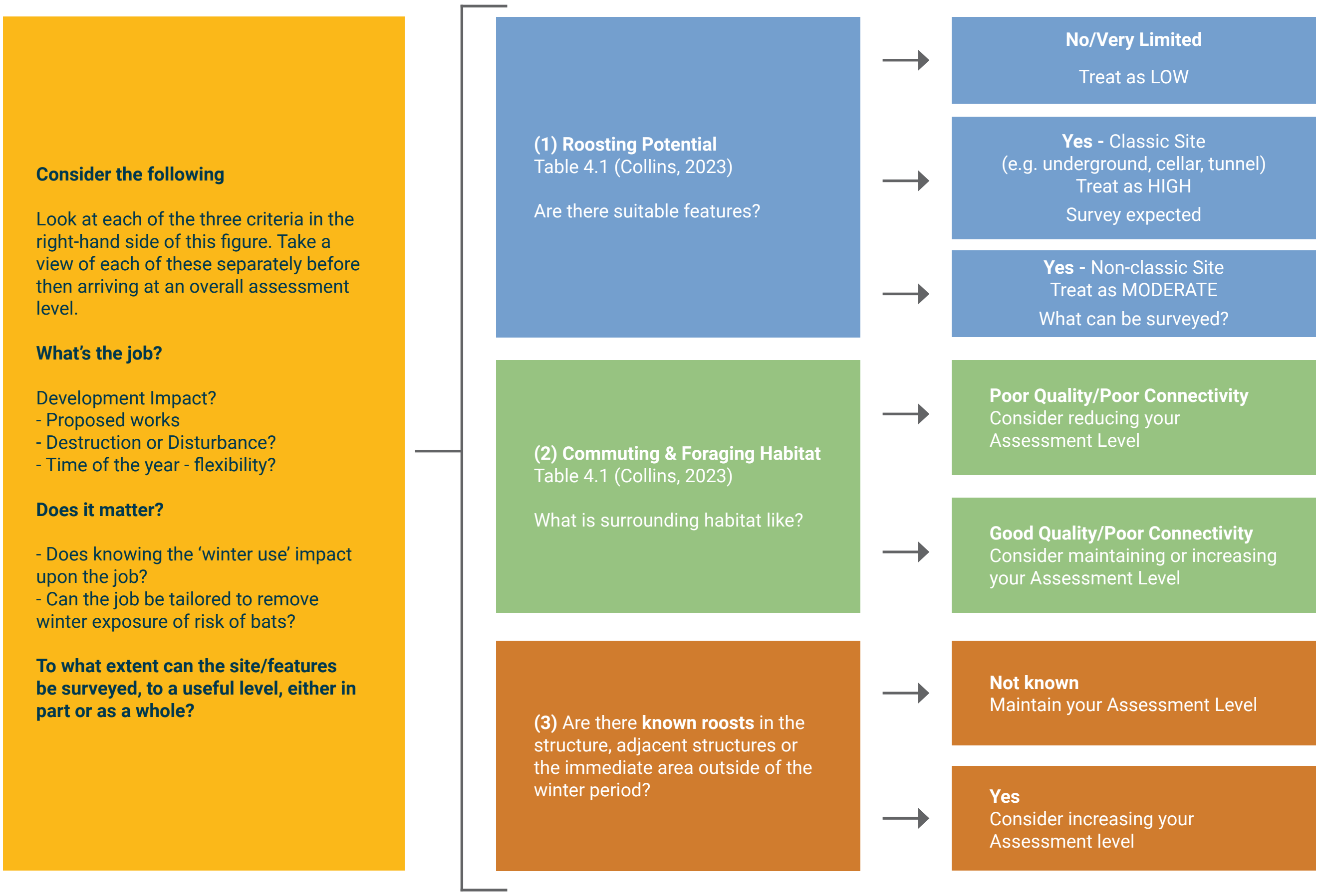
6.2.20. Consideration should also be given as to whether any proposed works would constitute a single disturbance event (likely to be tolerable) or carries a risk of repeated disturbance/arousal (ideally to be avoided).

6.2.21. Where the assessment determines that the likelihood of finding bats in winter is negligible or low, then works should be able to proceed without any temperature restrictions. Any bats found would be treated as 'unexpected finds'[48]. Records of bats (or evidence that bats have been present) should be collated to inform future approaches to working in the hibernation season (see **APPENDIX 7**).

47. Park *et al.* (2003) note that bats arouse periodically from hibernation even when they are unlikely to feed, drink or mate (and thus may not leave the roost); that arousals are normally synchronised to dusk so that foraging opportunities can be exploited if they arise; and that the minimum temperature thresholds for the flight of many insects can be as low as 8°C. Hope and Jones (2013) found similar patterns of arousals linked to dusk in Natterer's bats. Avery (1985) showed that pipistrelles will leave hibernation to feed in any winter month during the period of hibernation, and on a third of all winter nights.

48. This would also be the case if surveys had not previously established the presence of an opportunistic/transitional roost for which a licence had been sought, as it is not possible to apply for a licence on a precautionary basis.

Figure 6.1: Assessment of hibernation potential for 'non-classic' hibernation sites



6.2.22. Where the assessment determines that the likelihood of finding bats in winter is moderate, but that only very small numbers of bats are likely to be found (if any, based on an understanding of how bats appear to be using the site in question), then risk of harm for any torpid bats found can be reduced by only stripping roofs when:

- it is dry/calm; and
- temperatures are no lower than 8°C for at least an hour or two from dusk on 3-4 consecutive nights (which would be sufficient for bats to be active and to feed).

6.2.23. In addition (and as for works at other times of the year):

- the works should be covered by a method statement appropriate to the level of risk (see Section **6.10**);
- care facilities for any bats found should be in place (see **6.9.17**).

6.2.24. Very large rebuilding or renovation projects may take many months to complete and may need to continue through the summer, which is the favoured season for re-roofing. Where a maternity roost is affected, the aim should be to complete and secure the main roosting area before the bats return to breed. Where an important swarming site is affected, works should be timed to avoid the autumn swarming and hibernation periods[49]. For a smaller hibernation roost, work should commence prior to hibernation to deter bats from hibernating; if they persist in hibernating, it can be assumed that they find the level of disturbance acceptable. For longer-term projects where the impacts could be severe, it may be necessary to carefully phase works, with pauses between phases. Alternatively, it may be necessary to exclude bats throughout the development; in this case, compensation will be a key part of the approach.

49. https://www.bats.org.uk/our-work/buildings-planning-and-development/roost-replacement-and-enhancement/case studies/avoidance-of-swarming-site-loss-during-restoration-works-at-cliveden

6.2.25. Large-scale re-roofing projects will require a bespoke approach to determine how to proceed in terms of survey effort, licensing approach, timing of works and compensation measures. For such projects, early engagement with the relevant SNCB is strongly recommended. At the time of writing, the intention is to provide guidelines for such projects, likely to be hosted on BCT's website, from late 2023.

Screening

6.2.26. If bats are present, works may be able to continue by using methods such as temporary screening to partition works from the roost, and temporary exclusion methods (see **Section 6.9** for exclusion methods).

6.2.27. Such measures may avoid or reduce the severity of impacts, but any measures that significantly reduce roost area, block entrances, change the thermal regime of the main part of the roost, or require bats to be excluded using a device, would require a licence.

Check out the following case study in APPENDIX 3:

- *Case study 4: Use of screening to reduce disturbance.*

Lighting and noise

6.2.28. To avoid repetition, these issues are covered under **Section 7.3.**

6.3. Mitigation for building roost loss (excluding churches)

Approach

6.3.1. Roost loss may be temporary or permanent. The ideal scenario is to provide the same roost in the same place, like-for-like, with only temporary functional loss, and with any enhancements that can reasonably be provided. Where possible (temporary loss), the roost should be reinstated in the same location, with the same attributes. If the work is completed while the bats are seasonally absent, this is effectively avoiding impacts. Each modification is likely to lead to some loss of functionality, even if only temporary, and proportionate design enhancements should be included as compensation.

6.3.2. Projects such as the refurbishment of derelict or semi-derelict buildings, barn conversions, alterations to non-domestic premises and other structures used by bats, can all provide opportunities to incorporate existing roosts into the final structure (mitigation). This option is strongly preferred to the destruction of an existing roost and the provision of a new roost in compensation, though there may be physical constraints which make this impossible.

Check out the following case studies in APPENDIX 4:

- *Case study 3: Durslade Farm, Somerset;*
- *Case study 6: Peckforton Castle;*
- *Case study 7: Holiday Inn Hotel;*
- *Case study 8: Primary School, Forest of Dean, Gloucestershire;*
- *Case study 9: Stately Home Repairs, Worcestershire;*
- *Case study 10: Barn re-roof – Lancashire;*
- *Case study 11: Building reconstruction and bat barn construction – Lancashire;*
- *Case study 17: Re-roofing Hugh Sexey C of E Middle School, Somerset.*

6.3.3. For larger/infrastructure schemes, the aim should be to provide habitat heterogeneity and to benefit a range of species in a way that reflects and ideally improves on the roost resource being lost. In other words, a variety of box, loft, and stand-alone designs should be included.

Design criteria

6.3.4. When designing appropriate mitigation it is critical to understand species' roosting preferences[50] and the context in which that roost provision is located (Mackintosh, 2016, *inter alia*[35]). For all types of building roost (whether retained, modified or newly created), the physical characteristics of the final roost, the arrangement and number of entrances, and the flight-paths leading to those entrances (including the location of any exterior lighting or vegetation) all need to be considered. For retained roosts, some of these characteristics will already be established, but could be subject to adverse change, particularly lighting and connectivity. A perfectly designed roost in a poor location is unlikely to be successful. Indeed, Davidson-Watts (2007) noted that, for common and soprano pipistrelles, location is probably more important than structure.

6.3.5. There is some overlap in the design principles for repairing/reinstating building roosts, providing compensatory bat roosts in an alternative or modified roost space, or building a dedicated stand-alone 'bat house', though their relevance will depend on the specifics of any particular situation. For this reason, no distinction has been made between these different types of mitigation for most of the elements described, and they should be applied as needed.

6.3.6. A small number of additional criteria are provided for new constructions, where the risks of non-adoption by bats can be reduced through careful site selection and orientation.

6.3.7. In developing proposals for replacement bat roosts, due regard must be paid to any planning requirements. If planning permission is needed, this may take time to acquire and conditions may be imposed by the planning authority. Such requirements need to be clarified and any planning issues resolved before a replacement roost can be proposed. Replacement roosts, depending on their position and construction, may be subject to the requirements of Building Regulations, again to be clarified before a licence application is made.

6.3.8. Where possible (in terms of layout, access, buildability), replacement roosts should be ready for use by bats (i.e. installed as per all requirements) before the existing roost is destroyed. It is sometimes suggested that a newly provided roost should be *in use* before the existing roost is destroyed. This is almost never appropriate, as there is unlikely to be a strong driver for bats to explore new opportunities until they are excluded from the old roost.

6.3.9. In rare circumstances (i.e. where a new roost requires the existing one to be removed before it can be constructed), a temporary alternative may need to be in place for a period of time, so bats will always have a roost available during their normal periods of use. This would not normally be viewed as a satisfactory approach, and should always be considered an 'option of last resort'. It would require careful justification to demonstrate that other satisfactory alternatives are not viable and that the all the licensing tests are satisfied.

Roost height/volume

6.3.10. Crevice-dwelling species tend to use very small spaces and can be found within a wide range of internal and external components of a building for example; below tiles, under flashing or the ridge, behind soffit boards[51].

6.3.11. Species that tend to roost within roof voids and other internal spaces, and fly within those spaces before emerging (long-eared bats, *Myotis* species, horseshoe bats), will benefit from a space uncluttered by roof timbers (e.g. purlin and rafter) or other obstructions. Based on a sample of known roosts, Mitchell-Jones (2004) stated that an ideal roof void would have an apex height in excess of 2.8 m and a length and width of 5 m or more; there are currently insufficient UK data to give confidence in reducing these for maternity

50. Simon *et al.,* (2004). This was a very comprehensive study which expended over 13,000 hours in identifying bat roosts over a single large district of central Germany, identifying over 500 summer roosts and ringing over 20,000 individual bats (1997-2001). Details are given for very many different roosts so this is a valuable resource, with the caveat that roost preferences on the European mainland may not be precisely replicated in the UK (and not all UK species are included). See also Table 3.2 of Collins (2023) and Dietz & Kiefer (2016).

51. See BCT *Where might bats be roosting in my property?* https://www.bats.org.uk/advice/living-with-bats/where-might-bats-be-roosting-in-my-property for a guide/illustration to where bats might be roosting withing a residential dwelling.

roosts[52] . Collins *et al*. (2020) found that internal height and volume (which are correlated) in adapted lofts displayed highly significant positive relationships with bat counts. The highest bat loft measured 6 m; in that study, no bats were recorded in lofts where the highest internal point was less than 1.5 m[53]. However, other observations have shown that bats will roost in much more confined spaces such as roof voids, chimneys and cupboards, with lower heights from floor to apex/ceiling (see also **Box 6.2**).

6.3.12. Not providing pre-emergence flight space is very likely to lead to roost abandonment, as demonstrated by Briggs (2002). In her barn study, although Natterer's bats were roosting in the small gaps provided by mortise joints (which presumably mimic tree cavities), the lack of an internal area in which to fly following conversion led to roost abandonment even when the roost sites themselves were retained. [See also 'light-sampling'].

Box 6.2: Roof-void under 1.2 m – extenuating circumstances

Example of a lesser horseshoe maternity roost (50+ adults) where the void height was 1.2 metres, but 8 m long (double-pitched bitumen-lined slate roof) connected to a hayloft. The hayloft provided a light-sampling area and roost access via two round door apertures (diameter 300 mm), and was also used as cool roost. Located Herefordshire.

Photos: Ian Davidson-Watts.

6.3.13. There may be regional variations in species preferences. D. Vaughan (pers. comm.) has recorded maternity and significant post-maternity roosts of Natterer's bats regularly using exterior and interior wall crevices (some as low as 1 m above ground level) without the need for interior flight spaces (i.e. where there was no available interior space directly connected, adjacent, or close by the roost site), and examples where an available interior flight space has been ignored by the colony for pre/post roost flight activity. See **Box 6.3.**

52. The EUROBATS review of artificial roosts[40] includes two examples of non-traditional roosts created for greater and lesser horseshoe roosts. These low-cost structures are made of prefabricated concrete. The larger of the structures is 2.6 m square and 4 m high, the smaller is 2 m square and 3.2 m high. Both new roosts have been successful, with the larger site hosting a colony of 48 greater horseshoe bats, and the smaller 33 lesser horseshoe bats.

53. Where bats are roosting in a loft that is lower than the recommended 2.8 m height, and it is not possible to provide an alternative loft that meets this ideal, then aiming for 'no worse than' (i.e. replicating the existing situation, and improving it where possible (even if not to the desired height of 2.8 m) has to be an option. Brown long-eared bats are found in lofts of 1.5 m high, and in lofts with trussed rafters (R. Green, pers. comm.).

Box 6.3: Natterer's bat roost using low-down external crevice and external flight space

Swarming areas and roost site (red) of Natterer's bat (left). Detail of roost site below.
Photos: D. Vaughan

Roost access point location

Table 6.2: Considerations when locating access points

Design principle	Evidence/comment
If retaining roosts in buildings, it is preferable to maintain entrances in their original position and of a similar size, type and orientation.	Changing the access point can reduce numbers of bats using the roost (Berthinussen, Richardson & Altringham, 2021). Even minor alterations to access points may deter bats initially, acting as an "invisible barrier" (C. Packman, as reported at the Bat Mitigation Forum, 2017)[41]. Where practicable, it may be beneficial to 'train' bats to use a new access point before the existing access is removed (Reason, 2017).
New access points should be at a sufficient height and, for vesper bats, the landing area surface should be rough(ened)	Based on a very large sample of access points in Germany, Simon *et al.* (2004) recommend new access points should be located between 7 and 10 m above ground. In UK guidance, Williams (2010) recommends a more conservative 2-7 m height. In practice, height is likely to be dictated rather than a choice, and the range that is 'acceptable' is likely to differ between species. When creating new access points, factors such as the extent of shelter and the predicted levels of disturbance and predation should also be considered.
For some species, more than one access point may be beneficial; note that at least one should be close and similar to the original access point	Lintott and Mathews (2018) found a marginal but significant relationship between the number of roost entrances installed and the probability of bats returning to a roost at comparable levels with pre-construction surveys. However, there may not be a relationship between the number of access points available and those actually used; Collins *et al.*, (2020) found no relationship between the number of access points and either the use-rate or maximum bat counts. The majority of roosts in use in that study involved bats using a single access point. Conversely, Packman *et al.* (2016), found that Natterer's bats used many existing exit points from churches, and sometimes used different points to re-enter (C. Packman, pers. comm.). Assuming thermal conditions are maintained, offering additional access points may improve the likelihood of one being used.
Access points should be sheltered	Siting an access point adjacent to a corner or overhang may increase its effectiveness (Collins *et al.*, 2020).
Some species appear to require larger sheltered/covered areas for 'light-sampling' or socialising, during which they fly in and out of roost entrances before finally emerging.	The purpose of this behaviour is not confirmed (and sometimes vigorously disputed) but providing a large roof void or a covered area to facilitate this behaviour can lead to earlier emergence times[54]. A large roof void or covered area facilitates certain social behaviours such as information exchange, and assists egress for large numbers of bats (avoiding bottlenecks).
Access points should be close to cover.	A short distance to cover may increase the attractiveness of an access point (Mackintosh, 2016). See also Davidson-Watts (2007) for common/soprano pipistrelles.
Other considerations	New access points should not compromise the thermal regime of the roost by causing draughts (see below), let in light, nor allow access to birds[55] or predators. Access points should not be located above domestic windows and doors to avoid issues with droppings, and light-spill onto roost entrances.

54. https://www.vwt.org.uk/wp-content/uploads/2015/04/morris-c-effect-of-grilles-at-bryanston-bat-roost.pdf
55. See ROOST website for an example of this which includes a 'daylight tunnel': https://www.bats.org.uk/our-work/buildings-planning-and-development/roost-replacement-and-enhancement/case studies/llwyn-celyn-abergavenny-2

Box 6.4: Colin Morris tip-shelf (with permission)

A video showing operation of the tip-shelf is available on the UK Bat Workers Facebook group (posted November 2021).

This can be scaled up to suit greater horseshoe bats. Brick or stone walls will require a suitable matrix to allow the shelf to be fixed into place.

When a predator attempts to gain access, the shelf tips to close the access and prevent entry. This one has been created for a typical lesser horseshoe site, with an entrance of 300 x 200 mm. The shelf is a flat piece of shaped aluminium (or stainless steel) which, when fitted centrally with a hinge and weight-biased toward the rear (inside), will harmlessly tip off a cat or other predator should it try to get in, and temporarily stops the bats coming out; once the cat has been shed, the shelf returns to the horizontal.

This version includes a letter-box hole cut into it (the first one was solid). That means that, if the shelf is jammed shut for whatever reason (including lack of maintenance or vandalism), bats would still have access. Use graphite powder as a lubricant for the hinges, not oil or WD40.

Cutting out the letter-box may make the rear part of the shelf too light to operate correctly; if so, rivet the cut-out section to the rear underside the shelf, bringing it back up to the original weight.

6.3.14. The key principle is that new roosts should be as accessible to bats as possible, whilst avoiding the detrimental impacts of artificial lighting, draughts, weather incursion and predators. Access point dimensions can be reduced/adjusted over time if necessary.

Roost access point size

6.3.15. **Access points for crevice-dwelling bats** can be as small as 15-20 mm high x 20-50 mm wide (Williams, 2010), and can be as simple (and low cost) as creating a gap between a soffit and the wall. D. Vaughan (pers. comm.) recommends in excess of 50 mm as smaller access points can become colonised by spiders' webs, which then become blocked by accumulating small debris. There are also numerous adapted bricks and tiles available, or gaps can simply be left in masonry, under raised lead flashing, or over the top of a cavity wall. Lead used to create bat access tiles should be at least Grade 6 to prevent the entrance dropping closed, and the lead entranceway should be roughened or removed (so that the roof tile surface is the entrance), to allow bats' enough grip to crawl in.

6.3.16. **Access gaps** can be created under ridge tiles by leaving out mortar (particularly at the end of the ridge) and removing ventilation structures within them, or using access tiles. The roofing felt can be cut to allow access into the roof void. A slightly different approach is required for access into dry ridge systems.

Check out APPENDIX 4 for case studies illustrating access points in various locations:

- *Case study 12: Modern roofing systems;*
- *Case study 13: Creating a roost behind a fascia board;*
- *Case study 14: Bat access slate (Option 1);*
- *Case study 15: DIY construction of the 'Morris' Bat-slate (Option 2); Case study 16: More access options;*
- *Case study 17: Re-roofing Hugh Sexey C of E Middle School, Somerset.*

6.3.17. **Larger access points are required for horseshoe bats,** which fly into their roosts rather than crawl[56]. *The Bat Workers' Manual* (Mitchell-Jones & McLeish, 2004) suggested 400 x 300 mm for greater horseshoe bats and 300 x 200 mm for lesser horseshoe bats; the *Bat Mitigation Guidelines* (Mitchell-Jones, 2004) did not differentiate, and stated 600 mm wide and 300-400 mm high. *The Lesser Horseshoe Bat Handbook* (Schofield, 2008) recommends an overall area of 2,500 cm^2, as long as the height exceeds 200 mm (the width can be reduced for small numbers of bats). Others have noted that greater horseshoe bats can have a negative impact when a roost is shared[57], so smaller entrances may be appropriate for roosts designed for lesser horseshoe bats (unless the colony is large).

Check out APPENDIX 4 for a further case study illustrating access points at the eaves:

- *Case study 18: Eaves access for lesser horseshoe bats.*

Thermal regimes; maternity

Box 6.5: Lesser horseshoe bat access point

Shielded letter-box access to lesser horseshoe bat basement hibernaculum, in place now for over 15 years. The cover prevents draughts and access by birds.

The access point is quite low but, before the new door and access point were fitted, the bats gained access through a 5 cm gap at floor level.

Photo: Paola Reason (2018)

6.3.18. A study of summer roosts in central Germany (Simon *et al*., 2004)[50] demonstrated that most maternity colonies showed a preference for warmer aspects; where bats were found on cooler aspects, these tended to be non-breeding individuals. That study recommended that, when creating a maternity roost, this should have a southerly or westerly aspect[47]. They also noted that some species (e.g. whiskered bats, which avoid northerly aspects) are more conservative than others (e.g. pipistrelle species) [47]. However, climate change means that it is difficult to be prescriptive over aspect. Thus, when creating a roost structure to support a bat maternity colony, provision of areas reaching optimum temperatures should be a key consideration, taking into account likely solar gain.

6.3.19. Species-specific roost temperature ranges were collated by Shepherd and Stroud (2010) and in the study cited above. Optimum temperatures are difficult to discern from the available research; some studies provide a range (which can be as wide as 30°C, and therefore not all optimal); some a mean; some both. There are

56. Although lesser horseshoe bats clearly prefer fly-in access, they are able to negotiate obstacles (to the extent that they can fly through harp-traps). There is also anecdotal evidence that they can occasionally land and crawl into roosts. The lack of an obvious fly-in access and/or a complex route beyond the access point does not mean a structure will not be used by this species (see Reason, 2017), but there is insufficient evidence to indicate a preference for such complexity.

57. VWT are currently investigating this phenomenon; visit their site to contribute to their research: https://www.vwt.org.uk/projects-all/greater-and-lesser-horseshoe-bat-interaction

likely to be species-specific preferences and tolerances between species (as there are for hibernation, see **Section 6.8**). Those differences are likely to apply to the maximum and minimum temperatures that a colony will tolerate, but also to the degree of stability (buffering from outside variations) and the degree to which individuals can control this by moving closer together (clustering) or further apart, or using different areas of a structure. Where temperatures rise or fall too far, some may respond by moving roost; D. Wells (pers. comm.) reports a large soprano pipistrelle maternity colony that roosts in a north-facing wall only in July and early August, presumably when their other summer roosts are uncomfortably hot. P. Waring (pers. obs.) notes that cooler roosting areas are used throughout the year by brown long-eared bats, pipistrelles and lesser horseshoe bats (including use for mating). To add complexity, the relative importance of temperature compared to other factors (relating to the roost and/or its external environment) may also vary between species.

6.3.20. It would seem reasonable, certainly for larger/breeding colonies, to provide a range of microclimates (Kayikcioglu & Zahn, 2004; Reason, 2017; Schofield, 2008; Simon, Hüttenbügel & Smit-Viergutz, 2004) (*inter alia*) with **at least one area reaching at least 25° C** that offers some buffering from the variations in external temperature. To achieve this:

- larger access points should not be installed too high in a roof void as they will lose warmth as heat rises (poorly designed dormer-style access points can have a similar effect);
- draughts should be avoided (missing soffits and open eaves can mean that the roost space never becomes warm enough to maintain a colony).

6.3.21. According to Simon *et al.* (2004), the temperature in the roost should not exceed 35° C. More than one study has demonstrated that bats can overheat, both in artificial roosts[43] and in bat boxes (Flaquer *et al.,* 2014). Schofield (2008) provides a design for a 'cool tower' for horseshoe bats[58], where bats can go into torpor, functioning as a transitional roost space in spring and autumn and in periods of poor weather, or for respite if the roost becomes too hot.

6.3.22. It is preferable to design the roost to provide a warm thermal regime, rather than providing artificial heat sources (heater or radiator). This can be achieved through:

- passive heating via insolation from the sun;
- creating a 'hot box' which traps warm air (designs available for this in Schofield (2008)). A low-cost option for this is also shown in **APPENDIX 4** (Case study 19).

6.3.23. Artificial heat sources have a number of drawbacks and limitations, which include:

- ongoing costs;
- the need for maintenance;
- equipment failure or a lack of long-term funding could adversely affect heating provision and cause roost abandonment; and
- fire risk.

6.3.24. Normally, the only circumstances where heating should be considered are:

- roost locations where the roost is surrounded by trees (Schofield, 2008);
- locations where an existing colony has adapted to heat from boilers or pipework which has been decommissioned (see, for example, Reason, 2017);

58. Detailed instructions also found here/; https://www.vwt.org.uk/wp-content/uploads/2017/02/The-Lesser-Horseshoe-Cool-Tower.pdf

- where the only option for maternity roost provision is on a northern elevation (see Case study 23 in **APPENDIX 4**);
- situations where the risks from heating can be controlled (through formal agreements to secure long-term funding, oversight and monitoring), or reduced (fire detection equipment).

6.3.25. The benefits/uses of artificial heating:

- Prior to the installation of heated roost incubators at Woodchester Mansion from 1994, the sex ratio of the greater horseshoe bat babies born there was biased towards male babies. After installation, this bias was towards female babies, resulting in faster colony growth (R. Ransome, pers. comm.).
- Heated mats have been used in the Bats in Churches project in England (see **6.3.69** and Case study 23 in **APPENDIX 4**) to encourage bats to move into a cooler restricted roost location to reduce church-wide distributions of droppings whilst retaining the colony.
- Heating has been used to encourage bats from an unsuitable location to a more suitable but temporary location, and then to a permanent location on a long-running project in Portugal[43].
- Heating elements may be used throughout winter. See 6.3.69 and Case study 23 in **APPENDIX 4**), where soprano pipistrelles use a heated box within the church year-round; horseshoe bats use incubators year-round at Woodchester Mansion (N. Downs, pers. comm.) and Coombe Down (F. Mathews, pers. comm.). See also **Box 6.6** for selection of a warm winter roost.
- In northern latitudes, reliance on natural heat sources is likely to be inadequate for maternity roosts, and a thermostatically controlled artificial heat source is more likely to be required (R. Raynor, pers. comm.).

Box 6.6: Lesser horseshoe bat in a warm winter roost

Lesser horseshoe bat half-tucked into a crevice in a warm boiler room at 16-17 °C. .This was one of c.15 lesser horseshoe bats, and none were torpid, on 16 February 2023. External temperatures 11°C.

Photo: Glyn Lloyd-Jones.

6.3.26. Note that the effect of solar panels on a roof in terms of ecological functionality and bats are unknown. However, there is a risk that, as they absorb energy from the sun, the roof void beneath could be subject to a reduced upper temperature limit and overall temperature range. Where possible, and on a precautionary basis, the upper courses of tiles could be left uncovered, or the panels split, to maintain solar gain.

Box 6.7: Splitting solar panels to maintain solar gain.

D. Vaughan (pers. comm.) used this strategy on a south-facing roof which supported a maternity colony of common pipistrelle bats. The bats were entering at the eaves and crawling up either the roof-lining or the vaulted ceiling plaster board, and roosting anywhere from half way up to close to the apex (they could be heard crawling around). The owner still reports significant bat activity in in the south elevation of the roof and now also the other new extension roof areas that were built at the same time.

Photo, Den Vaughan

6.3.27. In all circumstances where a roof void is retained, enhanced or created with the aim of providing a roost space for bats, a range of microclimates should be included within that void. Modern methods of insulation all serve to reduce roof void temperatures; insulation may be deep floor (e.g. wool), preventing heat rising into lofts; affixed to the tiles (e.g. Celotex), preventing thermal gain; or within cavity walls (preventing access). Conversely, climate change makes extreme weather events more likely (Sherwin, Montgomery & Lundy, 2013), bringing a risk of over-heating[59]. A check, using temperature loggers, should be made that at least one (and preferably more) areas are within the broad temperature preferences of the species concerned (as far as these are known).

Check out APPENDIX 4 for case studies showing enhanced microclimate provision:

- *Case study 19: Providing additional microclimates for horseshoe bats; Case study 20: Modification of pedestrian subway to create lesser horseshoe bat roost.*

6.3.28. Collins, *et al.* (2020) found the number of small internal cavity types inside lofts showed a highly significant positive relationship with bat counts. Internal crevices can extend the range of microclimates available. Crevices on the cooler aspects of buildings could also be provided for use by male and non-breeding female bats throughout the year.

59. While such events may be rarer in the UK than in southern Europe, there have been cases of bats coming into the living-spaces of houses (Bat HelpLine, pers comm.) in periods of unusually hot weather. In 2022, the BBC also reported the loss of juvenile grey long-eared bats (https://www.bbc.co.uk/news/world-europe-jersey-63730706) in two maternity roosts on Jersey, speculating that extreme heat before they could fly had caused 'a significant mortality event'.

Check out APPENDIX 4 for case studies showing the provision of additional crevices:

- *Case study 21: Triple ridge system roosting opportunity.*

Perching opportunities within a roof void

- Rough timbers such as battens or Oriented Strand Boards (OSB), fastened close to the roof apex (placed carefully to avoid reducing or blocking solar heat gain), are a simple means of providing something for bats to hang from or roost against.
- Natural materials should be used in preference to synthetics (that said, chicken-wire is frequently used by horseshoe bats and is long-lasting). A semi-rigid plastic mesh with a 2 mm x 2 mm diamond hole size (insect mesh) can be suitable but should be tightly applied to the surface (A. Glover, pers. comm.). Wide-gauge mesh can trap some species, so should be avoided.
- Timber cladding mounted on 20-30 mm counter battens with bat access at the bottom or sides can provide cost-effective crevices. Although Collins *et al.* (2020) found internal boarding and panels to be almost the least used feature within a roost, evidence of use may underestimate actual use; they did find a relationship between the number of bats (all species) and the number of small internal cavities provided. Lintott & Mathews (2018) similarly found that such roost enhancements (rough sawn timber crevices etc) significantly increased the probability of pipistrelle bats returning to the roost (insufficient data were available to permit analysis of use).
- Pipistrelle bats have been found using the gap under boarding used to protect windows from vandalism in neglected buildings, even in winter (P. Reason, own observations; and see **Box 6.8)**. This provides a space similar to the above roost enhancements, indicating they have some value.
- The low cost and ease of installation of these features means that it is worth considering them.

Box 6.8: Confirmed roost behind window boarding on a dilapidated shed.

Photos: RSK Biocensus

Roofing membranes

6.3.29. A wide range of roofing membranes are now available; many pose a danger to bats. The underfelt to be used in bat roosts therefore needs to be carefully specified. Until recently, the position was that was that only bituminous roofing felt that did not contain non-woven spunbonded polypropylene filaments (i.e. only bitumen 1F) could be licensed in bat roosts. Prior to August 2022, no non-bitumen coated roofing membranes (NBCRMs; formerly referred to as breathable roofing membranes; BRMs) were considered safe to use in bat roosts. However, following extensive testing, that position has now changed for those membranes which have passed a 'snagging propensity test', at least in England and Scotland (at the time of writing). If using such a NBCRM, the certificate that proves the roofing membrane selected has passed a 'snagging propensity test' must be included with the licence application. Note that a certificate will not automatically guarantee that a licence application will be accepted, as every case is different.

6.3.30. BCT maintain a regularly updated online news feed on NBCRMs[60], which should be consulted (rather than relying on a manufacturer's claims). There are links to the various SNCB's position statements from that site.

6.3.31. Where an untested/uncertified NBCRM is already installed and re-roofing is not an option, it may be necessary to prevent bats coming into contact with it[61]. Such an intervention should only be used as a last resort, and not as a method to make NBCRMs acceptable in a bat roost (in any case, it does not protect bats roosting above the membrane). Importantly, installing a cover over the NBCRM could impact on the breathability of the NBCRM, creating later problems with condensation and therefore creating a liability for maintenance works.

Box 6.9: Damaged breathable membrane in a roof void supporting brown long-eared bat roost (35-36 individuals). The fluffed-up fibres can be lethal to bats (though no dead bats have been found here). The roof will be replaced and lined with bitumen in 2023.

Photos Jana Prapotnikova.

60. https://www.bats.org.uk/our-work/buildings-planning-and-development/non-bitumen-coated-roofing-membranes

61. A example of this, and the potential pitfalls, is included here: https://www.bats.org.uk/our-work/buildings-planning-and-development/roost-replacement-and-enhancement/case studies/retrospective-measures-to-prevent-death-and-injury-to-bats-from-non-bitumen-coated-roofing-membranes

Re-use of timber; seeding with droppings from existing roost

6.3.32. As noted in the EUROBATS review[43], new roost provisions may take many years to be adopted. The inclusion of old timbers and/or droppings may help with this, and olfactory cues (odours) seem to be importanat (**6.3.69**).

- Dedicated roost provision for brown long-eared bats (and other species), provided in compensation for a demolished old farmhouse, re-used timber materials, including rafters, the ridge beam, tie beam, purlins and battens. The original fibre insulation and associated droppings were rolled up and installed in the new roost, and the roof was mostly covered using tiles from the demolished farm buildings. The maternity colony re-established itself in the new bat house (Garland, Wells & Markham, 2017).
- The contribution of the re-used materials to success in the above example is unproven, but in many circumstances, their low cost means that it is worthwhile including them.
- If re-using timbers, this should be stated so that this measure can be tested; currently, there are insufficient cases where this has been done to be able to examine success.
- Droppings should only be transferred from the colony for which the compensation is designed, to avoid the risk of transferring zoonoses between colonies.
- If seeding with old droppings, they should be placed where they are unlikely to obscure evidence of new droppings (e.g. not under the ridge beam if that is where bats are most likely to roost). Alternatively, old substrates can be partly or wholly covered, or old droppings ground up, so that the evidence is retained without obscuring new deposits (an important approach when undertaking monitoring).

Timber-treatment

- Only approved products/application methods should be used for remedial timber treatment and pest control[62] (this should also be checked for new treated timbers).

Fire doors

6.3.33. Fire regulations require that larger roof voids are separated into sections with fireproof walls to prevent the spread of fire through the roof void. Such walls will prevent bats accessing all sections of a roof so, where required, they need to take bats into account. Access can be provided using a bat door, bat flap or bat shutter, set to automatically close in the event of a fire and preserve the separation of the roof sections. The aperture should be at least 150 mm high and 400 mm wide if larger bats use the roof void, but can be narrower (300 mm) if only smaller bats use the site.

- Bat doors: spring-loaded fire-proof doors set in a frame and held open by an electromagnet (as commonly used on fire doors in public buildings). When the fire alarms are activated, power is cut to the magnet and the door closes. The door provides human access so that maintenance work may be carried out in different voids without the need for ceiling access hatches into each void.
- Bat flaps: fireproof flaps, hinged at the top, which fall down into the aperture when activated by a fire alarm or heat. The release mechanism can be an electromagnet or a fusible link. A fusible link has the advantages of functioning only when there is an actual fire (so there is no need to re-set after fire-alarm tests or power cuts) and being maintenance-free. However, it is also impossible to test and will only operate when the fire has taken hold and the temperature has risen considerably.
- Bat shutters: steel concertina shutters which fall under gravity to close a small aperture when released.

6.3.34. The main disadvantage with the electro-magnetic link is the need for the doors to be re-set if there is a fire

62. https://www.gov.uk/guidance/bat-roosts-use-of-chemical-pest-control-products-and-timber-treatments-in-or-near-them. Note that much of this information is based on fairly old research, and there is a growing interest in eco-toxicology and bats, including pesticide risk assessments; further information may be available for the next version of these guidelines.

alarm or power-cut (including a test), which relies on human intervention. If there is no warning sign to alert staff that a door has been closed, or the doors are hard to access, there is a high likelihood they will remain closed, or at least not be re-opened promptly. A fail-safe is to ensure each section of the roof has its own access point, which will prevent bats being trapped whilst the doors remain closed (R. Crompton, pers. comm.).

6.3.35. A fusible link only closes the doors in an actual fire, but may function a little late i.e. once the fire has taken hold sufficiently for temperatures to have risen. There are several examples demonstrating how a fusible-link system has been implemented on BCT's ROOST web-site[63]. A commercial bat hatch with door is also available[64].

6.3.36. Another option is an intumescent collar, made of a substance that swells as a result of heat exposure (the substance increases in volume whilst decreasing in density). Again, this would only close the doors in an actual fire, which may be too late, but they were accepted by Building Control in a castle in Wales (R. Crompton, pers. comm.).

6.3.37. It is important that any system proposed is appropriate for the type/level of building use and checked against the fire regulations in force at the time and buildings insurance conditions.

External environment

- Existing flight-lines should be retained and, if necessary, enhanced.
- Roost entrances and commuting routes should not be subject to artificial lighting above ground level. No new sources of lighting should be introduced or, if essential, should be the minimum necessary (in terms of light-levels and duration etc).
- Existing lighting should be reviewed; it may be possible to modify its type, location, and timing and reduce any impacts this causes (enhancement).

6.3.38. Where roosts cannot be retained and it is not possible to incorporate roost space within a new development, free-standing bat lofts are often provided. They structurally resemble a typical building and incorporate features as set out in the previous sections. The cost may be reduced or made more palatable by incorporating a dual function to the construction, such as a car-port or shed.

6.3.39. Additional criteria for stand-alone (new) bat buildings are as follows:

Location and connectivity; external environment

- The replacement roost should normally be situated as close as possible to the roost to be lost.
- The location should be chosen to maximise the chances of the bats finding and adopting it. Ideally, it should be close to existing flight-lines and have an entrance close to appropriate habitat.
- Internal and artificial external lighting close to the new roost should be avoided.
- Good quality foraging habitat including a source of permanent fresh water such as a stream, pond, river or lake is likely to increase adoption. As noted above (Davidson-Watts, 2007), for common and soprano pipistrelles at least, location is probably more important than structure.

63. https://www.bats.org.uk/our-work/buildings-planning-and-development/roost-replacement-and-enhancement/case studies/maintenance-of-bat-access-in-roof-voids-after-fire-door-installations-1

64. https://envirograf.com/product/animal-door-flap/

Orientation and construction materials

- Passive heating generally requires a broadly south-facing, fairly steep roof pitch that isn't shaded by other buildings or trees. Dark-coloured roof coverings, such as black slates, will help to produce higher temperatures. Natural slate has much better thermal properties than artificial slate, which does not heat up from insolation and also loses heat through radiation as well (R. Green, pers. comm.).
- A building structure with different roof aspects will give more opportunities for different internal and external microclimates.
- Temperatures should be monitored to ensure they achieve appropriate thermal regimes given that the building will (in most cases) not be heated for human use but also (conversely) may experience extended periods of unusually high heat in summer due to climate change.
- Some species (notably horseshoe bats (Schofield, 2008)) avoid concrete; for these, building (or rebuilding) with brick or stone is preferable. If it is necessary to build in block-work, internal walls should be rendered. However, this is not true of all species; bats will roost behind wall panels set against cinder-block walls (P. Waring pers comm), and this material has been used to create cavities.
- New-builds can enable the provision of a range of environmental conditions, to benefit bats throughout the year; for example, a bespoke building may allow the construction of a cool room on the ground floor or basement (see Schofield (2008) for guidance on decreasing solar gain and increasing humidity).

Box 6.10: Using cinder blocks to create crevices

The building (here shown part-complete) is a purpose-built bat barn, to compensate for the loss of roosting features nearby. All examples of roost features have signs of use by bats, including sightings of actual bats using them.
Photos: Pat Waring

Cavity wall comprising compressed cinder block inner wall with brick outer leaf. Walls deliberately left rough for additional perching/roosting and with deep wall cavities also.

No access to these same cavities was provided from the outside, to avoid draughts. A number of other external roosting features were provided, including accessible barge boards at gable ends, and lead slips within roof coverings.

Building has been monitored; it is used by brown long-eared bats throughout the year (<10 at any one time) and also a single adult barn owl.

Hopper providing sheltered fly-in access (see Schofield, 2008).

Sharing buildings with humans

6.3.40. Schofield (2008) suggests a number of measures to ensure bats and humans can share a resource without conflict:

- locate roost entrances away from windows and doors;
- ensure flight-lines direct bats away from areas of human activity
- include insulation to reduce noise from human activities (and vice versa)
- allow out-of-season access to remove droppings (R. Raynor, pers. comm.)

6.3.41. It is occasionally appropriate (where high-value roosts are concerned) to install restrictions or place covenants to deter certain activities or modifications (for example, restricting the size of loft-hatches to discourage human entry; preventing the installation of lighting or roof-lights; and so on). Such restrictions should be used lightly, as people cannot be forced to share their properties with bats and are more likely to react negatively if undue restrictions are imposed.

Protection against vandalism

- Any structure designed for use by bats should be made as resistant to damage by vandalism as possible. Doors can be reinforced and sited some way above ground level to make it difficult to damage them; rainwater goods can be carried internally; flammable materials that can be reached from ground level should be avoided.
- Planting thorny shrubs around the building may help to discourage trespass by making access difficult (these need to be maintained to ensure they don't block access points).
- Creating a water body immediately outside the (human) entrance can also act as a deterrent, if deep enough to require waders to access the roost (see **Box 6.11**).
- In high-risk situations, a 'cage' can be constructed around the entrance point (see **Box 6.11**).

Box 6.11: Protecting access points.

Here, the window is also fitted with heavy-duty rebar (steel reinforcement bars), making it harder for vandals to prise these apart.

Photos: Richard Green

Creating a cage outside the access point. Photos: Pat Waring

Long-term security and management

- Arrangements must be in place for securing the long-term integrity, security and management of the replacement roost. This may require s.106 planning agreements[65] (or equivalent) or the transfer of ownership of the building to a suitable organisation (see **Section 5.4** and **APPENDIX 3**). Those agreements should consider restrictive covenants to control/prevent the later erection of external lighting and the maintenance of flight-lines.
- Planting will need to be managed so access points are not blocked, using suitable species. Mitchell-Jones (2004) recommends coppiced species which can take regular management to avoid them growing above the building apex. This will also help to avoid unwanted shade (and therefore cooling) of the building roof and walls.
- For important/significant roosts, remote monitoring systems could be considered.

Other design guidance

6.3.42. Design guidance (some more than ten years old, but still useful), on which some of the above is based, has been published as follows:

- *Lesser Horseshoe Bat Conservation Handbook* (Schofield, 2008): a comprehensive and practical guide to creating and enhancing roosts for lesser horseshoe bats, much of it also applicable to greater horseshoe bats.
- *Conserving Grey Long-Eared Bats in our Landscape: a management plan* (Razgour *et al.*, 2013) which includes recommendations for roosts as well as habitat management.

65. S.106 agreements in England and Wales (based on that section of The 1990 Town & Country Planning Act; s.75 in Scotland; s.76 in Northern Ireland) are legal agreements between a planning authority and a developer/landowner, that ensure that certain extra works related to a development are undertaken.

- *Biodiversity for Low and Zero Carbon Buildings: A Technical Guide for New Build (*Williams, 2010): includes advice, off-the-shelf product descriptions and architectural drawings to incorporate bats into new buildings whilst complying with carbon standards.
- *Bats in Traditional Buildings* (Howard & Richardson, 2009): contained advice and techniques for those involved in building maintenance, adaptation or repairs, or owning/managing traditional buildings. This publication has now been updated by Historic England and adapted to webpages that can be accessed via the Historic England web-site[66], but these appear to be less detailed than the earlier version.

6.3.43. The following are guides published in Europe (noting that species may behave differently to the way they do in the UK).

- *Bat roosts in the Alpine Area: guidelines for the renovation of buildings* (Reiter & Zahn, 2006) describes the roosting ecology of a range of species, and collates knowledge and experience relating to the renovation of buildings.
- *Ecology and conservation of bats in villages and towns* (Simon, Hüttenbügel & Smit-Viergutz, 2004). Results of the scientific part of the testing and development project 'Creating a network of roost sites for bat species inhabiting human settlement'. This is a very comprehensive study which expended over 13,000 hours in identifying bat roosts over a single large district, identifying over 500 summer roosts and ringing over 20,000 individual bats (1997-2001), with recommendations based on those findings.
- *Recueil d'expériences des aménagements pour une meilleure cohabitation Chiroptères – Homme en milieu bâti. Tome 2*. (Arthur & Chretien, 2019). A collection of projects to ameliorate conflicts between people and bats, with detailed photographs and plans. French language publication.

Bat boxes as compensation for roost loss from buildings

6.3.44. Bat boxes can form an important part of a mitigation, compensation and enhancement approach package, but there are limited circumstances in which they are acceptable as the entire solution. That said, it is important, particularly for small domestic/residential improvements, to strike a balance between the needs of bats and the needs of people who share their properties with bats. Where small roosts of low conservation status are present (e.g. day roosts of common species) in properties where living space is limited, bat boxes are often the most appropriate and reasonable solution.

6.3.45. Conservation Evidence provide a synthesis of over 40 studies of bat box schemes[67], looking specifically at uptake, use and design and location (though most are not from the UK, and include non-UK species). Some of the reported results were encouraging, others contradictory. However, the studies are a mixture of mitigation and enhancements, and cover a wide range of circumstances, not just replacements for building roosts. Some of the contradictions may result from a poor choice of model(s), poor siting/surrounding environments, or competition with other animals, notably birds. In other cases, bats may already have alternative roosts to go to (Stone *et al.*, 2015a), which they use in preference to artificial roosts, or indeed, the bat boxes may have been provided as enhancements rather than primary mitigation that was used in preference. Overall, the review rated 'effectiveness' of bat boxes as a tool to be 30% (highly effective would be 100% – see Conservation Evidence website for details).

6.3.46. Lintott and Mathews (2018) found that providing a bat loft as mitigation was usually more effective than using bat boxes to provide compensation for bats. Collins *et al.* (2020) found similar results, with 33% of bat lofts occupied compared to 20% of all bat boxes combined.

66. https://historicengland.org.uk/advice/technical-advice/buildings/building-works-and-bats/
67. https://www.conservationevidence.com/intervention/view/1024#

6.3.47. These findings support the general consensus that bat boxes are inappropriate substitutes for significant roosts in buildings and do not constitute the 'like-for-like replacement' that the SNCBs require to maintain FCS. Bat boxes are also often neglected after a short period of time, can be removed or deteriorate, and are more vulnerable to vandalism.

6.3.48. Bat boxes are made by a number of manufacturers, and come in a wide variety of shapes, sizes and materials. They can be built-in, attached to a wall or tree, or free-standing. Collins *et al.* (2020) found that wall-mounted bat boxes were more successful (36% occupied) than tree-mounted, wall integrated and internally mounted bat boxes (17%, 15% and 13% occupied respectively). However, which type of box should be selected will depend on the target species, where it will be sited, whether there are any maintenance considerations, whether the box needs to be accessible for monitoring checks and so on. One of the benefits of inbuilt/integrated designs is that they cannot be removed or easily vandalised (though their entrances could be blocked). They can also be added to architectural drawings to give a greater likelihood of being fitted in an appropriate position.

6.3.49. Figure **6.2** provides a list of design parameters set out by BCT as part of their partnership with manufacturers[68]. A further consideration is the quality of manufacture and the robustness of materials, especially for those parts that have a tendency to fail over time (doors, hinges and clips in particular).

6.3.50. For species-specific preferences for individual box types, refer to Conservation Evidence for the latest research available[69]. Note that all of the studies necessarily focus on a small selection of box types and species in specific situations, so their findings need to be interpreted with that caveat.

6.3.51. Competition with birds is cited by a number of studies, including Collins *et al.* (2020). Meddings *et al.* (2011) suggested that erecting bird boxes may help divert nesting activity away from bat boxes, but that was not supported by Dodds and Bilston (2013). Choosing models which do not encourage access by birds is therefore more likely to improve effectiveness. Collins *et al.* (2020) found no evidence of birds in bat box designs where the access point apertures were ≤17 mm; box models with the highest bird presence featured access apertures at least 25 mm wide. It's possible that smaller access points may deter larger bats (C. Packman, pers. comm.).

6.3.52. Lintott and Mathews (2018) found that increasing the number of boxes increased the probability of at least one being used. Although they state that, even when a large number of bat boxes was deployed (i.e. >20 boxes), the occupancy rate remained relatively low (fewer than 50% of boxes were used), the study was looking at compensation for building roost loss; higher rates may be expected where replacing roosts in trees. Occupancy overall is likely to vary over time and in response to different environmental conditions, and may increase over time.

68. https://www.bats.org.uk/our-work/buildings-planning-and-development/roost-replacement-and-enhancement/partnerships

69. https://www.conservationevidence.com/intervention/view/1024. For example, Dodds and Bilstone (2013) found Natterer's, brown long-eared and Daubenton's bats preferentially selected boxes in shaded, stable, non-intervention woodland with closed canopy above and lapsed coppice underneath. They also assessed preferences for different box models. There is a growing number of such studies focusing on different sub-sets of parameters including species and box types, and space precludes including all their results in these guidelines.

Figure 6.2: Design principles for bat boxes and access products (BCT)

- Crevice dwelling bats crawl into their roosts: the entrance slit should be at least 20 mm (w) and ideally 13 – 17 mm (h), maximum 25 mm (h), to prevent bird access.
- Roughened vertical surfaces or landing areas allow better access for bats (by landing and crawling); horizontal landing perches should be avoided as these may even deter bats and can encourage birds to nest within the bat box.
- A vertical opening at the base of the box aids the expulsion of droppings, making the box self-cleaning and preventing a horizontal area being used by birds for nesting.
- Materials used should be non-toxic and present no risk of entanglement for bats.

In addition, for wooden* bat boxes:

- The wood should be rough-sawn for grip and untreated.
- There should be no gaps where the sides and top join – the box should be well put together to prevent draughts.
- A box that cannot be opened is best – it will lessen the chances of the bats being harmed by becoming trapped under the opened lid, or disturbed by non-licensed people opening the box. Monitoring can be done from beneath with a torch or by endoscope by a suitably experienced licensed person, without the need to open the box.
- To increase the box's longevity, use screws rather than nails.
- Any screws, hardware or staples used must be exterior grade (galvanized, coated, stainless, etc).

**wooden boxes are not recommended where there will be no after-care.*

6.3.53. Siting boxes requires the same considerations as any other roost compensation; i.e. boxes should be erected in a sheltered location, in close proximity or with a strong unlit linear connection to good quality foraging habitat. A source of permanent fresh water such as a stream, pond, river or lake is likely to increase adoption.

6.3.54. For all types of boxes, Collins *et al.* (2020) found that the box height most frequently occupied was 4m. A height of at least 3 m is desirable to avoid interference, but the higher the box, the more difficult the access to clean/maintain and monitor.

6.3.55. Boxes integrated into buildings offer much greater longevity but need to be considered in the design process. One study found that incorporating bat boxes into walls could cause cold spots on the interior, leading to condensation and possibly mould. Insulation is normally installed behind the box to prevent this; input from an architect may be advisable.

6.3.56. Boxes erected on trees need to be fixed to allow for tree growth and to avoid damage to the tree supporting them, and should be sited away from public footpaths in case they fall (this will also minimise disturbance and interference).

6.3.57. Providing a range of boxes of different sizes, types and/or materials (including multi-chambered options) and in different locations/aspects (particularly in terms of the amount of exposure to sun and shade) is likely to be increasingly important in the face of climate change. As noted above, over-heating in boxes has been reported; see also 'the Goldilocks approach' – providing multiple options so one is always 'just right'[70]. This applies to boxes of all types, not just tree-mounted boxes.

70. The Revelator https://therevelator.org/bat-houses/

6.3.58. When boxes are erected, they should be numbered and a detailed plan should be made of each box's location, together with details of its height, aspect and type.

6.3.59. All boxes (unless on private land) should be monitored, and detailed records kept against each box number. The monitoring, including responsibilities for repair and replacement, should be set out in a formal agreement between relevant parties. Where possible, a partner, such as a local bat group or wildlife trust, should be secured (with a budget) to maintain and monitor the boxes in the longer term (not all such groups have the resources to assist).

Non-traditional 'boxes'

6.3.60. In the USA, large crevice-type bat-boxes or 'bat houses' are successfully used by certain species as maternity roosts[71].

- Collins *et al.* (2020) noted that a bespoke timber, unheated, 'American-style' model supported an average of 48 bats/box, and was the only type to feature > 6 bats at any one time in their review (though this is not representative of bat box use generally). This model provided a large surface area-to-volume ratio and wide range of internal microclimates, and was installed following the exclusion of a soprano pipistrelle maternity colony directly behind one of the boxes.
- Richard Green Ecology describes two successful so-called 'American' style bat houses[72] close to a site where a small number of soprano pipistrelles roosted. These were positioned adjacent to tree-lined rivers, in full sunlight and painted matt black, to maximise solar thermal gain. The mitigation was almost immediately successful, with bats recorded using both houses on the first monitoring visit. Subsequent visits also confirmed bats present in January when there was frost on the ground. Ten years later, piles of guano were found under the houses.

Check out APPENDIX 4 for a case study using this type of box:

- ***Case study 22: Replacement roost using an 'American style' bat box, selected on the basis of previous successes elsewhere in Ireland.***

6.3.61. Another design is the so-called 'rocket box[73], a tall, thin pole-mounted design successfully used in the USA (Hoeh *et al.*, 2018).

6.3.62. Vincent Wildlife Trust (VWT) have pioneered the Cathedine Night Roost[74], a design on wheels which could be moved into different positions (and, as a temporary structure, does not require planning consent). This is a useful solution where a low-status roost is lost, and two VWT trials have proved successful; both were adopted fairly rapidly (within a few weeks), and one has been used by up to 30 individuals (A. Glover, pers. comm.). In both cases, the locations chosen were based on existing knowledge that the woodlands were/were likely to be foraging areas for the colony. However, this should not be considered an adequate replacement for a permanent structure, because of their relatively short life-span.

6.3.63. Small structures based around concrete drainage rings, with an internal baffle and upper chamber, have been created in the Forest of Dean[75]. Radio-tracking data from an existing main roost site, habitat suitability assessments and future Forestry Plans were used to select locations which were considered likely to be the most useful to the bats and reduce the chance of substantial disturbance. Monitoring appears to show they

71. https://www.batcon.org/about-bats/bat-houses/
72. https://www.richardgreenecology.co.uk/successful-bat-mitigation/
73. https://www.batcon.org/files/RocketBoxPlans.pdf
74. https://www.vwt.org.uk/wp-content/uploads/2015/04/lesser-horseshoe-night-roost-design.pdf
75. https://www.bats.org.uk/our-work/buildings-planning-and-development/roost-replacement-and-enhancement/case studies/lesser-horseshoe-bat-night-roosts-forest-of-dean

have been regularly used, but more data are needed. These are substantial structures likely to have a long life-span, at relatively low cost.

6.3.64. Including novel boxes like these in a mitigation scheme will generate useful information about their wider value (or otherwise) as replacement roosts, but only if adequately monitored and the results reported.

6.3.65. Swift (2004) found heated bat boxes were the only type which came close to replicating conditions of roosts in buildings and therefore might be used by maternity colonies. They have been used with mixed results in review papers, as set out in Swift (2004), Mackintosh (2016) and Collins *et al.* (2020), though each study only examined five or six boxes. In these small samples, not all of the heaters could be confirmed as working, not all of the boxes were located in or adjacent to suitable commuting or foraging habitat, and some were affected by artifical lighting. These issues obscure the likely value of heated bat boxes if placed in optimal conditions, and more case studies are needed.

- ERAP described a larger heated roost (somewhere between a heated bat box and a small bat house) at Boot Station, Ravenglass and Eskdale Railway, Cumbria[76], successfully adopted by an excluded maternity colony of common pipistrelles.
- The Kingfishers Bridge nature reserve in Cambridgeshire provided a summer roost for bats in a sheltered spot attractive to flying insects[77]. This bat house has a solar radiator which heats water, which in turn heats bricks within the house to maintain consistently warm temperatures both day and night. However, it was little used until modifications were made (see **Box 6.12**). Even then, the bats preferred an existing building.

Box 6.12: The Kingfisher Nature Reserve solar heated bat box

The photo shows the box in its original position (photo credit: *Kingfishers Bridge Nature Reserve*). James Moss, the Reserves Manager, reports that it was relocated in 2015 from its site in the glade.

Minimal numbers were using the heated box, probably due to its low height from the ground and poor circulation of the heating water from the external panel to internal heat storage. Since relocating it to the south-facing rear of the estate shed, the temperatures have remained reliably high throughout the night and it supported 30-40 pipistrelles during the breeding season. This is determined using the internal camera to avoid disturbing the bats by opening the house.

In 2021, numbers decreased to about 15, as the colony seems to prefer the space behind the black ship-lap of the estate office.

Although there is no way of reliably recording the numbers which are using the estate office, activity can be easily heard along the whole 9 m section of wall.

76. Described in the Mitigation Forum proceedings available from this webpage: Bat Roost Mitigation Project - Bearing Witness for Wildlife - Bat Conservation Trust (bats.org.uk)
77. https://www.kingfishersbridge.org/bat-cave.html

6.3.66. As with roosts integrated into buildings, the use of heating in bat boxes is often not recommended due to unpredictability around management, the potential fire hazard, the cost of electricity, the risk to dependent bat roosts if heating fails and so on. However, there may be circumstances where the benefits outweigh the risks (or the risks can be adequately managed); refer to **6.3.24** for caveats and **6.3.25** for benefits/uses.

Bespoke bat-box designs within properties

6.3.67. Large colonies can be problematic for their human hosts, and one possible solution is to allow bats continued access to one or more of their roost sites, but restricting their access within a property. Early attempts have had mixed success according to a limited review (Bat Conservation Trust, 2006) which recommended:

- It must be possible to prevent access to any other part of the roof. All gaps of 6 mm or over[78] must be blocked, since it has been shown that bats can gain entry through any gap of this size. It is important, however, to ensure that measures taken do not conflict with the ventilation requirements of the roof.
- The temperature within the box should be at least that within the existing roost spaces; an additional source of heat may be required (again, see **6.3.24** for caveats and **6.3.25** for benefits/uses).
- The entrance should be designed to be similar to the existing one, and should be composed of suitable rough(ened) material.
- The box should be of a suitable size to accommodate the species and the number of bats roosting.
- The box should be constructed outside the season in which bats normally occupy the roost (i.e. usually during November to March).
- The box should be positioned within part of the roof already used for roosting.

6.3.68. In reviewing these recommendations in 2021, J. Haddow (pers. comm.) has added that supervision is important to ensure design details are closely followed (e.g. access points in the right place, a roughened surface for bats to land on, avoidance of direct illumination and so on). In addition, as indicated earlier in **Section 6.3,** heating such a box can lead to problems e.g. when properties change hands or management, and the heating unit is not switched on, or disconnected, either by intent or accident. The need for heating and its long-term security of supply, as in all circumstances, needs to be carefully reviewed.

6.3.69. The pilot study for the Bats in Churches project in England tested the concept by providing a large artificial roost for soprano pipistrelles built into the church interior, with the aim of reducing conflict between bats and church users. The maternity roost was successfully excluded from the church interior (despite being a very 'bat-porous' building), and retaining the original roost access meant bats quickly found their way into the artificial roost. As with many examples presented in this document, uptake was gradual; bats started to visit/investigate the artificial roost, then night-roosted, then small numbers day-roosted, and so on. This was only part of the mitigation strategy; nonetheless, the early signs were encouraging. Of interest is that olfactory cues appeared to be very important (infra-red cameras recorded many hours of footage of bats sniffing the roost entrance) – which perhaps gives an insight into how bats adopt new provision.

Check out APPENDIX 4 for more details of this project:

- *Case study 23: Conflict resolution: relocating a soprano pipistrelle maternity colony from a building's interior to artificial roosts.*

78. Note that this gap is very small. This text has been taken directly from the 2006 report referring to built-in bat boxes, and does not mean that every gap with at least one dimension exceeding 6 mm would need to be blocked to effect an exclusion in all situations.

6.4. Mitigating the impacts of bats in churches

6.4.1. Many medieval churches are used by bats, and occasionally there are conflicts between the desire to keep bats in a church and the needs of the congregation, or when repair work is required. The aim should always be to retain bats within a church (they are often reliant on what can be a limiting resource), but practical solutions are only now being developed and tested. Following a pilot project (Zeale *et al.*, 2014), the 'Bats in Churches' project[79] is currently studying issues and solutions in 100 churches across England.

6.4.2. Issues include droppings and urine, resulting in a substantial cleaning burden and bleaching and staining to the fabric of the building and historical artefacts. These can be particularly challenging where the bat colony is large and/or the congregation small. The use of deterrents and the provision of alternative or restricted artificial roosts are some of the solutions being tested.

6.4.3. As solutions are currently being tested and modified, this section of the Mitigation Guidelines will be completed during a subsequent revision. More information is available on the BCT website[80], including how and where to get help and advice, practical solutions to issues around bats in churches, and a limited number of case studies[81].

6.5. Mitigating tree roost loss

6.5.1. The different roosting habitat of bats and the difficulty of locating roosts in trees requires separate consideration from roosts in buildings. As tree-roosting bats move roost frequently, it is important to consider the entirety of the tree resource available to bats, and which could be impacted, rather than focus on individual trees (particularly for larger schemes). This approach should be taken into account during mitigation design, and when determining any management required (including tree-safety works).

6.5.2. The Bat Tree Habitat Key[82] describes species-specific roost requirements and is under continual review. The survey and assessment of trees is covered by Collins (2023). This material is not repeated here, but the process of mitigating tree-roost loss begins with adequate surveys and assessment. Adequate data will also be needed to underpin any licensing required to avoid an offence.

6.5.3. This section assumes that the necessary surveys have been undertaken, the value of the tree resource has been established, an impact assessment has been undertaken, and relevant consent(s) and licence(s) are in place for removing the trees that are to be felled. The aim of this section is to provide guidance on **mitigating the impacts of tree-felling,** both during the felling process itself and for roost loss.

Pre-construction tree inspections

6.5.4. Where trees are to be felled, a variety of inspection and survey techniques can be used to establish the likelihood of a roost being present in any potential roost feature (PRF) at the time of felling and, if so, what type of roost it is. **Figure 6.3** below shows the decision-making flowchart for felling a tree.

6.5.5. For simplicity, this flow-chart does not refer to licensing, though **felling a roost or obstructing access to a roost would require a licence.** For the same reason, the flow-chart does not include any reference to timing. The presence of bats is only one ecological constraint; the likelihood of nesting birds (particularly between March and mid-August) will also need to be taken into account when planning works.

79. https://batsinchurches.org.uk/
80. https://www.bats.org.uk/our-work/buildings-planning-and-development/bats-and-churches
81. https://www.bats.org.uk/our-work/buildings-planning-and-development/bats-and-churches/church-case-studies
82. http://battreehabitatkey.co.uk/

6.5.6. It also does not specify how many emergence or return surveys or repeat inspections are required, as this will be determined by the survey results. Night-vision aids (NVAs) such as infra-red or thermal cameras are **strongly** recommended in 2022 interim guidance[83].

6.5.7. For larger schemes where multiple trees are to be removed, using many different personnel, and potentially different sub-contractors, a consistent tree-marking scheme is strongly recommended. This will ensure that everyone inspecting and removing trees recognises what the markings mean, which will reduce the risk of misinterpretation and communication errors.

Check out APPENDIX 4 for case studies:

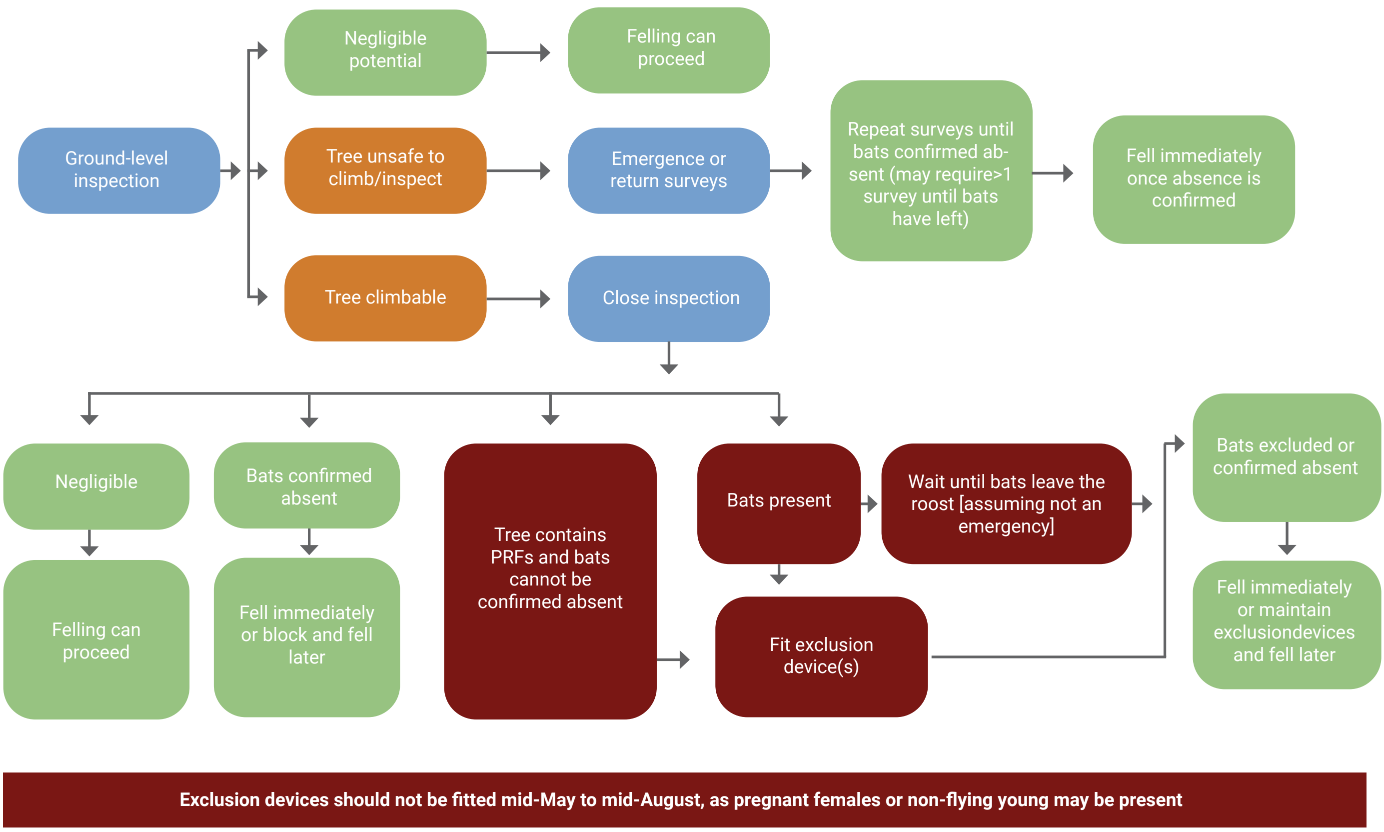
- *Case study 24: Tree-marking protocol; Case study 25: Tree-removal protocol for large numbers of trees.*

Figure 6.3: Flow-chart for inspections and felling

[see caveats in 6.5.3 *et seq.* regarding the surveys and assessment that need to take place prior to this point].

Inspections need to take place immediately prior to felling unless PRFs are removed or blocked. For simplicity, this flow-chart does not refer to licensing though felling a roost, obstructing access to a roost, or excluding bats from a roost (see **Section 6.9)**, would require a licence.

Seasonal considerations are outlined in **Section 6.2**, with details on the timing of exclusions given in **Section 6.9**.



Note: the prescription against fitting exclusion devices between mid-May and mid-August does not need to be enforced where it is certain that a roost feature does not contain pregnant females or non-volant young.

83. https://www.bats.org.uk/news/2022/05/updated-guidance-for-use-of-night-vision-aids-for-bat-surveys

Removing trees with PRFs where the absence of bats is not confirmed

6.5.8. When managing or removing trees with PRFs, it may be necessary to employ reasonable avoidance measures to reduce the likelihood of killing or injuring bats. These measures should only be used once all survey options have been exhausted, as they are time-consuming, costly and put the arborist at increased risk. The most widely used avoidance measure is section-felling.

6.5.9. Section-felling involves removing parts of the tree in sequence rather than the tree being felled in one. This technique is usually employed in arboriculture when there is insufficient space to fell a tree in one operation, or to reduce the risk of people or property being harmed or damaged during the operation.

6.5.10. Section-felling is a complex task and requires the arborist to undergo additional training. Before specifying this type of avoidance measure, it is important to discuss with the arborist what is safe and feasible for the tree in question. It should not be assumed that the same approach can be used for all trees. When recommending the use of section-felling, the ecologist should be clear what objectives they are trying to achieve and whether section-felling is the best solution. It should not be used to make up for poor survey data.

6.5.11. A more detailed consideration of the practicalities and pitfalls of the section-felling technique is provided by Mullholland (2015). This article also describes the practice of translocating tree sections, discussed further below. The Arboricultural Association have a series of Technical Guides that provide guidance on a range of topics, including Rigging (the lowering of tree parts during the process of section-felling), Crane Use in Tree Work and MEWP [Mobile Elevating Work Platform] Use in Tree Work. The arborist should follow guidance in these documents when planning the work.

6.5.12. Where a tree cannot be climbed, it is usually possible to use tracked MEWPs (see **Box 6.13**), even in areas where access is limited or the site is sensitive (e.g. ancient woodland). Temporary roads/tracks made from thin plastic mats (moveable by hand with a team of people) can be used to avoid compaction and keep the ground pressure below 4 psi to access trees with high bat potential that cannot be climbed. They can then be section-felled from the MEWP and potentially rigged from other neighbouring trees to lower sections if needed.

Box 6.13: Tree-felling operations

Using a MEWP (left and top-right); using a grapple saw (bottom).
Photos RSK Habitat.

6.5.13. Where many unsafe trees need to be felled (e.g. for ash dieback), it may be cost-effective to use excavators fitted with grapple saws which can simultaneously hold and cut sections; however, decisions on cutting locations are normally carried out from the cab, rather than from close inspection by an aerial arborist. Where PRFs are present, the cuts would therefore need to be planned in advance to avoid PRF features (as far as possible). This limiting factor will be the lift capacity of the excavator, and therefore the size/weight of section being removed (see **Box 6.14**).

Blocking PRFs

6.5.14. Where there is doubt about the size/extent of a PRF within an internal cavity, and it is not possible to rule out the presence of bats by survey, section-felling is advisable as a precautionary measure, as outlined above. However, where the absence of bats is confirmed, PRFs can be filled or blocked to prevent bats gaining access. The choice of materials will depend on whether the block is required to be permanent (i.e. the PRF or roost is certain to be removed) or temporary (e.g. there is some doubt over whether a particular tree will be felled on the boundary of an area which is covered by all necessary consents to fell).

6.5.15. One option is to securely tack a fine-gauge metal mesh (maximum gauge of 15 mm) over the PRF. Other removable materials include sticks (for simple holes), rags or upholstery foam blocks. Sticks will need shaping to fit but have the advantage of being natural and unobtrusive (mimicking a dead branch once in place). Blocks must remain fully in place; if they are dislodged, the PRF will need to be re-inspected, so should be monitored frequently in most circumstances. The materials used should not harm bats or other species, and should be resistant to squirrel and corvid damage. Expanding polyurethane foam should not be used as it is difficult to apply safely, is not environmentally sustainable, may not last long in situ, and adversely affects climbing equipment.

6.5.16. Where trees may have more than one PRF, the best course of action for each may differ within the same tree.

6.5.17. The decision to block PRFs from which an absence of bats has been confirmed, prior to consents having been obtained, is controversial. BCT have released a Position Statement[84] noting that pre-emptive blocking of PRFs, when carried out significantly in advance of confirmed operations is poor practice, and on a project-by-project basis should be scrutinised for the appropriateness of the approach.

6.5.18. If blocking a PRF prior to all consents being in place is justifiable, then precautionary mitigation to ensure 'no net loss' should be put in place at the time of the blocking. Note that this could only apply to PRFs which have not been confirmed as roosts, as a licence would be needed for confirmed roosts, and consents would need to be in place to apply for such a licence. 'Sufficient' survey should be undertaken to demonstrate that any blocking is justifiable (likely to depend on many factors including habitat type and quality, other roosts in the vicinity and so on). Visual aids for such surveys are strongly recommended to ensure they are robust.

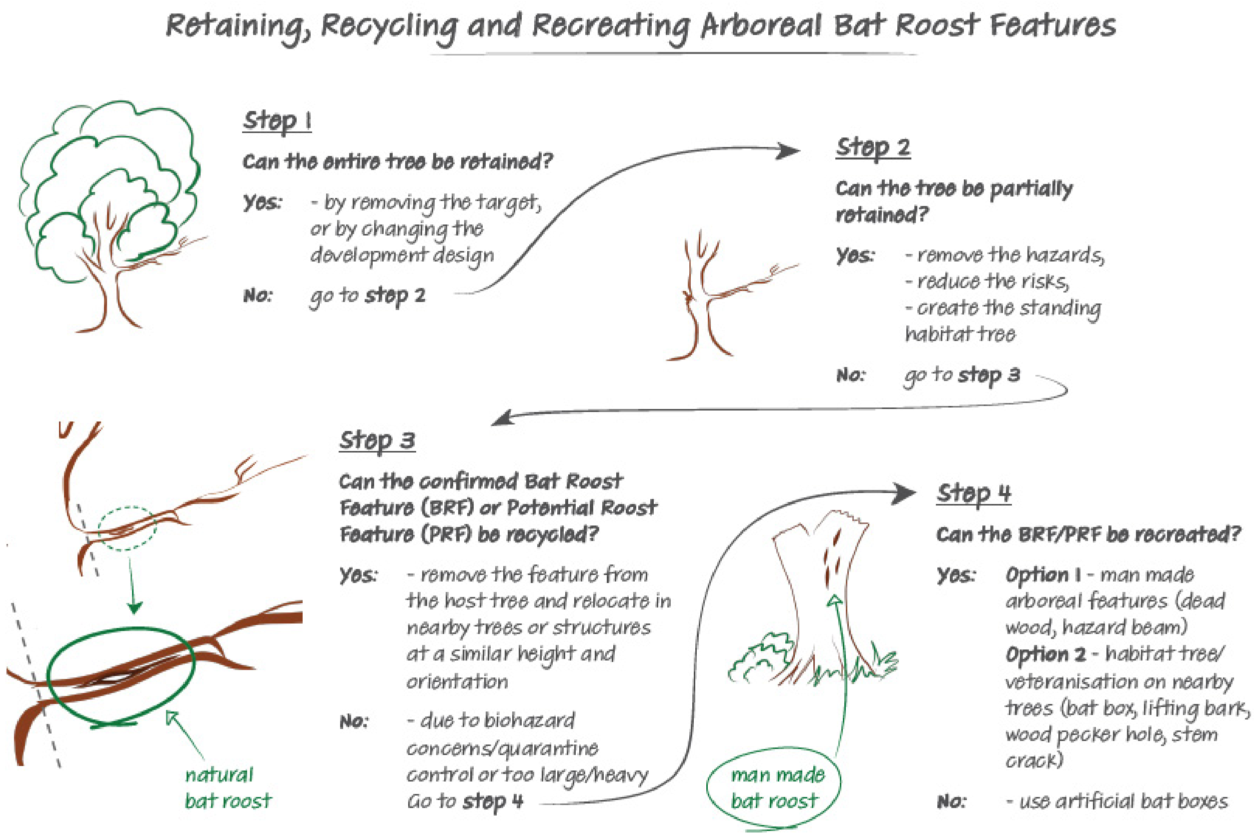
6.5.19. The process of blocking/excluding PRFs in autumn so that trees can be felled in the subsequent winter may be necessary to work around seasonal licensing restrictions (see para 6.2.13).

Compensation for loss of tree roosts

6.5.20. Compensation is sometimes focused on confirmed roosts which have been lost, as this is what the licensing process focuses on. However, compensation should consider the whole of the roost resource: i.e. not just current roosts, but current and likely future PRFs over the long-term, especially for complex habitats such as woodland. Bat boxes should be the last resort. A flow-chart to illustrate a suggested hierarchy of tree roost mitigation is included as **Figure 6.4**. An example of large-scale mitigation focusing on the roost resource not individual trees, and indicating compensation ratios for resource loss, is provided in Hinds and Davidson-Watts (2022).

84. https://www.bats.org.uk/news/2019/10/blocking-potential-roost-features-in-trees-in-advance-of-clearance-felling-non-forestry

Figure 6.4: Flow-chart to illustrate hierarchy of tree roost mitigation (artist: Kailzie Erskine)



Planting to replace PRF loss

6.5.21. Planting intended to compensate for PRF loss will usually take decades to mature. Early senescent fruit trees develop veteran features, and therefore (it is assumed) natural PRFs, much earlier than other tree species (Harper *et al.,* 2020). Including them within planting mixes provides medium-term mitigation for bats (and other ecological benefits) whilst other trees mature, and last longer than bat boxes which are not often replaced at the end of their life-span. They therefore provide a more robust and holistic approach to mitigation/compensation than boxes.

Veteranisation

6.5.22. It is clear that the natural development of hollows within newly planted trees will not occur fast enough to offset the ongoing loss of mature trees caused by activities such as land clearing for agriculture, logging, and urban expansion (Griffiths *et al.,* 2020). Veteranisation is a tool to help speed up the processes of habitat development that normally take many decades. It should not be used on trees that support or are developing value, nor where safety may become an issue, such as in parks or towns (Bengtsson, Hedin & Niklasson, 2012). However, where appropriate, it can be used to increase the amount of potential habitat that can be used by bats and other species.

6.5.23. Veteranisation techniques mimic the effects of the natural tree ageing process and decay, as well as events such as lightning strike/storms and damage caused by deer, grey squirrels, and woodpeckers. Bengtsson *et al.* (2012) have set up a trial of five veteranisation methods (not all of which are designed to create roost features for bats): Treatment one – nest box in a living oak; Treatment two – woodpecker hole; Treatment three – 'horse damage' to the trunk; Treatment four – a broken branch; Treatment five – ringbarking a branch. The project is being monitored in the long-term (over 25 years) but is already showing promising results in relation to bats (V. Bengtsson, pers. comm.). Recent inspections of 225 oak trees in the study (Bengtsson & Wheater, 2021) found live bats or evidence of bats in 20 'nestbox' and 14 'woodpecker hole' features that had been deliberately created using veteranisation techniques. A more specific study measuring uptake by bats over a longer period is needed.

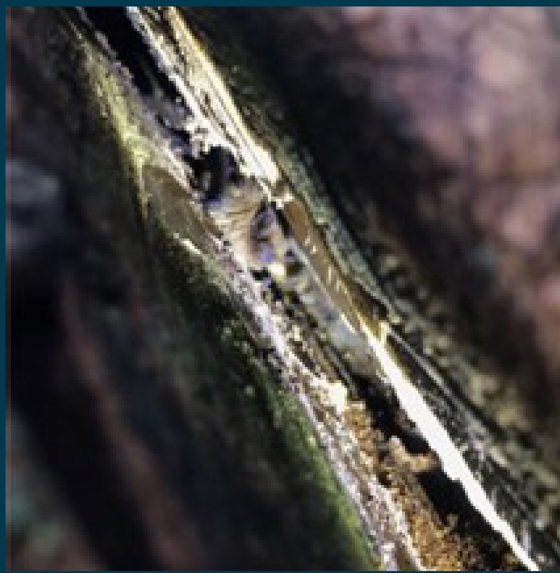
Check out APPENDIX 4 for examples:

- *Case study 26: Examples of tree mitigation and Case study 27: creation of PRFs in 'habitat poles'.*

Box 6.14: Successful veteranisation

A 'woodpecker hole' with bird nesting material in the base and a roosting soprano pipistrelle.
Photo: Vikki Bengtsson, Pro Natura.

A created feature and a roosting roosting soprano pipistrelle
Photo: David Whyte, Professional Tree Climbing Ltd.



6.5.24. Temperature may be one factor in the success of features created through veteranisation. Griffiths *et al.* (2018) compared the thermal profiles of natural tree hollows with three types of artificial hollows designed for small marsupial gliders and tree-roosting insectivorous bats: 'chainsaw hollows' carved directly into the trunks and branches of live trees; 'log hollows'; and plywood nest boxes. Chainsaw hollows had thermal profiles that were similar to natural tree hollows: they were consistently warmer than ambient conditions at night, while remaining cooler than ambient during the day. In contrast, glider and bat boxes had the opposite pattern of heating and cooling, being slightly cooler than ambient at night and substantially hotter during the day. Glider log hollows had greater variation in internal temperatures compared to natural hollows and chainsaw hollows, but fluctuated less than glider boxes. The cavities generated by veteranisation therefore had better capacity for buffering their occupants from temperature extremes.

6.5.25. Similar results were found in relation to humidity (Maziarz, Broughton & Wesołowski, 2017) i.e. relative humidity is higher in tree cavities than in nest-boxes, indicating that nest-boxes cannot be treated as a direct substitute for tree cavities. Rueegger (2017) studied adoption of chainsaw-created features, and found high occupancy rates by a range of species including bats (50% of the artificially created hollows were used by long-eared bats (*Nyctophilus* sp.).

6.5.26. If veteranisation may be an appropriate option for a development (in combination with other techniques), it is essential to involve a suitably-experienced arborist who understands tree physiology and can create features which are very close to natural features, rather than simply cutting a 'bat box' into a tree.

6.5.27. There is a distinction between creating instant features and those that will develop over time, and each has its role to play. Instant features provide short-term (perhaps 2-5 year) habitat that is created by cutting the required features into the tree; these will change over time as the tree continues to grow. Future features are created by wounding the tree in such a way that the woundwood response will create the desired feature in the medium term. This is where the arboricultural expertise is required[85].

Translocation of limbs (reclaimed PRFs)

6.5.28. Reclaimed PRFs can be very simple, such as mounting sheets of loose bark or logs with woodpecker holes onto trees. However, the translocation of larger limbs containing bat roosting features from one tree to another has also been attempted. Key aspects to consider for larger PRFs are outlined in Mullholland (2015) and summarised as follows:

- Are there suitable trees nearby on which the feature can be erected?
- Can the translocated limb be safely attached; will it stay safe in the longer term, allowing tree-safety inspections to be properly conducted?
- Will the section have sufficient life left to merit translocation, or will it decay quickly and/or affect the host tree adversely?
- Would other mitigation/compensation measures be more practical, longer-lived or more effective?

6.5.29. Mullholland (2015; Figure 2) shows a re-erected feature and bat boxes; monitoring has shown that the boxes have been used as frequently as the feature (though not necessarily by the same species) and are considered likely to last longer.

6.5.30. In 2011, an ash tree known to support a large noctule roost was accidentally felled out of safety concerns. The felled trunk was reinstated against the nearest suitable tree (another ash), using a high-lift and straps. The mitigation was shown to work in the short term, and allowed the noctule colony time to adapt to alternative roosts in woodpecker holes within the woodland (Damant & Dickins, 2013). Informal monitoring indicated that the bats were still using the translocated limb in 2017, demonstrating success[86]. Elmeros *et al.* (2016) notes that this is "the only successful example", despite providing photographs of other translocated limbs, but the practice is probably under-recorded (see **Box 6.15**).

Box 6.15: Reclaimed PRFs

Examples of reclaimed PRFs that have been in place for six years (2022) without any maintenance required, and showing no signs of further decay. No bats have been observed in either of these features; however, smoothing around the entrance and black staining has been observed.
Photos: David Whyte, Professional Tree Climbing Ltd.

85. In Australia, a conservation ecologist has developed a tool called the 'Hollowhog' designed to to "create new homes for Australia's endangered wildlife". Video of tool in use: https://www.reuters.com/business/environment/australias-endangered-wildlife-gets-lifeline-invention-that-hollows-trees-2023-02-14/
86. See Shenley Wood Noctule videos: 2012 https://youtu.be/J-t6Rmehscg; 2012 https://youtu.be/vhGKF24UmpQ; 2013 https://youtu.be/0dg_0kVNJQ4.

6.5.31. In summary, limb translocation: can be expensive and difficult; increases the risk of recipient tree-failure; could create a hazard in some locations (e.g. hanging a section of deadwood in the crown); is likely to provide short-lived benefits, including limited uptake by bats. However, it may be useful in a limited set of circumstances where rapid response is required (i.e. not as a planned mitigation tool).

6.5.32. The principles of translocation (assuming the key aspects above have been satisfactorily addressed) are:

- the height and aspect of the roost feature should be replicated as closely as possible;
- the top end of the limb should be protected against the elements by capping it with timber or roofing felt, to slow down the onset of wood decay;
- the translocated limb must be securely attached to the receptor tree by means that will not compromise tree health, and in a safe location not used by the public;
- the attachment should be adjustable and re-inspected on a regular basis. Current guidance for cable bracing in trees (the closest thing with which to compare) indicates an annual inspection from the ground and a 5-yearly aerial inspection.

6.5.33. As with other 'new' roosts, bats being able to find the translocated limb will be a factor in its success.

Standing dead trees (monoliths)

6.5.34. Unsafe, dying and dead trees can be retained as habitat for wildlife, after making them stable, if they would otherwise be felled. This can be achieved by removing some or all of the main branches and/or shortening the stem over time. Whilst the retention of standing deadwood is considered good ecological practice[87], [88], its value for roosting bats is limited to roosts that are low enough within the tree to be retained safely. Data on roosting heights (BTHK, 2022) indicates that most roosts below 5 m are occupied by small numbers of bats (1-4 bats) during the spring flux, autumn flux or winter period, whereas maternity roosts are generally found at 5-10 m.

6.5.35. The action of removing branches and/or shortening the stem will increase dysfunction, accelerating rates of decay and altering the internal conditions of features (temperature, humidity, size of cavity). These changes, over time, will make the feature unsuitable for roosting.

6.5.36. In summary, this approach may provide a short-term fix for roosts that are low enough to be safely retained (and could be combined with veteranisation techniques). Arboricultural advice should be sought to ensure the tree is (or can be made) adequately safe, and is inspected periodically, since the decaying stem and decayed roots may mean that tree itself may become hazardous over time.

Check out APPENDIX 4 for examples:

- *Case study 27: creation of PRFs in 'habitat poles' and Case study 28: Placement of standing deadwood (monoliths).*

Bat boxes

6.5.37. Loss of tree roosts can be compensated to some extent by the provision of bat boxes, provided that:

- the species that are displaced from the lost tree roosts readily use bat boxes;
- the boxes selected are of a suitable type for the species and roost type concerned;
- they are located appropriately;
- monitoring is adequately resourced to ensure longer-term maintenance, repair and replacement.

87. https://www.trees.org.uk/News-Blog/Latest-News/Dead-standing-trees-%E2%80%93-to-keep-or-not-to-keep
88. https://www.ancienttreeforum.co.uk/ancient-trees/ancient-tree-sites-to-visit/veteran-tree-trails/hampstead-heath/i-chubb-path/

6.5.38. The numbers and types of bat boxes that are required in compensation should be determined by the available roost resource affected, not only by the numbers of confirmed roosts that will be lost. Different cavity forms will be used by different species for different purposes; thus the different types of cavity (PRFs) within the roost resource that will be affected should inform the extent and types of mitigation boxes proposed. The principle should be of no net loss of roosting opportunity.

6.5.39. That said, bat boxes are not always suitable, and may only provide partial compensation, particularly for rarer species (see Chapter 9 for determining mitigation 'success'). Lintott and Mathews (2018) and Collins *et al*. (2020) both found that, where bats were present in bat boxes, the overwhelming majority were identified as *Pipistrellus* species.

6.5.40. The use of bat boxes should therefore not be used to justify the removal of larger areas of woodland, nor of mature trees, as they will not be able to provide the same robust long-lived roosting opportunities as trees supporting features such as woodpecker holes. A broader mitigation strategy that retains such trees, and considers the future roost resource (a younger pool of trees that will develop such features in the longer term) is required to maintain species that are woodland specialists. Bat boxes cannot provide the same level of long-term opportunity, particularly since their longer-term maintenance, repair and replacement is hard to secure (and indeed, they can be removed without notification). It is important therefore that the roost compensation strategy provides compensation for the entire roost resource affected (current and future roost potential), and not just for confirmed roosts.

6.5.41. There are limited circumstances where they are appropriate as the primary means of compensating roost loss (see **APPENDIX 3**). However, they can be a useful 'interim' solution, providing an alternative roost resource while new plantings mature, and/or as a 'safe haven' to place bats found during tree-felling works, out of the reach of harm. It is important to note, however, that plantings will take many years to mature and support features bats can use, and the length of time that boxes might need to function as an 'interim' solution should be factored into maintenance, replacement and monitoring. As noted above, they should not be relied upon as a adequate solution for large-scale roost loss.

6.5.42. Where there is an abundance of natural roost opportunities for a target species, it is possible that additional artificial roost sites will be ignored (though not necessarily by all species). For example, in one site in Buckinghamshire, numerous bat boxes are used by Natterer's and brown long-eared bats but not by Bechstein's bats (though they do use boxes in other sites), and no purpose would be served in this location by replacing Bechstein's bat roost trees that are to be lost with additional boxes. Resources would be better directed to other measures that might have greater benefit to bats, such as introducing nocturnal insect-friendly planting.

6.5.43. Consideration should be given to tree growth and boxes may need rehanging over time. Headless or domed nails not fully hammered home should be used to allow for tree growth. Aluminium alloy nails are less likely to damage saws and chipping machinery. Boxes should always only be attached to healthy trees, as otherwise they can be damaged in bad weather (e.g. by a falling branch). In areas where edible dormouse are present, boxes may need to be adapted to prevent entrances being enlarged and boxes taken over.

6.5.44. Other considerations for bat boxes are covered in **6.3.44** *et seq.*

BrandenBark™ [89]

6.5.45. BrandenBark™ is an artificial bark used as a long-term mitigation/habitat enhancement tool, specifically designed for bark-roosting bats in the US. BrandenBark™ roosts have been regularly monitored, and the company which developed this material (Copperhead Environmental Consulting, Inc.) have reported impressive results. BrandenBark™ roosts provide roost temperatures similar to that found under natural bark,

89. http://copperheadconsulting.com/brandenbark/ There is currently no distributer for BrandenBark™ in the UK, but it can be ordered directly from Copperhead Environmental Consulting, Inc.

are adopted rapidly, are used by large numbers of bats (including the rare Indiana bat, *Myotis sodalis*), require little to no maintenance, and are easy to monitor.

6.5.46. The cost to purchase and ship BrandenBark™ is much higher than a single traditional bat box, but this approach could be tested on projects that affect tree-roosting bats with a preference for lifted bark (notably barbastelle), particularly if alternative roosts are in short supply.

6.6. Working around bats in bridges and tunnels (remedial work)

6.6.1. Bridges and tunnels are rarely demolished, but do require maintenance/repairs that pose particular challenges when their structure and/or condition makes them more likely to support bats. Bats roost in many different locations within old and new bridges – holes, cracks and crevices, as well as voids (which may not be readily apparent from the surface). Roosting locations in which bats have been recorded in bridges include expansion joints; gaps at the corner of buttresses; widening gaps; cracks and crevices between stonework and brickwork where mortar has eroded; drainage pipes and ducts; and internal voids within box girder bridges. There are often good roosting opportunities where bridges have been widened, at the interface of different materials between the old and new elements.

6.6.2. There are similarities between bridges and tunnels, not least that it can be difficult to assess how bats are using this type of structure. They also tend to have similar construction materials, levels of humidity, types of PRF, levels of disturbance, association with waterbodies and roads, and so on. They are infrequently used as maternity sites as they often do not provide warm stable conditions in the UK. However, studies have shown that large numbers of bats may use bridges as maternity roosts elsewhere (e.g. the US)[90]. There are exceptions; for example, where a cavity is directly behind an unshaded south-facing surface. They may be used as pre-hibernation or hibernation roosts (which can be difficult to identify and assess effectively) or swarming sites (see **Section 6.7**).

6.6.3. Bridge and tunnel repairs can be difficult to plan and manage cost-effectively in relation to bats and roosts. This is particularly true if close inspection requires specific equipment (such as a boat, scaffolding, or a MEWP), training (confined spaces), permits, and/or road or rail closures. Larger bridges can be difficult to view effectively, and potential emergences can be confused with commuting/foraging bats, particularly over water, and for late-emerging species. Visual aids such as infra-red or thermal cameras are strongly recommended[80].

6.6.4. Timing the works is key to avoiding impacts, and any consents/licences needed should be sought well in advance. If a bridge or tunnel has cavities that might be suitable for hibernation and the presence of bats cannot be ruled out, it is preferable to undertake works in the bats' active season (assuming a maternity roost is not present). If non-breeding roosts are present outside of the hibernation season, they may need to be temporarily excluded from the site of the works. Not all non-breeding roosts are small: larger male roosts of Daubenton's bats are sometimes found in bridges.

6.6.5. The impacts of construction lighting on bats and roosts need to be considered, particularly for structures on the road and rail network, where night-working is often required to avoid daytime transport disruptions.

6.6.6. It is therefore important to establish, as far as possible, both the likely seasonal value of the bridge or tunnel to bats *and* the likely extent of any work that might affect bats to determine the approach to mitigation.

6.6.7. Not all works require the presence of bats to be confirmed. For example, when pinning bridges to provide stability (a process which was assessed as creating a short-lived and fairly limited amount of disruption that was unlikely to result in the offence of 'disturbance'), it was considered sufficient to ensure that bats were absent from the trace of the pins (R. Crompton, pers. comm.) rather than from the whole bridge. This avoidance approach minimised the extent of survey work required and reduced seasonal constraints.

90. See Harvey & Associates (2019) for an assessment of the ecology of bats in California and associated bridge mitigation. Caution is required when viewing mitigation from different countries applied to different species.

6.6.8. The possibility of avoiding/minimising the extent of works that affects cavities where use by bats cannot be ruled out should also be explored (though may not be possible for safety reasons).

6.6.9. If cavities or other roosting opportunities will be lost, they will need to be compensated. Just as for tree roosts, most non-maternity roost crevices in such structures will be unoccupied on most checks, so the available resource of suitable PRFs should be the measure of compensation provision, and not just the number of occupied crevices. Permanent features integrated into the non-structural elements of bridges and tunnels are preferable. These generally take the form of bat bricks, but occasionally it is possible to build in larger chambers. It is important that the flightpath from such replacement roosts avoids artificial lighting and collision risks from vehicles.

Check out APPENDIX 4 for an example of working around bats in a culvert:

- *Case study 30: Silverton Mill.*

6.7. Working around bats using swarming sites

6.7.1. The types of structures used as swarming sites are, like bridges and tunnels, less likely to be demolished; however, they may require modification or repairs. As they can be used by many hundreds, even thousands, of bats travelling from some distance away, it is important to recognise their use for swarming in order to determine the best approach and season for such works. The potential for a mine, cave or tunnel to be an autumn swarming site is often recognised, but the potential for other types of site to support swarming bats, and at times outside of autumn (see **Table 6.1**), is less often considered when determining survey effort. This may lead to important swarming sites being missed. Less obvious swarming sites include castles, stately homes and large barns. However, even small underground structures such as old cellars can act as swarming sites, and numbers can be difficult to determine.

6.7.2. Mass swarming events of common pipistrelle bats in the autumn (followed by mass hibernation in a diverse range of building types in urban environments) has been seen in the Netherlands (e.g. Korsten, *et al*. (2016)). Although there are anecdotal reports, this has not yet been formally reported in the UK[91].

6.7.3. It is important to recognise that swarming by bats is a highly three-dimensional activity, with groups of bats 'towering' up high into the canopy, or dashing around at all levels, and that it is not necessary to have an opening underground for bats to swarm (K. Cohen pers. obs.). Works affecting tree canopy cover or other above-ground features must be considered for potential impacts (see **Box 6.16**).

91. The highest concentration of pipistrelle bats so far reported (60+) is at Seaton Delaval Hall, but this differs from the mass modern hibernation sites found in the Netherlands (see https://www.bats.org.uk/news/2018/08/home-to-roost-largest-hibernation-of-pipistrelle-bats-recorded-at-seaton-delaval-hall). There are at least two other similar (castle/church) sites supporting larger numbers of hibernating pipistrelle bats in Northumberland (T. Wiffen, pers. comm.). Durham Cathedral is also visited by large numbers of common pipistrelle each autumn, but generally by females and juveniles (https://www.durhambats.co.uk/durham-cathedral/).

Box 6.16: Small swarming sites

Buried former cellar of very modest size (2.5 x 3 m footprint by 2 m high) that supports hibernation and swarming; only visible as a small slot at ground level (in one corner of the structure). The site at Nieuw Milligen, Netherlands, supports three *Myotis* species (Natterer's, Daubenton's and Bechstein's bats) as well as brown long-eared bat. Since the void was dug out, wintering numbers have increased from 0 to 90 in 2015, and averaged about 70 since 2014, though counts have been lower in the recent warmer winter months.

Photographs by Rutger Kaal via K. Cohen.

Similar behaviour (i.e. bats flying rapidly in and out of similarly small gaps as part of swarming behaviour) has been recorded in Fife. Left/centre-top shows bats accessing through a gap (~30 x 40 cm) left when boulders were historically used to seal the mine entrance. Right/centre bottom: gap is around 20 x 60 cm.

Photos/records: K. Cohen.

6.7.4. Where a swarming site is identified, the most important part of any mitigation approach will be timing the works (e.g. to avoid light-spill at critical times), but design modifications may also be needed to safeguard the site. As swarming sites differ, a bespoke approach will probably be needed[92]. This approach is likely to include careful management of impacts on flightpaths, input from ecologists to design plans, supervision of works by ecologists, and other elements.

6.8. Mitigation for the loss of hibernation sites

6.8.1. Hibernation preferences differ between species. According to Dietz and Kiefer (2016), common pipistrelle and noctule are found in frost-exposed crevices outside the entrances of caves; just inside are the cold-hardy species (long-eared bats, barbastelle, serotine). Small *Myotis* are found further into a cave, in the middle zone; larger *Myotis* and horseshoe bats in the climatically stable deep zone, at around 7-9°C. Observations of

92. https://www.bats.org.uk/our-work/buildings-planning-and-development/roost-replacement-and-enhancement/case studies/avoidance-of-swarming-site-loss-during-restoration-works-at-cliveden

bat species in UK wintering sites show that species tolerances are not this simple; for example, some lesser horseshoe bats may be found just inside cave and mine entrances and may even emerge to fly and forage in mid-winter when snow lies on the ground (P. Waring, pers comm). That said, the principle of creating larger hibernation sites to encompass the temperature preferences of different species still holds (though other factors such as geology and airflow interact to create ideal conditions for particular species).

6.8.2. Bats hibernate in natural and artificial structures such as mines, ice houses and abandoned buildings. Creating successful artificial hibernation sites for bats is challenging, requiring a suitable air-flow, an optimal temperature range buffered against external conditions, and high humidity. Most failures are due to too much movement of air through the structure, which leads to inconsistent/shifting humidity. However, there have also been many examples of successful projects[43]. Note that humidity preferences may also differ between species (Downs & Wells, 2021), though this has not been widely tested.

6.8.3. Guidance on all aspects of the conservation and management of underground sites used by bats is given in EUROBATS Publication No. 2 (Mitchell-Jones *et al*., 2007). In addition to protecting and maintaining sites (legally and physically), there is a short section on creating sites for use by hibernating bats. Whilst this draws heavily on *The Bat Workers' Manual* (Mitchell-Jones & McLeish, 2004), there are further examples from Wiltshire (UK) and Portugal. The former is a disused railway tunnel and the latter a bespoke design (broad details provided).

Check out APPENDIX 4 for UK examples:

- *Case study 20: Modification of pedestrian subway to create lesser horseshoe bat roost;*
- *Case study 31: Kingfishers Bridge hibernaculum, Cambridgeshire*
- *Case study 32: Middleton Upper Quarry mine-workings, Midlothian;*
- *Case study 33: Two Mile Bottom artificial hibernation tunnel, Thetford Forest;*
- *Case study 34: Denbury Lime Kiln.*

6.8.4. EUROBATS has collated a number of other examples, some with plans, from across Europe. Currently only a draft report is publicly available, shortly to be updated[43].

6.8.5. If a replacement hibernaculum is required, the guidance and examples cited above are a useful source of advice on location and design considerations, as well as costs, potential pitfalls and longer-term management.

6.9. Avoiding killing/injury to bats in roosts

Exclusion of bats from roosts prior to works

6.9.1. Excluding bats may need to be carried out under licence where a roost has been identified, but it is not possible to be certain that all bats have left through inspection. [See also **6.5.8** to **6.5.11** for tree roosts.]

6.9.2. Bats can be excluded from a roost by blocking the access points once all bats have been recorded leaving, thereby preventing their return. For this to be successful, all of the roost access points must be known and there must be confidence that all bats have emerged to avoid entrapment (this is easier for species such as horseshoe bats). Works during the maternity period should be avoided to avoid trapping non-flying young. This type of exclusion (where bats need to be monitored as they leave) can only be undertaken during the bats' active period.

6.9.3. Where it is not possible to be certain all bats have left a roost, exclusion devices will be required. These allow bats to exit but not return and come in a variety of forms. NatureScot have produced a comprehensive report, *Annex II - Preventing bat access in domestic dwelling houses* (Scottish Natural Heritage, 2018), giving several different examples of devices in place, and detailed instructions.

Timing

6.9.4. NatureScot state that exclusion devices must only be fitted in April or during September to October, when bats are active, because this is the optimum time to maximise the likelihood of success. These short periods are defined to avoid the periods when bats are either heavily pregnant, have dependent young or are hibernating.

6.9.5. It is NatureScot's view that, if an exclusion device was fitted during winter, it would still need to remain in place until April. As it would be affected by the weather, it would require more monitoring and maintenance to ensure that it had not moved or become dislodged. It is therefore unlikely that any licence to exclude bats outside of the periods stated above would be granted in Scotland.

6.9.6. In England (K. Walsh, pers. comm.) the presumption against fitting exclusion devices from May to October is only routinely applied to maternity roosts. Natural England would not permit the fitting of exclusion devices in winter, but there may be circumstances where devices fitted before winter remain on a structure during the winter. In southern parts of the country it may be acceptable to install exclusion devices in March (depending on conditions).

6.9.7. In all areas, winter exclusions should be avoided. If circumstances suggest an exclusion is unavoidable due to exceptional circumstances, then this should be discussed with the SNCB before proceeding. It will likely require a bespoke approach, based on the structure from which the bats will be excluded, the species concerned, the status of any roost, and the weather.

Duration

6.9.8. Advice on the length of time that exclusion devices should be left varies across the UK, presumably related to differences in average weather conditions at different latitudes. NatureScot state that, as bats do not always leave the roost every night to feed (e.g. due to cold temperatures, heavy rain or winds), their licences require that an exclusion is left in place for at least 14 days to be confident that all bats have left the roost before access points are sealed. They expect this period to be extended if the weather has been unusually cold and/or wet for much of that time, which means that weather conditions need to be monitored. In Northern Ireland, a period of ten days is usually specified, at least for domestic exclusions.

6.9.9. Shorter periods have been accepted on licences issued in England (five consecutive days/nights throughout a spell of suitable weather conditions). Letters issued via the Bat Helpline (largely to householders) specify a minimum period for each device of at least seven consecutive nights throughout a spell of suitable weather conditions (i.e. conditions in which bats would be foraging). In both cases, the onus is on the ecologist to ensure that appropriate weather conditions have been in place.

6.9.10. Once the exclusion has been effected, the exclusion device(s) should be replaced with permanent exclusion measures to ensure the bats do not re-occupy the site. If this is not possible for a roost space that is being removed, the exclusion device should be left in place, but such devices may be less secure. If there is any doubt as to whether bats may still be present, an inspection of the relevant areas should be carried out where practicable and safe to do so, either directly or using endoscopes etc (dependent on structure and species).

Destructive searches

6.9.11. Passive exclusion through altering the roosting environment may encourage bats to leave a roost prior to works. For example, partially stripping roof tiles away from sensitive areas, or exposing the top of a cavity wall, may encourage bats to leave as a result of altered conditions (temperature, airflow) and indirect disturbance. It is important that this is not so great as to force bats to emerge in daylight or in unsuitable weather conditions; however, the conditions under which this exercise is undertaken need to be balanced against the likely risk of bats being present (see also **6.2.14** *et seq.*).

6.9.12. Roosting opportunities located under external features such as roof/hanging tiles or weatherboarding should be dismantled by hand by the roofer/building contractor, under the direct supervision of the bat ecologist named on the licence (or their accredited agent). This is best undertaken at a close distance from a safe means of access, such as scaffolding or a cherry picker, so that the ecologist is immediately available to capture any bats that may be roosting beneath the feature. Where applicable, materials should be removed carefully and not rolled or sprung, to avoid potential harm to bats. Their undersides should be checked for any bats clinging to them, and the space exposed examined for signs of bats, particularly droppings. Any evidence should be carefully recorded (including location and extent). As above, the conditions under which this type of work is undertaken need to be balanced against the likely risk of bats being present.

Use of lighting

6.9.13. It has sometimes been suggested that leaving lights on (or bringing in mobile lighting) might help to exclude bats from roosts prior to works. However, this technique can have the reverse effect, discouraging bats from emerging, giving the impression that they have left the roost when they are in fact 'entombed', and therefore it cannot be advocated. See Zeale *et al*. (2014) for an example which suggests that this is a behavioural response that is shared among *Myotis* spp. It's not clear if other species are affected in the same way, but the technique should be avoided, and is highly unlikely to be licensed.

Check out APPENDIX 4:

- *Case study 35: Exclusion of bats from an inaccessible mine adit using smoke for another example where lighting failed to dissuade bats.*

Bat capture

6.9.14. Occasionally, it may be necessary to capture and relocate bats. This assumes that the licence allows capture, and that the species to be captured are included on that licence, unless bats are in imminent danger of injury. The following assumes that weather conditions are suitable for bats to be active (see following section for adverse weather).

6.9.15. Bats should be captured by a survey licence holder (or their accredited agent) using a gloved hand or hand-held net, given a health check, and then placed carefully inside a clean draw-string, calico cloth holding bag or similar (free of loose threads inside) for transport (one bat per bag). Alternatively, captured bats can be placed in carry-boxes (see bat care advice in Mitchell-Jones & McLeish (2004) and Brown (2010) for details). Suspending the bag during transport helps to avoid the bat being crushed. Captured bats must be:

- relocated (ideally on site) to a suitable roosting feature for the species; or
- released on site at dusk into suitable foraging/commuting habitat in safe areas that are close to the site of capture (provision should be made for this as a precaution prior to the works.

6.9.16. When weather conditions are less suitable bats may not fly or be able to forage, or they may go into torpor, and it may be necessary to temporarily hold them prior to release under more suitable conditions. Importantly, provision should be made for this as a precaution prior to the works, so that temporary bat care will be available if required. It is not appropriate to assume that a volunteer carer will be available or provide care without recompense if responding to commercial work.

Bats discovered unexpectedly (under licence)

- Works must stop immediately. If the named ecologist[93] or an accredited agent is not present, they must be contacted immediately to attend site.
- The bat must not be exposed or 'encouraged' to fly out of the roost of its own accord. It should be left undisturbed unless this would be unsafe.

93. The devolved administrations may use different terms, e.g. nominated ecologist (Wales).

- Unless it is in immediate danger, the bat must only be handled by the named ecologist or accredited agent. If there is a suitable alternative roosting location on site then, assuming the bat is checked and in good health, it should be placed there to minimise stress and holding time. If not, it must be carefully placed in a lidded ventilated box with a piece of clean cloth and a small shallow container with some wetted cotton wool. The box must be kept in a safe, quiet location.
- The named ecologist must re-assess the location where the bat was found and determine whether works can continue under the licence in force, whether further survey is required, and/or whether a modification to the licence is required before works re-commence. A written record must be kept of this decision and made available to the relevant SNCB or any police officer on request. This incident must also be reported on the licence return form.
- If capture and relocation is already included on the licence, then details of suitable carer(s) will have been included as part of that licence for bats that cannot immediately be released. If not, and no carers are known, call the National Bat Helpline (0345 1300 228) to be put in contact with a bat carer. If there are none, then a local wildlife rescue centre or vet may take the bat.

Additional considerations in adverse weather conditions

6.9.17. If individual bats are discovered unexpectedly during periods of adverse weather, the following steps must be taken:

- If the bat is in torpor, take care to avoid rousing the bat during transfer to a suitable location, which may be a suitable hibernation box or another alternative roost that provides a quiet environment with a stable, suitable temperature and relatively high humidity, safe from further disturbance.
- Any underweight or injured bats must be taken into temporary care by an experienced bat carer and looked after until such time that the bat can be transferred to a suitable replacement roost at/close to the same site, and/or weather conditions are suitable for release at the same site. As noted above, this should be provided for as a precaution prior to the works, so that temporary bat care will be available if required.

Check out APPENDIX 4 for some atypical examples of capture/exclusion:

- *Case study 35: Exclusion of bats from an inaccessible mine adit using smoke;*
- *Case study 36: Working around asbestos.*

6.10. Precautionary working method statements (PWMSs)

6.10.1. A licence is not always necessary. Good practice and avoidance measures are promoted by all the UK SNCBs to minimise the impact of a proposed activity on wildlife, and in particular EPS, to avoid committing offences. Licensing should be seen as the last resort where all other alternative ways of avoiding impacts on the species have been discounted.

6.10.2. The need for a licence may be avoided through appropriate timing (see **Section 6.2**), or where working methods are in place to ensure the roost is not impacted. For example:

- the roost is not directly affected, connectivity to adjoining habitat can be maintained, and there is a buffer within which plant and materials are not stored or active nearby; or
- low-impact refurbishment works are undertaken in the same building as the roost, but the roost and its access are left intact, and working methods avoid disturbance (see **2.5.6**) even when the roost is occupied.

6.10.3. Another example where a non-licensable approach to works can be adopted includes buildings of ‘low potential’ with no evidence of use, but where the presence of a bat (or very low numbers of bats) cannot be ruled out even where the requisite number of surveys have been completed. In these circumstances, a precautionary approach to design and construction methods is sensible.

6.10.4. If such an approach is recommended, then a PWMS [94] should be produced, and the reasons why a non-licensable approach is recommended should be documented. **Figure 6.5** outlines what a PWMS should include, and a more detailed template is set out in **APPENDIX 6**.

6.10.5. A PWMS documents the thought process behind any decision not to apply for a licence, and demonstrates that risks were minimised, and how. The failure of the client, or anyone working under the client's direction, to follow the method statement may result in a breach of the law and leave the client or others open to prosecution.

6.10.6. It is helpful, therefore, to ensure that all parties understand the PWMS and how, when and where it will be applied, and physically sign up to the document as evidence of that commitment. This can be done as part of a precautionary 'toolbox talk'. A copy should be kept on site during the works.

6.10.7. Where a bat or evidence of a roost i.e. droppings) is found unexpectedly and not covered by a licence, then the SNCBs advise that all work must stop and an ecologist should advise on the most appropriate course of action (it is not the SNCB's role to advise on all of these situations). This would depend on the exact circumstances and the appropriately-licensed ecologist on the ground (or their accredited agent) would be best placed to make a judgement call. For example, it may be appropriate for the bat's welfare to remove it; or conversely to re-instate the roost.

6.10.8. If a bat (or evidence of presence) is unexpectedly found, this is likely to result in delays to avoid a breach of the law. Low-impact licences are available in England[95] and Scotland[96] , which allows for many of these situations to be resolved relatively swiftly (though this does not apply to all roost types, nor in all seasons). If a roost has already been destroyed, then the offence will already been committed, and licences cannot be issued for retrospective works. However, there may be works remaining that still need to be covered under licence, and consultation over the extent of compensation required for the destroyed roost.

6.10.9. Where urgent consultation is required (e.g. in an emergency situation, see next sections), then the appropriate country licensing team should be contacted.

94. Other names are also in use: e.g. Non-licensed Method Statement (NLMS) and so on.

95. https://www.gov.uk/government/publications/bats-licence-to-interfere-with-bat-roosts-cl21

96. https://www.nature.scot/doc/guidance-bat-low-impact-licensing-blimp-ecologists-guide

Figure 6.5: PWMS and tool-box talk contents

Outline technical contents of a PWMS

- Site details, responsible parties, summary of proposals, planning status, relevant legislation; justification that licence is not required
- Site and survey information relevant to the activities covered by the PWMS, supported by maps and photographs
- Impact assessment as relevant to subject of PWMS, supported by maps and photographs
- Mitigation, compensation and enhancement strategy, to include details of each of the measures to be employed
- Supporting materials such as toolbox-talks and signage
- Emergency provisions
- Proposals and responsibilities for monitoring and management/after care
- Programme

Existing documents may be referenced but the PWMS should include sufficient information to ensure that an offence is avoided.

Outline contents of a toolbox-talk

Best practice and reasonable avoidance measures to prevent killing/injury during construction should include, as relevant:

- the activities that require supervision by a licensed bat worker
- how to recognise a bat; what to do if a bat is found during work (notably for unexpected discoveries when a licensed bat worker is not present); what to do/record if droppings are found
- methods to minimise killing and injury (e.g. removing roof tiles by lifting not sliding to avoid injuring bats that may be underneath; checking on their underside prior to stacking/disposal to ensure no bats are clinging to the underside)
- methods to minimise disturbance (including timing restrictions)
- lighting restrictions

Emergency Works

6.10.10. Where there is an immediate danger to the public, a decision may be made to undertake actions outside of licensing. According to published guidance, immediate danger:

> *"… should reasonably be interpreted to mean that the structure or tree will fail or collapse, and is at risk of harming the public, within a short timescale (e.g. hours or days rather than weeks) and thus gives little scope for obtaining a licence"*[97].

97. See Annex D of Natural England guidance *European Protected Species: Mitigation Licensing - How to get a licence* (WML-G12) (2013), page 62.

6.10.11. Please note, however, that there is no defence under the Habitats Directive, or the various Habitats Regulations transposing the Habitats Directive into domestic law, which allow for emergency works. The only statutory defence that may apply in these circumstances is under the W&CA where (as discussed above) it can be demonstrated that the "act was the incidental result of a lawful operation and could not reasonably have been avoided". However, this defence only has the potential to protect against the bat offences under s.9(4)(b) and (c); it does not protect against the Habitats Regulations offences.

6.10.12. In all such cases, it would be advisable to contact the relevant SNCB, if circumstances allow, to determine if a licence might be available at very short notice (i.e. do not assume that this would not be possible). If this is not possible, then expert legal advice should be sought before proceeding.

6.10.13. In practice, it will rest with the relevant authority to judge, at their discretion, whether or not to take enforcement action when wildlife offences were carried out in an emergency. In accordance with the Code for Crown Prosecutors, a prosecution will usually take place unless the prosecutor is of the view that the public interest factors tending against prosecution outweigh those tending in favour, and unless the evidence is insufficient.[98]

6.10.14. The following steps are recommended where a decision is made to continue with emergency works:

- employ all possible measures to minimise damage and harm to bats (including appropriate provision for any bats needing to be caught and released or taken into care);
- inform the police that an offence is about to be committed (or has been committed by exposing a roost, and works need to continue);
- ensure detailed written records of all planning/survey work undertaken are kept to demonstrate good practice (this will strengthen the case for the actions being 'reasonable');
- ensure that a written record is kept of the date, the decision, names of persons involved and times and details of the actions, as well as a photographic record; this should include supporting written evidence from an appropriately qualified person, such as a structural engineer, arboriculturist or tree surgeon (as appropriate) to support any claim of *immediate danger;* and
- ensure that appropriately qualified persons plan and carry out the work to minimise ecological impacts.

6.10.15. Ideally, suitable compensation for any impacts would be agreed with the police (and preferably the SNCB) prior to works commencing. If the site is subject to a subsequent licence application, the incident should be referenced.

98. See https://www.cps.gov.uk/publication/code-crown-prosecutors

7. Mitigation and compensation: habitat loss, degradation and fragmentation

7.1. Introduction

7.1.1. Bats need places of shelter (roosts), habitats in which to forage, and safe connected flight-lines between these. Whilst the previous chapter (and much mitigation effort) is focused on roosts, the landscape around those roosts and beyond is as important, and arguably more so. Habitat quality is likely to be the overriding factor determining species presence, so this chapter should not be treated as the 'poor relation' or a bolt-on to the previous one. The most successful mitigation strategies are those which consider all needs.

7.1.2. This section describes methods used to mitigate (or compensate for) impacts to bat habitat, following the mitigation hierarchy. In line with the aim to avoid repetition, where standard recent texts are available, these are signposted not condensed. Only a brief summary of what each text covers is provided, to direct consultants to appropriate resources.

7.1.3. As in the previous chapter, methods to avoid impacts (e.g. leaving a commuting corridor or important foraging area intact by changing an element of a design that would have removed or degraded it) are not described here but should always be considered first. It is always advisable to involve an ecologist at an early stage, as the many factors that could affect habitat quality (as well as habitat loss) may not be readily apparent to the design team.

7.1.4. As in the previous chapter, timing is an important tool in avoiding or reducing impacts, and the same periods of vulnerability apply. When assessing impacts, the focus is often on avoidance during the bat active season, but note that bats are not dormant throughout the entire hibernation season, and rely on habitats close to their winter roosts.

7.2. Mitigating habitat loss and degradation

7.2.1. Habitats may be lost temporarily or permanently, directly or indirectly, as outlined in **Chapter 4.0**). While these factors dictate the *extent* and *duration* of mitigation required, the principles are the same. Understanding a species' ecology, and the key functional aspects and benefits of different habitats, are key to the design and implementation of habitat provision for specific impacts, though more than one species or species group may benefit.

7.2.2. Such habitat provision (excluding mitigation/compensation required by any EPS licence) may also contribute to net gain, and BCT have recently (2020) published Good Practice Principles for Biodiversity Net Gain with a focus on bats and their Core Sustenance Zones[99]. It may also contribute to the Nature Recovery Network[100], a UK government-led initiative that "aims to restore habitats to encourage biodiversity, linking together [the] very best nature-rich places [and] restore landscapes in towns and the countryside".

7.2.3. EUROBATS (Kyheröinen *et al.*, 2019) has recently published guidance on the conservation and management of critical feeding areas and commuting routes for bats. It includes general management principles for the protection and enhancement of woodland, waterbodies, agricultural landscape, urban areas/parks and linear features, and details successful case studies of habitat enhancement for barbastelle and greater horseshoe bats (three of these from the UK). For each species, they provide a summary of their feeding ecology (habitat

99. https://www.bats.org.uk/resources/guidance-for-professionals/bat-species-core-sustenance-zones-and-habitats-for-biodiversity-net-gain
100. https://www.gov.uk/government/publications/nature-recovery-network

and diet) and commuting behaviour, and a bullet-point list of recommendations. The guidance is freely available and the prescriptions for each species are not repeated here[101], but include:

- seek up-to-date data on bat species and their habitats (roosts and feeding areas);
- pay attention to the connectivity of landscape, especially between roosts and feeding areas;
- secure good habitat close to important maternity (to support newly-volant juveniles) and hibernation sites;
- avoid fragmenting the landscape by reducing or removing existing structures (especially linear elements) or creating large open areas;
- preserve and create landscape elements such as hedgerows and treelines;
- favour small-scale forest management practices (no clear-cutting);
- retain deadwood and trees with cavities;
- avoid the use of pesticides in forests and anti-parasitic drugs for livestock;
- increase the availability and quality of riparian habitats, including ponds and streams;
- support ecological measures to increase insect biomass and arthropod diversity within feeding areas;
- maintain dense riparian vegetation, especially marshes, shrubs and broadleaved trees; and
- avoid light trespass to bat habitats.

7.2.4. These principles are universal. For the species-specific measures, as the guidance covers the entire EUROBATS range, it should be supplemented with UK and regional guidance so that it is locally relevant. Examples related to habitat management in the UK include:

- Habitat management for bats – *A guide for land managers, landowners and their advisors* (Entwistle *et al*., 2001).
- *The complete hedge good management guide* (Hedgelink, 2013).
- *Hedge management for greater horseshoe bats* (Devon Greater Horseshoe Bat Project, 2018a).
- *Rivers, streams and ponds for greater horseshoe bats* (Devon Greater Horseshoe Bat Project, 2018b).
- *Landscape and urban design for bats and biodiversity* (Gunnell, Grant & Williams, 2012).
- *Conserving grey long-eared bats in our landscape: a management plan* (Razgour *et al*., 2013) which includes recommendations for habitat management.
- BCT collate a wide-range of woodland/tree management resources on their web-site[2].
- The Ancient Tree Forum web-site provides links to resources which the Ancient Tree Forum and its partners have produced[102].

7.2.5. The aim of creating habitat for bats is principally to promote prey biomass. Andrews and McGill (2022) have collated and published an account of "bat prey species associations for bat resident in the British Isles for use in designs proposed for the creation and enhancement of bat hunting habitat". The primary tool is an Excel spreadsheet that can be downloaded free of charge from www.aecol.co.uk and consulted to help ensure that the habitats to be created will be of benefit to the bat species for which habitats are being designed.

7.2.6. There is also regional/local planning guidance, some of which includes habitat management advice (see **Section 7.4**).

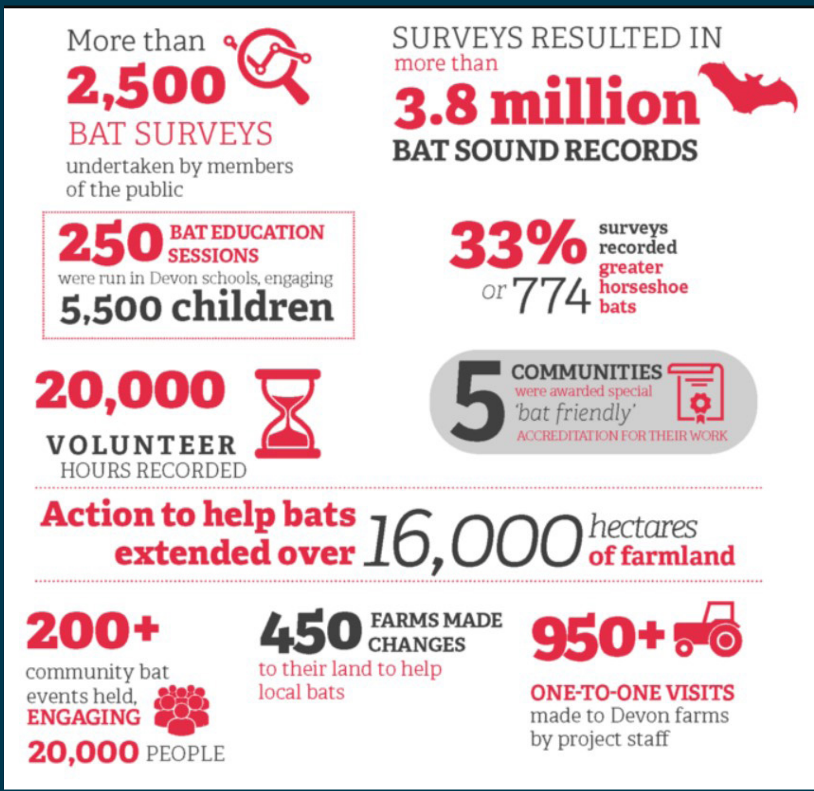
7.2.7. Importantly, any habitat measures should be secured via planning conditions, legal consents or alternative funding mechanisms, and their management safeguarded in the longer term (see **Section 5.4** and **APPENDIX 3**) These should be sufficiently comprehensive that important features, whether retained, created or enhanced, should be buffered and protected from further development or land use change.

101. A small caveat is that the guidance applies Europe-wide and, while they are relatively high-level, the individual recommendations prescriptions may need to be interpreted differently within the UK regions.

102. https://www.ancienttreeforum.org.uk/resources/ancient-trees-books-shop/; in particular, publications by Read (2000) and Lonsdale (2013) on veteran tree management.

7.2.8. Successful mitigation may require the cooperation of multiple landowners (e.g. farm clusters[103]). The Devon Greater Horseshoe Bat Project[104] , which ran from October 2015 until January 2021, was a very large-scale (county-wide) initiative that used multiple methods to engage local communities, landowners and other stakeholders.

Box 7.1: Outreach generated from the Devon Greater Horseshoe Bat Project (reproduced with permission)



7.2.9. Other landscape-scale projects are included under the 'Back from the Brink'[105] initiative, which includes a project focused on the grey long-eared bat (Razgour *et al.,* 2013).

7.3. Mitigating fragmentation

7.3.1. Linear infrastructure can act as a direct physical barrier to movement by making bats reluctant to cross, or unable to cross safely (Laforge *et al*., 2019). Part of the solution to this is to provide safe crossing-points to reduce mortality, and this is detailed in **Chapter 8.0**. However, they can act as an indirect barrier, which also leads to populations becoming fragmented.

7.3.2. Fragmentation is often caused by habitat loss, particularly the severance of commuting routes between roosts and foraging areas. However, even low-medium traffic roads can have a major negative impact on bat activity,

103. https://www.farmerclusters.com/

104. https://www.devonwildlifetrust.org/what-we-doour-projects/devon-greater-horseshoe-bat-project;
flip-book: https://www.flipsnack.com/devonwildlifetrust/dghbp-online-book-final/full-view.html;
final report: https://www.devonwildlifetrust.org/sites/default/files/2021-02/Devon%20Greater%20Horseshoe%20Bat%20Project%20Final%20Report.pdf

105. https://www.bats.org.uk/our-work/landscapes-for-bats/back-from-the-brink

with negative effects said to extend to about 300 m from the roads in woodland and >500 m in open field habitat (Medinas *et al*., 2019). The same study also found that habitats that were of high suitability for bats buffered the negative effects of roads. Mitigation measures considered should therefore include:

- bolstering existing alternative commuting routes (preferred) by filling gaps;
- retaining suitable buffers, and securing long-term management;
- measures to improve habitats (even in the absence of direct habitat loss); and
- providing new alternative commuting routes.

7.3.3. In habitat management, both the management of roadside vegetation and bat habitat improvements in areas that are further from the roads should be considered to mitigate the negative effects of roads but, in road-dominated landscapes, there are trade-offs between habitat management and road-kill risk if road verges are enhanced to provide good foraging opportunities (Medinas *et al*., 2019).

7.3.4. Elmeros *et al*. (2016) summarised the evidence for the effectiveness of alternative commuting routes, though more research is needed. Alternative commuting routes can be temporary (to address disruption during construction) or permanent.

- All such routes should be well connected to existing flight-paths.
- Plants used to create a permanent commuting route should be of an adequate size; Elmeros *et al*. (2016) recommend 3-5 m high trees of fast-growing species which should be planted as early in the construction phase as possible.

7.3.5. Older/taller plants can provide a more immediate benefit, but take longer to establish with a higher proportion of failures. It may therefore be better to use smaller stock, but this will depend on the lead-in time to the impact and the critical nature of the feature being replaced. Establishment periods can vary considerably with size of stock, timing of planting, underlying geology and weather. A landscape architect may need to be consulted to ensure best practice in terms of timing, establishment periods/care, maintenance, species choice (appropriate to region/area, resistance to climate change and diseases) and so on. An example is shown in **Box 7.2.**

Box 7.2: Lines of planted willow leading to a culvert

Lines of planted willow leading to a new culvert entrance (photo taken from culvert mouth). Photograph by K. O'Neill.

7.3.6. Temporary hedging may be needed to provide continuity in the short- to medium-term while permanent plants mature.

- Temporary flightlines (TFLs) should be at least 2 m high, without gaps, and left *in situ* and maintained until permanent flightlines have become established.
- TFLs may comprise a line of potted shrubs/trees, screening, and/or temporary fencing: **Box 7.3.**

Box 7.3: Alternative flightlines to guide bats to structures

Dead painted birch twigs in boxes (light-weight and inexpensive); could give more height to a TFL (above). Instant 'textured' plastic hedgerow (front and rear faces) (right). Spotted in Europe (not in use as mitigation); efficacy not tested.

Photos: P. Reason.

7.3.7. More robust/complex TFL designs are being used on some projects, and one design which has been monitored (albeit briefly) can be found in *British Island Bats Vol 3* (Slack & SPA, 2022). This is based on Heras panels covered with camouflage netting (see **Box 7.4**). An important consideration for all such designs (G. Slack, pers. comm.) is that the wind-loading on a covered Heras panel is substantial. In that study, the initial standard single line of Heras fence was replaced with triangular bracing, design resulting from calculations to ensure it could resist the high winds experienced. In addition, two strands of paracord secured the camouflage netting to the fence panels by weaving them in and out of the net and the metal grid (one line about quarter of the way up the panel and a second about three-quarters up).

Box 7.4: Covered Heras panels (Slack & SPA, 2022)

Front face of panels (Photo: G. Slack).

Rear face of panels showing triangular bracing (Photo: A. Logan).

7.3.8. Other robust designs, used during the construction of the HS2 railway, are shown in **Box 7. 5.**

Box 7. 5 TFLs of different designs as used on HS2 (credit: HS2 Ltd/EKFB)

Single-width flightline

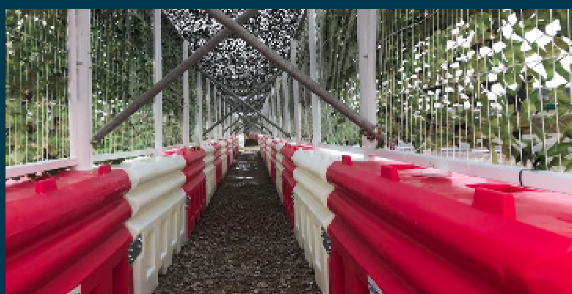
Single-width flightline: close-up

Interior of double-width flightline

Trees in Intermediate Bulk Containers spaced 10m apart

Willow fencing – front and back

Semi-permanent scaffolded flightline



Interior of semi-permanent scaffolded flightline

7.3.9. When designing a temporary hedge, there is likely to be a trade-off between ease of movement and robustness. The designs shown above (**Box 7.4 a**nd **Box 7.5**) have multiple components and cannot be moved easily, so would not be acceptable where daily movement for access is required. One solution is to use more mobile units to create the flightline; another is to include vehicle gateways within the above design.

7.3.10. Features used as flightlines act as navigational aids, but also provide shelter, protection from predators and foraging opportunities. New features to support flightlines should therefore be of a sufficient size and height to provide all of these benefits in most situations. There has been no research to establish the minimum acceptable dimensions of such features, but the Trowbridge Bat Mitigation Strategy (Wiltshire Council, 2020) recommends that hedgerows used for bat mitigation must be capable of being managed to meet the following criteria:

- at least 3 m wide;
- at least 3 m high;
- contain standard trees planted frequently along their length;
- be cut/trimmed every 2-3 years; and
- have sufficient space adjacent to the hedgerow to allow for 2-3 years growth and access for maintenance, with this area to be managed as species-rich grassland (no spraying or mowing at hedge base).

7.3.11. Guidance to protect bats from waterside developments (BANES, 2018) also advocates outgrown mature hedgerows (noting that heavily clipped low hedges/tree-lines are not suitable) and adds that dark corridors should be:

- well-connected within the bat landscape, linking to existing flight-paths, roosts or foraging areas; and
- planted with native species to encourage insect populations, thereby allowing bats to forage along the corridors.

7.3.12. Green bridges can provide safe crossing-points (thereby reducing mortality; see **Chapter 8.0**) as well as mitigating the impacts of fragmentation. The Infrastructure Ecology Network Europe (IENE) publishes (and regularly updates) their Wildlife and Traffic handbook, which is a source of information and 'lessons learned' from across Europe.

7.3.13. Few substantial green bridges have been created in the UK to date. A notable example is the Scotney Castle landscape bridge over the A21 Lamberhurst bypass in Kent. This is a substantial (30 m wide) structure and, although it carries a paved minor road, it is well vegetated with dense and continuous mature trees and shrubs along each side that are well connected with treelines and surrounding woodland. Although not constructed primarily for bats, Berthinussen & Altringham (2015) judged this structure to be effective in guiding bats safely over roads, with 97% of bats using it to cross. It has subsequently set the template for five green bridges crossing the HS2 railway. These 'Type 1' bridges, in Bernwood Forest in Buckinghamshire (an area which supports Bechstein's bats), will similarly have an overall minimum vegetated width of approximately 30 m[106]. 'Type 2' bridges, designed to minimise fragmentation effects on bats where there are no Bechstein's bats recorded, will be 15 m wide. As these bridges are yet to be built, their effectiveness remains to be confirmed; their monitoring will inform design principles to be included in the next iteration of these guidelines.

7.3.14. At the time of writing, a 30 m width is aspirational (based on the Scotney Castle example), and the need for such a wide and expensive structure should be determined in the basis of risk (the conservation status of species that may be affected), and the feasibility of incorporating such a large structure into the landscape. In many circumstances, the optimal width will be influenced by landscape, topography and the extent of habitat loss required for construction.

106. https://www.gov.uk/government/publications/high-speed-rail-london-west-midlands-bill-register-of-undertakings-and-assurances

7.3.15. Fragmentation can also occur where both linear and footprint developments cause disturbance through noise and light-spill, effectively degrading habitats by making them inaccessible or unattractive to bats, or acting as a barrier.

Mitigating the impacts of lighting

7.3.16. The Institution of Lighting Professionals (ILP), BCT and, separately, EUROBATS, have published detailed guidance on the impacts of lighting on bats and how to mitigate these when designing lighting schemes (ILP, 2023; Voigt *et al*., 2018). The guidance highlights the importance of early involvement and collaboration between a lighting professional and the ecologist. This will help to ensure that the design is informed by a baseline lighting survey, that all features of importance to bats are considered, and both internal and external lighting are modelled. Lighting assessments on the vertical plane are also recommended, and increasingly requested by planning authorities, as they are a more effective way to demonstrate that retained habitat will remain dark.

7.3.17. The UK guidance includes the following mitigation techniques:

- dark buffers and concentric zonation;
- appropriate luminaire specifications;
- sensitive site configuration;
- physical screening;
- dimming and part-night lighting.
- glazing treatments on buildings;
- creation of alternative valuable bat habitat on site.

7.3.18. It is important to note (and often overlooked) that lighting engineers often model the *contribution* of a new lighting scheme and not the overall light that will be experienced following a development. It is important, therefore, to request baseline lighting levels (horizontal and vertical planes) and likely changes to those levels to get a real indication of the likely impacts. A commuting route where the existing light levels are tolerated by bats, augmented by additional light which seems to be relatively low as modelled, may cumulatively render the post-development commuting route unattractive to light-averse species.

7.3.19. Lighting from headlights (rarely modelled or even considered) may also need to be controlled/limited by screening if there will be frequent vehicle movements next to features used by bats. In these cases, permanent structures such as bunds are preferred to, for example, fencing, which can be lost over time.

7.3.20. Examples illustrating some of the principles above are provided below and in **APPENDIX 4.**

7.3.21. Case study: 'Bat-friendly' wildlife crossing installed in Netherlands[107]

In a 'world-first', the Rijkswaterstaat in the Netherlands (Directorate-General for Public Works and Water Management) installed 'Batlamps' in the construction of an 'ecoduct' over the A74 motorway near Tegelen in 2011. The Batlamp, which has a long lifespan and requires little maintenance, contains LED lights that emit UV-free amber light. This has been chosen as bats do not avoid this light, but people can still clearly perceive the traffic situation. In addition, the lighting columns are no higher than 6 m; the road lighting only comes on when cyclists or pedestrians pass; and an astronomical clock determines the switching on and off of the lighting. When switched on, the lamps come on slowly; when switched off they dim gently. The Batlamp has now been used in many projects in the Netherlands. Rijkswaterstaat now generally prescribes bat-friendly[108] lighting in project plans and it is anticipated that, in the long term, about 5% of the total number of lighting columns will be equipped with bat-friendly lighting. *The lighting avoids fragmentation, but does not provide safe crossing-*

107. https://www.rijkswaterstaat.nl/wegen/wegbeheer/natuur-en-milieu/verbinden-natuurgebieden/vleermuisvriendelijke-verlichting/
108. EUROBATS recommends avoiding the term 'bat friendly' to reflect the fact that all types of lighting may have some level of impact.

points, so the impact of mortality remains. They have mostly been installed in situations where bats would pass underneath highways, and vegetation has been removed along the carriageways where the Batlamps are installed so there are no structures to guide bats across the road (Victor Loehr, pers. comm.).

Check out APPENDIX 4 for another example of a sensitive lighting scheme:

- *Case study 37: Urban riverside lighting; also see case studies included in the latest BCT/ILP Guidance Note 08/23 (ILP, 2023).*

Mitigating the impacts of noise

7.3.22. The study of noise impacts on bats is in its relative infancy, and the circumstances in which noise mitigation might be needed remain uncertain. Tolerance to noise will (almost certainly) differ between species and behaviours (roosting, hibernating, foraging, commuting). The point at which noise causes sufficient disturbance to result in an offence under the legislation in force in each country also differs; see **2.5.6** *et seq*. The need for mitigation in any circumstance will similarly differ (Reason & Bentley, 2020).

7.3.23. Baseline conditions indicate existing levels of tolerance. However, in most situations, the distance at which construction noise attenuates to background noise levels (as suggested by West, 2016) would be over-precautionary. In many cases, appropriate information will be lacking and professional judgement will be required to decide whether construction impacts are likely to be severe enough to trigger detailed bat-specific (i.e. unweighted high-frequency) noise assessments (Reason & Bentley, 2020). More research is needed, but some data collected using appropriate methods have recently become available.

7.3.24. Berthinussen & Altringham (2015) summarised the operational impacts of roads as barriers, concluding that noise (and light) are only likely to have a significant effect over relatively short distances. The operational impacts of noise from many other types of developments may be similar. Again, more research would be helpful.

Table 7.1: Mitigation options (could be combined)

Mitigation options	Likely effectiveness
Managing the times during which noise is produced.	Easier to do for smaller projects or activities of limited duration; very hard to achieve for larger long-term infra-structure projects where noisy processes may be prolonged or part of a critical path. Likely to require good onsite management and with a competent ECoW involved in project decision making.
Locate noise-generating activities away from receptors.	Difficult to achieve for many activities, especially if reliant on data calculated for human receptors to achieve background noise levels, which may over-estimate the distance over which impacts to bats are significant (see Case study 38).
Reducing the noise at source (barriers, different types of plant).	Barriers are easier to implement for small-scale plant; very hard to achieve otherwise (though high-frequency noise is easier to block). Locations of receptors and the likely effectiveness of screening should be assessed before incurring costs. Some plant is inherently less noisy: e.g. vibrating rather than percussive pile-drivers.
Protecting the receptor (barriers).	May be possible for roosts in buildings where the building fabric itself will interrupt some of the noise; very hard to achieve for tree roosts at height. May be possible for commuting routes or foraging areas but could be costly if extensive.
Compensating for lack of access to resources (roosts or foraging areas) should these be affected to the extent that they are no longer attractive to bats, resulting in abandonment or avoidance.	If large-scale effects are predicted (geographical/temporal), compensatory roosts or foraging areas linked by commuting routes should be provided.

7.3.25. If an impact is likely, possible options for mitigation are set out in **Table 7.1**, which includes references to roosts as well as foraging and commuting routes.

Check out the following case study in APPENDIX 4:

- *Case study 39: Barbastelle Tree Roost, Somerset, where construction buffers were imposed.*

7.3.26. Direct observations of bats, in combination with unweighted high-frequency noise measurements where disturbance could be significant, as well as environmental parameters such as light levels, temperature and/or humidity as relevant, should be undertaken where disturbance is possible. This will enable disturbance to be managed/controlled and inform future risk assessments.

Check out the following case study in APPENDIX 4:

- *Case study 40: Management of disturbance.*

7.4. Regional and species-specific guidance

7.4.1. Local planning guidelines are designed to be applied within a specific area and (often) to benefit specific species. Some contain relatively specific guidance on habitat management/creation, or aspects such as lighting. The *principles* can often be applied elsewhere to drive a robust design process, and therefore are included here.

- *Somerset County Council's Habitat Evaluation Procedure* (Burrows, 2016) to evaluate a site's suitability to support bats, in order to determine the minimum area of compensation habitat to mitigate habitat loss. The methodology adopts the CSZ principles for assessing the importance of foraging habitat relative to roost location. The methodology is detailed in the *North Somerset and Mendip Bats SAC: Guidance on Development* (Burrows, 2019c) and *Hestercombe House SAC Technical Guidance* (Burrows, 2019b).
- *South Hams SAC Greater Horseshoe Bats HRA Guidance* (South Hams SAC Steering Group, 2019) clarifies HRA requirements and provides advice on which planning applications may have a likely significant effect on the SAC greater horseshoe bat populations. It identifies sustenance zones (4 km from the roosts) and Landscape Connectivity Zones (LCZ) (landscape between designated roosts and up to 10 km from the designated maternity roosts) and recommends measures to reduce impacts and ensure no adverse effect on the SAC.
- *Waterspace Design Guidance, Protecting Bats in Waterside Developments* (BANES, 2018) applies where developments have the potential to impact on watercourses or key bat habitat linked to the Bath and Bradford-on-Avon SAC. It provides specific advice on avoiding fragmentation through appropriate lighting design.
- *Bat Special Areas of Conservation (SAC) Planning Guidance for Wiltshire* (Wiltshire Council, 2015) is aimed at applicants, agents, consultants and planners involved in producing and assessing development proposals in the landscapes surrounding Wiltshire's most sensitive bat roosting sites.

- *Trowbridge Bat Mitigation Strategy* (Wiltshire Council, 2020) is aimed at developers, consultants and planners involved in assessing development proposals in the landscapes in and surrounding Trowbridge, and provides a clear and detailed approach to considering impacts of development in the Trowbridge area on the Bath and Bradford-on-Avon Bats SAC.
- *Exmoor and Quantocks Oak Woodlands Special Area of Conservation (SAC)* (Burrows, 2019a) is guidance aimed at developers, consultants and planners involved in planning and assessing development proposals in the landscapes used by barbastelle and Bechstein's bats surrounding the SAC. This includes some detailed habitat/prey information.

Check out APPENDIX 4 for Case study 41: Use of a s.106 agreement to secure long-term funding for management of an are close to the South Hams SAC.

8. Methods to reduce mortality

8.1. Overview

8.1.1. The previous chapters largely relate to impacts arising from implementing a development (from siting and design through to site clearance), i.e. construction in the broadest sense. This chapter relates to the risk of mortality from the normal operation of wind farms and linear infrastructure. However, in keeping with the aim to avoid repetition in this document, where specific and detailed guidance has already been published, this is signposted, not condensed. Only a brief summary of what each text covers is provided, to direct consultants to appropriate resources.

8.1.2. There is cross-over between the measures needed to address fragmentation (such as green bridges) and mortality (safe crossing-points). Green bridges are discussed in relation to fragmentation in the previous chapter but also provide safe crossing-points. A 'whole landscape' approach can contribute to the effectiveness of such specific mitigation (Laforge *et al*., 2019).

8.2. Mitigating mortality from linear infrastructure

8.2.1. Underpasses (including culverts) and overpasses (bridges) are widely used as mitigation measures to allow bats to cross road and rail schemes safely, reducing mortality (and also fragmentation).

8.2.2. Comprehensive reviews of the effectiveness of mitigation measures implemented for highway severance have been published by O'Connor and Green (2011) and Berthinussen and Altringham (2015). Based on the available evidence, Berthinussen and Altringham (2015) provided a series of 'Best practice principles' for bat mitigation along linear transport infrastructure, as follows:

- **Mitigation should be integrated into the scheme from the earliest opportunity**
  Mitigation should be considered during the planning and design stage of the infrastructure so that it can be incorporated effectively.
- **Crossing structures should be placed on the exact location of existing bat commuting routes**
  Attempts should not be made to divert bats from their existing commuting routes.
- **Crossing structures should not require bats to alter flight height or direction**
  This will depend on the topography of the site. If the road is to be elevated above ground level, an underpass may be used to preserve the commuting route below it. If the road is in a cutting, a green bridge may be used to carry the commuting route over the road.
- **Crossing structures should maintain connectivity with existing bat commuting routes**
  Connectivity must be maintained with undisturbed bat flight-paths (e.g. treelines, hedgerows, woodland rides and streams), and bat habitat (e.g. woodland) within the surrounding landscape. Crossing structures should not be exposed or sited within open ground.
- **Over-the-road structures such as green bridges should be planted with vegetation**
  Vegetation should be continuous and connected (see above) and sufficiently mature before road construction (e.g. by planting either relatively mature trees or fast-growing tree species in advance of construction commencing) to ensure 'continued ecological functionality'.
- **Underpasses should be of sufficient height**
  Underpasses should be as spacious as possible with height being the critical factor. The minimum requirements for underpass height will be species-specific. Required heights will generally be lower for woodland-adapted species (around 3 m) compared to generalist edge-adapted species (around 6 m), but larger underpasses will accommodate more species (*see the CEDR report* (Elmeros *et al*., 2016) and the *A40 case study* (Davies, 2019) for specific information on culvert dimensions, both described below).

- **Green bridges should be of sufficient width**
  In addition to being vegetated, green bridges should be as wide as possible, to provide a large area for bats to commute across. Further research is needed to determine optimum dimensions [*see 7.3 Mitigating fragmentation for more on green bridges, and check out Case study 42: A487 Porthmadog, Minffordd and Tremadog Bypass*.]
- **Crossing structures should be unlit**
  The effects of light on bats are species-specific and lighting should be avoided. [Refer *to Case study 43: Maes-yr-Helmau to Cross Foxes Improvement Scheme* for how *lighting has been used in combination with safe crossing-points to reduce mortality*.]
- **Access and connectivity must be maintained**
  It is important that access to crossing structures is maintained (e.g. grilles should not be installed on underpasses) and that connecting vegetation is retained indefinitely or for as long as the mitigation structure is required.
- **Disturbance should be minimised during installation of mitigation structures**
  For example, by limiting noise and light pollution along the bat flight-path, minimising vegetation clearance, installing suitable temporary crossing structures (which should also be subject to monitoring and evaluation), completing the installation as quickly as possible, and ideally avoiding the summer months when bats are most active.

8.2.3. Clearly these principles must be integrated into the design from a very early stage, based on a sound knowledge of bat presence, status and behaviour. This will require **significant** collaboration with designers/ engineers. A challenging example is the maintenance of vegetation over green bridges, which requires a structure that will support an adequate soil depth as well as irrigation/ drainage mechanisms to keep plants healthy in the long term.

8.2.4. The above principles do not adequately address circumstances where linear infrastructure bisects larger woodland blocks, and bats do not have clear crossing-points where mitigation could be targeted and/or forage along existing transport corridors that are to be upgraded. In such circumstances, the impacts are likely to be determined by the species present, their use of the surrounding landscape, and topography (amongst other factors). As the solutions are equally complex and need to take into account many factors other than ecology, they fall outside of the scope of these guidelines.

8.2.5. As with all interventions specified in this document, further research, appropriate monitoring and documenting results from future mitigation schemes will improve the evidence base and these principles. In addition, effectiveness must be properly defined and measured. Berthinussen & Altringham (2015) recommended that, to characterise a crossing structure as effective, at least 90% of crossing bats should use the structure to cross the road safely, and the number of bat passes at the site should not be substantially lower than before the road was constructed. In some circumstances, where rarer species are affected, the relevant SNCB may request higher levels of certainty (for example, Bechstein's bats crossing HS2).

8.2.6. Advice has also been published in Europe by the CEDR Transnational Road Research Programme (Elmeros *et al*., 2016). The guidelines comprise three main parts:

- relevant bat biology and species differences which must be considered when planning and developing road and railway infrastructures;
- methods for pre- and post-construction surveys and monitoring of effectiveness of mitigation measures;
- best practice mitigation recommendations based on reviews of published evidence of bats' use and the effectiveness of bat mitigation measures.

8.2.7. Particularly helpful is the division of bats into five functional groups, dependent on the ecological niche they occupy (e.g. bats that feed in clutter or in the open), and relating this to the types and sizes of mitigation that would be suitable in different circumstances (for example, culvert dimensions). These groups are reproduced in **Table 8.1.**

Table 8.1: Functional groups of UK bat species (taken directly from Elmeros *et al.,* (2016))

Group	Behaviour	UK species
Group A	Extremely manoeuvrable bats, which often fly within foliage, or close to vegetation, surfaces and structures at variable flight heights. When commuting, they often follow linear and longitudinal landscape elements. Low-flying (typically < 2m) when commuting over open gaps.	Lesser horseshoe bat Natterer's bat Bechstein's bat Brown long-eared bat Grey long-eared bat
Group B	Very manoeuvrable bats that most often fly near vegetation, walls, etc. at variable heights but occasionally hunt within the foliage. When commuting, they often follow linear and longitudinal landscape elements. Flying at low to medium height when commuting over open gaps (typically < 5 m).	Greater horseshoe bat Daubenton's bat Brandt's bat Whiskered bat Alcathoe bat
Group C	Bats with medium manoeuvrability. They often hunt and commute along vegetation or structures at variable heights, but rarely close to or within the vegetation. May also hunt in open areas. Commuting over open stretches generally takes place at low to medium heights (typically 2–10 m) with no clear tendency to lower flight.	Greater mouse-eared bat Common pipistrelle Soprano pipistrelle Nathusius' pipistrelle
Group D	Bats with medium manoeuvrability with a [more direct] flight pattern than bats in Category C. They hunt and commute ... away from vegetation and structures [at] a variety of flight heights. May occasionally fly but never hunt within vegetation. Commuting over open stretches tends to occur at medium heights (2–10 m) with no clear tendency to lower flight.	Serotine Barbastelle
Group E	Less manoeuvrable bats that most often fly high and in the open airspace away from vegetation and other structures. These bats generally commute over open stretches at medium heights or higher (10 m and often higher). It must be stressed that even these species may fly quite low over open areas under certain conditions, e.g. when hunting insects over warm (road) surfaces, or when they emerge from a roost site.	Noctule Leisler's bat

8.2.8. The mitigation reviewed by Elmeros *et al*. (2016), and its effectiveness, includes: bat gantries (unlikely to be effective); hop-overs (limited circumstances and species-specific responses); wildlife overpasses; modified overbridges and other technical structures; underpasses, culverts and tunnels; and viaducts and river bridges. Best-practice principles for each type of mitigation, supported by a literature review and links to case studies, are included. The guidelines also cover related impacts of lighting and noise as contributors to fragmentation, to a limited extent.

8.2.9. Examples illustrating some of the principles outlined above are provided below; see also *Claireau et al*. (2019).

8.2.10. Case study: Monitoring the effectiveness of mitigation for horseshoe bats associated with a new road in Wales (Davies, 2019).

Mitigation for foraging habitat loss, fragmentation and traffic collisions was provided for greater and lesser horseshoe bats associated with the Slebech Park roost within Pembrokeshire Bat Sites SAC. 'Safe' bat crossing points were provided on existing flight-lines, in the form of open-span bridges, equestrian underpasses, a cattle underpass and over-sized drainage culverts. Mitigation areas were created as replacement foraging habitat (swales, hazel translocation, hedgebanks) and to guide bats towards the new crossing structures. The mitigation measures were designed and positioned to increase the likelihood of their use by bats. The cross-sectional area of a crossing was positively correlated to the proportion of bats crossing safely, ranging from 15% for a 750 mm culvert, to >85% for cattle/equestrian underpasses and a box culvert. In hindsight, it would have been cost-effective to over-size even more of the culverts and increase permeability further (but in fact, the scheme is very permeable to bats given the crossings that were over-sized).

8.3. Wind turbine-related mortality

8.3.1. EUROBATS (Rodrigues *et al*., 2014) reviewed the evidence of the impacts of wind turbines on bat populations, and developed guidelines for assessing potential impacts on bats, taking into account their ecological requirements. These guidelines were designed to form the basis for each country to develop their own national guidelines.

8.3.2. The EU have subsequently published broader guidance on wind energy developments and nature legislation (Directorate-General for Environment (European Commission), 2020). This supersedes the 2011 EU guidance which focused on Natura 2000 sites and the species for which they were designated, thereby excluding the majority of bat species known to be most at risk from mortality caused by wind turbines. The more recent volume builds on Rodrigues *et al*. (2014) and summarises recent research from across Europe. In 2022, a new EUROBATS resolution was adopted[109] which places broader range of requirements on member states (including assessing impacts in offshore developments, and conducting pre- and post-construction monitoring).

8.3.3. The EUROBATS guidelines have been adapted and interpreted in a UK context by the UK SNCBs and other members of a Steering Group, who have jointly published comprehensive guidance relating to bats and onshore wind turbines (NatureScot *et al*., 2021). These supersede guidance published by Natural England in 2012 (Natural England, 2014) and BCT (Hundt, 2012).

8.3.4. Mitigation begins with an assessment of risk, which considers the likelihood of high-risk species and site-based risk factors, using a two-stage process which takes local bat activity records into account through reference to Ecobat[110]. This process is intended to identify those sites which are of greatest concern in terms of potential collision risk, though caution and professional judgement are required in interpreting the results, even where the results suggest the risk could be low.

8.3.5. Avoidance is the primary means of avoiding impacts:

- siting turbines away from bat migration/commuting routes and important foraging/roosting areas;
- creating buffer zones around nationally and regionally important roosts;
- establishing a buffer to other habitats specifically important for bats (tree lines, hedgerow networks, wetlands, waterbodies, and watercourses); and
- adjusting the layout of turbines.

8.3.6. It is important to note that UK advice diverges significantly from EUROBATS' in terms of the recommended distance from woodland and other important habitats.

8.3.7. Strategies to reduce mortalities by altering blade rotation (NatureScot *et al*., 2021) comprise:

- reduced rotation speed while idling (feathering).
- curtailment (raising the cut-in speed for power generation)

8.3.8. These systems can be applied bluntly (between dusk and dawn over the entire bat active period), or using more sophisticated mechanisms which respond to environmental data (wind speed, temperature, acoustic bat records): 'smart curtailment'.

Bat Deterrents

8.3.9. Sonic bat deterrents modify bat behaviour and have been trialled for use in a range of situations, including churches (to control the areas to which bats have access (Zeale *et al*., 2014; Packman *et al*., 2015); a tunnel-like structure (Burton, 2019); and wind turbines.

8.3.10. While deterrents show some promise for reducing mortality at wind turbines (Weaver *et al*., 2020), the results indicate species- and location-specific responses, i.e. only some species and locations show reductions in fatalities (Romano *et al*., 2019; Arnett *et al*., 2013). More research is required to improve species-specific

109. https://www.eurobats.org/sites/default/files/documents/pdf/Meeting_of_Parties/Resolution%209.4%20Wind%20Turbines%20and%20Bat%20Populations.pdf

110. A measure of relative bat activity can be obtained using the secure online tool *Ecobat* (http://www.mammal.org.uk/science-research/ecostat/), initially designed by the University of Exeter and now hosted and developed by the Mammal Society and the University of Sussex (Lintott *et al*., 2018). The tool compares data entered by the user with bat survey information collected from similar areas at the same time of year and in comparable weather conditions.

effectiveness. As of now, they cannot be recommended in place of the measures outlined above; and their effectiveness is likely to be limited in turbines with blades >110m because of the rapid attenuation of high-frequency noises in air.

9. Monitoring

9.1. Introduction to post-development monitoring

9.1.1. There is a broad consensus that monitoring to date is often incomplete, inadequate and/or poorly reported (even when the mitigation itself is successful). Building the evidence-base of what works and what does not (and defining what is meant by 'works') is essential to reduce impacts on bats, improve outcomes and avoid ineffectual expenditure (a poor conservation message).

9.1.2. There are two distinct stages of post-development monitoring:

- ensuring all mitigation is implemented as stated (not least, to ensure compliance with any licences and planning conditions in force); and
- assessment and reporting of outcomes.

9.1.3. This chapter focuses on *post-development* monitoring; however, a range of survey methods are very likely also to be required *prior* to and *during* project implementation, both as part of working methods (PWMSs etc) and to ensure compliance with licences (see **Section 5.4**).

9.1.4. Every mitigation scheme should be supported by a monitoring strategy, however brief, which should identify:

- who is responsible for monitoring;
- how it will be funded;
- how the monitoring will be carried out (methods, equipment, survey effort, licensing);
- how access for monitoring will be ensured (even after assets have changed hands);
- how and when the results are to be reported, and to whom; and
- the party(ies) responsible for any remedial measures that are required.

9.1.5. The monitoring strategy should:

- define the elements that are to be monitored, and when (noting 9.1.3);
- have clearly defined and ideally measurable objectives;
- include a clear definition of success for each mitigation and compensation feature;
- include proportionate and appropriate methods for data collection and analysis;
- outline triggers (thresholds) for remedial action, and what that remedial action should be; and
- contribute to a wider understanding of the measures applied (see 9.2.10).

9.1.6. Funding can be contentious, and it can be difficult to ensure all monitoring commitments are met and all remedial measures secured. This is particularly true for long-running projects where the last few years of after-care and monitoring may take place well after contractors have left site, or where assets have been sold. **It is therefore advisable for funds to be secured and ring-fenced upfront** (perhaps linked to a s.106 agreement or equivalent) to ensure long-term compliance.

Check out APPENDIX 4 for Case study 41: Use of a s.106 agreement to secure long-term funding for management of an are close to the South Hams SAC.

9.2. Setting monitoring objectives

9.2.1. **Stage 1 – ensuring that all mitigation has been implemented as designed.** This stage should begin during construction, and continue until all elements are in place (and all remedial requirements resolved). Complex proposals will require the involvement of other disciplines such as lighting engineers or landscape architects, and their roles and responsibilities should all be defined. As noted in **Section 5.5,** this stage extends throughout construction and beyond, and requires compliance checks against design objectives at regular intervals.

9.2.2. **Stage 2 – the level of detail collected should be sufficient to determine whether or not the monitoring objective has been met.** Licences are granted on the assumption that the test of maintaining FCS can be met, therefore the objective(s) set and data collected should demonstrate that this test has indeed been met. Examples of suitable objectives are set out in **Table 9.1,** reflecting the original impacts. Identifying only the 'presence of bats' on a site where higher-status roosts have been affected is rarely sufficient.

Table 9.1: Example tests for monitoring objectives and triggers for remedial actions.

This assumes that all measures have already been implemented as intended, and there are no remedial actions outstanding. **(Note that 'implemented as intended' should be interpreted in spirit; it should not prevent improvements being made to the original mitigation proposed should new information come to light).**

Objective (suitability determined by nature of impacts)	Test	Trigger for remedial action [notes]
The low-value compensation roost (e.g. a day roost) is being used by bats or The low-value compensation roost is being used by bats of the same species as the roost lost	Confirming the condition and suitability of the roost, in compliance with the agreed mitigation proposal, may be sufficient (unless the roost can be directly inspected for evidence).	None [there will be an element of chance to re-occupation] Note: the value of presence/absence monitoring for this type of compensation roost should be carefully considered, particularly where use is likely to be intermittent, and a negative result would not be informative[111].
The compensation roost is being used by the same species of bats, using the roost for the same function (e.g. night-roost, maternity) as the roost lost.	Evidence of species, status, numbers, assessed at appropriate time(s) of year.	None, assuming all measures are implemented as intended and an appropriate temperature regime is in place. [There will be an element of chance to re-occupation]
The compensation roost provides an acceptable range of temperatures (or humidity).	Temperature logger data, ideally compared to temperature measurements in the original roost.	Temperature data indicate no critical areas of the roost reach the temperatures required, and amendments are needed (e.g. a hot box added).
New access points are being used. [it may be possible to test this before existing access points are lost – see Reason (2017)]	Observations of bats exiting and returning to the roost via the new access points (or alternatives they have found that provide the same function).	Potentially none. If the roost is not in use, consider amending, moving or adding access points. [will not be appropriate or possible in all circumstances, and will depend on the value of the roost]
Commuting route is still being used.	Bats recorded/observed following the new commuting route *or*, where critical, the species/number or proportion of bats doing so is within specified range.	Bats are not using the new commuting route. [If not used, look for reasons: is the roost still in use; is the commuting route subject to new disturbance; has connectivity been breached; has any planting failed – and address these as necessary]
An alternative commuting route is being used.	Bats recorded/observed following the new commuting route *or*, where critical, the species/number or proportion of bats doing so is within specified range.	
Light levels (to be specified) are acceptable on commuting routes.	Light levels (observations of bat behaviour may also be warranted).	Light levels exceed levels specified in conditions/lighting strategy.
New habitat is increasing in value to foraging bats.	Habitat condition assessments Bat passes increase over time (standardised measure using the same equipment). Prey availability increases over time (moth-trapping or dung-beetle counts[112]) – for highest value sites.	Habitat does not meet condition assessment standard required. If bat passes do not increase over time, but the habitat has improved, confirm that bats are still using nearby roost(s) and there are no local trends in numbers.
Where human interference is considered to be a potential impact: foraging or roosting activity levels of key bat species are maintained in adjacent/affected habitats.	Evidence of species presence, status, breeding success, numbers, tree roosts, at relevant time(s) of year.	Reduced roost presence or breeding in more than one year. Loss to vandalism of multiple roosts. Reduction in foraging activity (level of decrease to be specified).
Bats are crossing a new road (or railway) safely.	90% of bats that are crossing the road on any given night are crossing safely, rather than crossing the road at traffic height.	Effectiveness is below 90%.

111. Natural England do not usually require post-development monitoring for proposals affecting low-status roosts where these affect up to three of the more common species (currently defined as common pipistrelle; soprano pipistrelle; whiskered bat; Brandt's bat; Daubenton's bat; Natterer's bat; noctule, brown long-eared bat), and are used by low numbers of each

112. https://www.bsg-ecology.com/portfolio_page/landscove-holiday-park-devon-resolving-sac-issues-and-delivering-biodiversity-benefit-to-horseshoe-bats/

9.2.3. **Case Study:** Hopyard Farm Underpass, A465 Heads of the Valleys, Section 1[113]

Monitoring showed that the Hopyard Farm Underpass continued to be used by lesser horseshoe bats after it was extended and slightly reduced in cross-section during road improvements. It was therefore assumed that the bats were not hindered by new grilles fitted during the improvements, as 'good numbers' were crossing safely. However, later monitoring for a slightly different purpose indicated that a significant number of bats were flying over the road, exposing them to the risk of collision. This observation triggered detailed monitoring, which revealed that up to 30% of bats were crossing the road unsafely. The grilles were removed and replaced with a palisade fence with a gap above; this resulted in 93-98% of bats observed crossing safely by flying through the underpass. This example shows the importance of setting appropriate monitoring objectives: the initial test of 'use' was met but was not enough to identify that a significant proportion of individuals avoided the grille and crossed unsafely. The test here should have been effectiveness from the outset. Applying that test subsequently meant that modifications could be made that resulted in effective mitigation.

9.2.4. To make valid pre- and post-development comparisons, consistent survey methods should be employed. It may be that specific data need to be collected to allow pre-/post-construction comparisons that are robust and repeatable. This means (where possible) selecting and recording parameters in sufficient detail that they are accessible even when personnel change. For example:

- survey types;
- surveyor/equipment locations (grid references);
- equipment makes, models, settings and locations; and (but not limited to)
- dates, weather and other data pertinent to the interpretation/comparison of results.

9.2.5. Ideally, at least some methods should be applicable before and after the development, taking into account the way the site is likely to change. For example, on a linear scheme, designing transects through habitats that are just outside the red-line boundary may make little difference to the habitats sampled, but allow the transects to be repeated post-development (the same could be done with the placement of static detectors).

9.2.6. To understand the reasons for success or failure of compensation roosts, data relating to the original roost(s) such as internal temperatures, humidity[114], volume, adjacent habitat (particularly the presence and placement of vegetation cover, water, artificial lighting and so on) should be collected.

9.2.7. Larger infrastructure schemes with landscape-scale impacts of habitat loss and fragmentation are likely to require similar landscape-scale habitat creation. Woodland habitats could take decades to establish, and this would require multiple generations to be considered in order to fully satisfy the test that FCS has been met. In such circumstances, longer periods of habitat monitoring may be required, and a more holistic approach to monitoring populations considered. These bespoke monitoring strategies would need to be agreed with the relevant SNCB, and are outside the scope of these guidelines.

9.2.8. An example of a large-scale transect study was proposed by Berthinussen and Altringham (2015), but this was not particularly cost-effective nor widely adopted; static detectors and auto-identification software are now more likely to be used. Other strategies are being developed which may prove more cost-effective in the longer term. For example, Wright *et al*. (2018) looked at mitochondrial DNA, and used this to develop a system of population monitoring, albeit over long time-frames at present (Wright, Schofield & Mathews, 2021).

9.2.9. Post-construction monitoring should be reported in sufficient detail to inform a wider understanding of effectiveness. For example, not just the number of bat boxes deployed, but the make and model of bat boxes used, their location, aspect and height, and how this relates to their subsequent use.

113. Case supplied by Richard Green with consent from the Welsh Government.
114. See Kurta (2014) for a review of the use/interpretation of humidity measurements.

9.2.10. Data should be shared with Local Record Centres (often a condition of licensing). Bat ecologists are also strongly encouraged to share their successes and failures by publishing in Conservation Evidence (or other peer-reviewed journals) or uploading to BCT's Roost website.

9.3. Monitoring effort

9.3.1. If the monitoring objectives are well-defined and proportionate to the impacts of a development, and take into account the importance of the resource affected, then the monitoring effort will be driven by the objectives and the effort needed to test these. **Table 9.2** gives indicative monitoring periods for features (roosts, commuting routes and foraging areas) that were impacted and those impacts mitigated. These are a starting-point, not absolutes; deviations should be justified.

9.3.2. Adherence to this table will not guarantee that the relevant SNCBs will approve a monitoring proposal, as each situation is different, and a simple table cannot reflect all considerations. This is particularly true where a development/scheme is complex/multi-phased.

Table 9.2: Indicative periods of monitoring

The point at which monitoring *begins* will be case-specific, driven by the construction programme, the type of mitigation, and the techniques used (see below).

		Importance of resource affected				
		Less than district	**District**	**County**	**Regional**	**National**
Scale of impact (before mitigation)	**Less than district**	Up to 1 year*	Up to 1 year*	1 year*	1 year	1-3 years
	District	n/a	1 year*	3 years	3 years	5 years
	County	n/a	n/a	5 years	5 years	10 years
	Regional	n/a	n/a	n/a	10 years	10 years
	National	n/a	n/a	n/a	n/a	10 years

*Not in Year 1 (see below)

9.3.3. Several studies have determined that the uptake of building roosts[43] and bat boxes (McAney & Hanniffy, 2015; Poulton, 2006) increases over time, suggesting bats need a period to find and/or become accustomed to new roosting opportunities. For this reason, fewer later monitoring checks are better than intense early effort. Once the mitigation has been correctly implemented ('Year 0'), the following schedules could be adopted:

- Within Years 2-5 (where only one year of monitoring is required; not in Year 1)
- Year 2; Year 4; Year 5 (three years within a five-year monitoring schedule)
- Year 3; Year 5; Year 7; Year 10 (at least four years within a ten-year monitoring schedule)

9.3.4. The stated periods above should be extended where the techniques are novel, where there is uncertainty over their efficacy, or where remedial actions are required. Note also that some monitoring actions, such as measuring temperature/humidity, should not be delayed, but are part of ensuring compliance.

9.3.5. Schemes with construction periods that run into years, or phased developments which may take years to build, will require bespoke (and potentially much longer) monitoring programmes, with different monitoring elements taking into account the point at which different elements of mitigation/compensation are in place. In other words, 'Year 0' may differ between elements, and the end-point may need to be extended for some.

9.3.6. The periods and durations of monitoring should carefully reflect the impacts, the periods of change and the relevant time-frames within which responses may arise (or be detectable). For example, for large-scale residential developments, impacts such as disturbance, as new residents arrive and increasingly spend recreational time in habitats of value to bats (e.g. local woodland) may require monitoring for longer. The time-scales will be strongly influenced by the objectives that are set as part of the monitoring strategy.

9.3.7. It may not be necessary for every monitoring technique to be used in every single year. The frequency for repeating each technique will depend on the objectives set at the outset, and the likelihood of change between monitoring events for each technique. For example, light levels could be measured immediately after a modification; habitat condition assessments or prey biomass assessments at two- to three-year intervals. However, gathering information over more visits (and/or over a longer period) will often give greater confidence in the conclusions that can be drawn. The number of visits can be reduced (if fewer are appropriate) but cannot be retrospectively increased.

9.3.8. Where factors outside human control and intervention may have affected results (e.g. a particularly harsh winter), the monitoring period may need to be extended to allow general trends to be identified. This may mean longer gaps between monitoring events, rather than more monitoring.

Check out APPENDIX 4 for Case study 44: Example large-scale monitoring protocol for tree clearance for a very comprehensive monitoring programme for a large infrastructure scheme.

10. Resources

Table 10.1: **Legislation texts, statutory guidance and standing advice**

<table>
<tr><td>The Habitats Directive:</td><td>http://ec.europa.eu/environment/nature/legislation/habitatsdirective/index_en.htm</td></tr>
<tr><td colspan="2">Post-'Brexit', even though the Habitats Directive no longer directly applies to the UK, the provisions therein are enshrined in both domestic legislation and international agreements under s.6(3) of the European Union (Withdrawal) Act 2018.

Further information relating to England and Wales can be found here:

https://www.gov.uk/government/publications/changes-to-the-habitats-regulations-2017/changes-to-the-habitats-regulations-2017.

Further information relating to Scotland can be found here:

https://www.gov.scot/publications/eu-exit-habitats-regulations-scotland-2/pages/2/

Further information relating to Northern Ireland can be found here:

https://www.daera-ni.gov.uk/topics/biodiversity/biodiversity-and-eu-exit

Please note that in Harris & Anor v Environment Agency [2022] EWHC 2264 (Admin) the High Court confirmed that under the terms of the European Union (Withdrawal) Act 2018, Article 6(2) of the Directive has continuing "direct effect" meaning that it continues to stand independently of the Conservation of Habitats and Species Regulations 2017 and is directly enforceable by the domestic courts against public bodies: "By reason of s.4 of the 2018 Act [s.4(2)(b) of the European Union Withdrawal Act 2018], Article 6(2) continues to be recognised and available in domestic law and is to be enforced accordingly" (para 94 of the judgment). These provisions apply to all of the United Kingdom.

However, the Retained EU Law (Revocation and Reform) Act (2023) gives the Government significant powers in England to revoke and repeal European Union-derived law that was carried over into domestic legislation following Brexit.</td></tr>
<tr><td colspan="2">England and Wales</td></tr>
<tr><td>Wildlife & Countryside Act (1981):</td><td>https://www.legislation.gov.uk/ukpga/1981/69</td></tr>
<tr><td>Conservation of Habitats and Species Regulations (2017):</td><td>http://www.legislation.gov.uk/uksi/2017/1012/contents/made</td></tr>
<tr><td colspan="2">Scotland</td></tr>
<tr><td>Conservation (Natural Habitats, & c.) Regulations 1994</td><td>https://www.legislation.gov.uk/uksi/1994/2716/contents/made</td></tr>
<tr><td>Legislation relating to leaving the EU</td><td>https://www.legislation.gov.uk/sdsi/2019/9780111041062</td></tr>
<tr><td colspan="2">Northern Ireland</td></tr>
<tr><td>Conservation (Natural Habitats, & c.) Regulations (NI) 1995</td><td>https://www.legislation.gov.uk/nisr/1995/380/regulation/34/made</td></tr>
<tr><td colspan="2">Licensing and Enforcement</td></tr>
<tr><td>Licensing</td><td>- England: www.gov.uk/government/collections/bat-licences
- Scotland: https://www.nature.scot/professional-advice/safeguarding-protected-areas-and-species/licensing/species-licensing-z-guide/bats-and-licensing
- Wales: https://naturalresources.wales/permits-and-permissions/protected-species-licensing/european-protected-species-licensing/bat-licensing/?lang=en
- Northern Ireland: https://www.daera-ni.gov.uk/articles/wildlife-licensing#toc-1</td></tr>
</table>

Enforcement	For further information see: www.gov.uk/guidance/enforcement-laws-advice-on-protecting-the-natural-environment-in-england#natural-englands-compliance-and-enforcement-position **To report a suspected breach of a species licence** - In England, email Natural England: speciesenforcement@naturalengland.org.uk - In Wales, email the NRW Species Licensing team: trwyddedrhywogaeth@cyfoethnaturiolcymru.gov.uk - In Scotland, email the NatureScot Licensing team: licensing@nature.scot - In Northern Ireland, see: https://www.wildlifecrimeni.org/ - Proceeds of Crime Act 2002: https://www.legislation.gov.uk/ukpga/2002/29/contents

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APPENDIX 1:
Additional information underpinning Chapter 2

The information below provides additional background information, including case law that assists with the interpretation of terminology and offences.

European Union law

The Habitats Directive represents the European Union's attempt to fulfil its obligations in international law arising from the Bern Convention. Because of that close link between the Bern Convention and the Habitats Directive, the UK's compliance with the Bern Convention was taken for granted on the basis that it complied with the requirements of the Habitats Directive.

Although the UK has now left the European Union, Section 6(3) of the European Union (Withdrawal) Act 2018 (as amended) states that retained European Union law (which includes the England and Wales Habitats Regulations, the Scottish Habitats Regulations and the Northern Ireland Habitats Regulations) is to be interpreted in line with retained case law, so far as the retained European Union law is unmodified on or after exit day (and subject only to the Court of Appeal or Supreme Court, which are entitled to depart from retained EU law in their decisions but which so far have not chosen to do so). Therefore, both domestic case law in relation to European Union law (pre-31 December 2020) and Court of Justice of the European Union (CJEU) case law (pre-31 December 2020) is retained, including the environmental law principles and decisions from the CJEU which are still binding.

CJEU decisions made after 31 December 2020 are not binding on UK courts. It is also not possible to refer a case from the UK courts to the CJEU after 31 December 2020. However, a court or tribunal may have "regard" to anything done by the CJEU or another European Union entity/the European Union so far as it is relevant to any matter before the court or tribunal (see s.6(2) European Union (Withdrawal) Act 2018 (as amended)).

The relevance of European Commission Guidance

Whilst guidance is not law, and therefore not binding, it carries weight in terms of understanding how the law should be applied. This guidance document therefore refers to the European Commission's revised version of its *Guidance document on the strict protection of animal species of Community interest under the Habitats Directive* published on 12 October 2021 (the '2021 Guidance'). This is a revised version of the European Commission guidance dated February 2007.[117]

Although the UK has now left the European Union, the 2021 Guidance remains a key reference source for anyone working with EPS which include bats, whether ecologists (consultants or in local government), developers or regulators. The 2021 Guidance, along with other relevant pieces of European Commission Guidance, remain relevant to practitioners in the UK because s.6(2) EU (Withdrawal) Act 2018 (as amended) states that:

> *"A court or tribunal may have regard to anything done by the Court of Justice of the European Union or another EU entity or the EU so far as it is relevant to any matter before the court or tribunal".*

This is relevant, as the 2021 Guidance has been "done" by the European Commission.

For example, in R *(Wyatt) v Fareham BC & Natural England* [2022] EWCA Civ 983[116] regarding the legality of Natural England's nutrient neutrality mitigation guidance, the Court of Appeal referred to the potential applicability of EC guidance. Although the Court discounted its relevance to the particular issues under consideration, it did not suggest that EC guidance had no relevance when interpreting the law.

115. For aspects of the 2021 guidance which might have relevance to interpreting the EPS criminal offences in Regulation 43 of the Habitats Regulations (2017) and the associated licensing framework in Regulation 55, a helpful summary and interpretation can be found here: https://www.freeths.co.uk/2021/11/10/key-messages-from-the-european-commissions-revised-european-protected-species-law-bible-dated-12-october-2021/

116. https://www.bailii.org/ew/cases/EWCA/Civ/2022/983.html

Potential reform of retained European Union law

The legal position post-Brexit remains largely the same as the position pre-Brexit until action is taken to amend the domestic law. This may mean amendments to domestic legislation or changes as a result of new precedent forming in the Courts.

Post-Brexit, the UK Supreme Court and the Court of Appeal can now decide in future cases to depart from EU case law. This may mean that developments in the law will take place over time in the UK and, potentially, within the different devolved administrations. With regards to legislative reform, the Government has already:

- stated in its Nature Recovery Green Paper[117] published in March 2022 that it is interested in reforming the Habitats Regulations in England now the UK has left the EU, including the law regarding the licensing of protected species;
- included powers in the Environment Act 2021 which allow the Secretary of State to amend parts of the Habitats Regulations in England (though not expressly to amend the species provisions of the England and Wales Habitats Regulations); and
- on 29 June 2023, introduced the Retained EU Law (Revocation and Reform) Act[118] giving itself significant powers to revoke and repeal EU-derived law in England which was carried over into domestic legislation following Brexit. This will make it easier for Ministers to amend and replace retained EU law through secondary legislation.

There may, therefore, be reform to the regulatory framework over the coming months and years. Expert legal advice may be needed on the consequences of those reforms in this context should they occur.

Guidance on the offence of damage or destruction of a breeding site or resting place for bats

The criminal offence of "damage or destruction of a breeding site or resting place" of a bat derives from Article 12 of the Habitats Directive.

According to the 2021 Guidance, the regularity of use of sites or places by bats is relevant to whether the site or place is legally protected under this offence. According to the 2021 Guidance, a site and place is legally protected as a "breeding site" or "resting place" if there is a reasonably high probability of the site/place being used again. The 2021 Guidance says:

> *"The protection applies all year round if these sites are used on a regular basis … [thus] it follows from Article 12(1)(d) that such breeding sites and resting places also need to be protected when they are used only occasionally or are even abandoned but where there is a reasonably high probability that the species concerned will return to these sites and places. If, for example, a certain cave is used every year by a number of bats for hibernation (because the species has the habit of returning to the same winter roost every year), the functionality of this cave as a hibernating site should be protected in summer as well so that the bats can reuse it in winter" (pages 32 and 33).*

The 2021 Guidance also states that breeding sites and resting places "that are used regularly either within or between years, must be protected even when not occupied" (see page 33 and page 35[119]).

The fact that bat species are wide-ranging in nature is also important in determining whether a site or place is a breeding site or resting place. The 2021 Guidance explains that:

117. https://consult.defra.gov.uk/nature-recovery-green-paper/nature-recovery-green-paper/
118. https://www.legislation.gov.uk/ukpga/2023/28/contents/enacted
119. This element of the 2021 Guidance is confirmed by a European hamster judgment C-357/20 dated 28 October 2021 (released after the 2021 Guidance was published). This case also states that resting places and breeding sites are covered by the offence when they are no longer occupied by the animal species but where there is a "sufficiently high probability that the animal species will return" (see paras 47 and 40 of the judgment).

> *"…for some species that have small home ranges, breeding sites and resting places can overlap. In such cases, it is important to protect a functionally viable and coherent area for the species that includes both its resting and breeding sites and other areas that are considered necessary to maintain the ecological functionality of the breeding and/or resting site" (page 36).*

For wide-ranging species, however, the 2021 Guidance states that:

> *"…it may be advisable to restrict the definition of breeding and resting sites to a locality that can be clearly delimited: e.g. the roosts for bats, … or other areas that can be clearly identified as being important for breeding or resting" (page 36).*

In other words, for the loss of supporting land to amount to damage or destruction of a breeding site or resting place, there must be a very strong association between any supporting land and the breeding site or resting place, such that the supporting land is essential to maintain the ecological functionality of the breeding site or resting place. This is more likely to occur with species with small home ranges, as they are unable to travel for food. For a wider-ranging species (such as bats) the breeding or resting site may not extend to wider habitats as their survival is not based directly on the favourability of the immediately surrounding habitat.[120]

Under the 2021 Guidance (and the earlier 2007 version of that guidance) the European Commission also expands on this offence with reference to the concept of "continued ecological functionality". This concept means that if the ecological functionality of a breeding site or resting place is maintained (notwithstanding activities in relation to the site or place) then this offence would not be triggered and so no licence would be required. This is because, according to the 2021 Guidance:

> *"Article 12(1)(d) [of the Habitats Directive] should therefore be understood as aiming to safeguard the continued ecological functionality of such sites and places, ensuring that they continue to provide all the elements needed by the animal to rest or to breed successfully" (page 32)[121].*

Guidance on the bat disturbance offences

Table A1.1 summarises the statutory language for the disturbance offences in England, Wales and Scotland so they can be compared side-by-side.

120. Since the 2021 Guidance was published, the CJEU hamster judgment C-357/20 was handed down. This states (at para 33) that this offence could be triggered if human activities carried out in the vicinity of the breeding site (or presumably resting place) had the aim or effect of that animal species no longer frequenting the breeding site (or resting place) concerned. In that case the developer had removed all the habitat around the hamsters' burrows so effectively sterilising the area, even though the developer had left the burrows themselves intact.

121. The 2021 Guidance does contain some further constraints on the use of this "continued ecological functionality" concept which should be reviewed in the 2021 Guidance before reliance is placed on this concept so as to avoid seeking a licence.

Table A1.1: Offences and defences applicable to the disturbance of bats in England, Wales, Scotland and Northern Ireland

	Offence	England and Wales Habitats Regulations/W&CA; (both as amended)	Scottish Habitats Regulations (as amended)	Northern Ireland Habitats Regulations (as amended)
1	Disturbing bats (affecting ability to survive, breed or rear young)	to ***deliberately*** disturb wild ***animals*** of an EPS [note, wherever they are occurring] (Reg 43(1)(b)). This refers to ***animals*** and therefore ***bats*** (plural) rather than a bat. disturbance of animals includes in particular any disturbance which is likely to impair their ability to survive, to breed or reproduce, or to rear or nurture their young (Reg 43(2)(a)(i)) guidance on this offence is to be published and must then be taken into account by the Court. (Reg 43(9))	to ***deliberately or recklessly*** disturb a wild ***animal*** of an EPS [note, wherever they are occurring] in a manner that is, or in circumstances which are, likely to impair its ability to survive, breed or reproduce, or rear or otherwise care for its young (Reg 39(1)(b)(vi)). This refers to ***an animal***, not animals as in England and Wales. (subject to defence of mercy killing (Reg 40(1))	***deliberately*** to disturb such an ***animal*** of an EPS [note, wherever they are occurring] in such a way as to be likely to impair its ability to breed or reproduce, or rear or care for its young (Reg 34(1)(c)(ii)). This refers to ***an animal***, not animals as in England and Wales. [added in 2007; numbering reflects 2009 amendment] (subject to defence of mercy killing (Reg 35(3))
2	Disturbing bats (impairing ability to migrate or hibernate)	to ***deliberately*** disturb wild ***animals*** of an EPS [note, wherever they are occurring] (Reg 43(1)(b)) disturbance of ***animals*** includes in particular any disturbance which is likely to impair their ability in the case of hibernating or migratory species, to hibernate or migrate (Reg 43(2)(a)(ii)) guidance on this offence is to be published and must then be taken into account by the Court (Reg 43(9))	to ***deliberately or recklessly*** disturb a wild ***animal*** of an EPS [note, wherever they are occurring] while it is hibernating or migrating (Reg 39(1)(b)(vii)) (subject to defence of mercy killing (Reg 40(1))	***deliberately*** to disturb such an ***animal*** [note, wherever they are occurring] in such a way as to be likely to impair its ability to hibernate or migrate (Reg 34(1)(c)-(iii). This refers to an ***animal,*** not ***animals*** as in England and Wales. [added in 2009; numbering reflects 2009 amendment] (subject to defence of mercy killing (Reg 35(3))
3	Disturbing bats (affecting local distribution or abundance)	to ***deliberately*** disturb wild ***animals*** of an EPS [note, wherever they are occurring] (Reg 43(1)(b)) disturbance of animals includes in particular any disturbance which is likely to affect significantly the local distribution or abundance ***of the species to which they belong*** (Reg 43(2)(b)). Note the reference here to "the species". guidance on this offence is to be published and must then be taken into account by the Court. (Reg 43(9))	to ***deliberately or recklessly*** disturb a wild animal of an EPS [note, wherever they are occurring] in a manner that is, or in circumstances which are, likely to significantly affect the local distribution or abundance ***of the species to which it belongs*** (Reg 39(1)(b)(v)). Note the reference here to "the species". (subject to defence of mercy killing (Reg 40(1))	***deliberately*** to disturb such an animal [note, wherever they are occurring] in such a way as to be likely to affect the local distribution or abundance ***of the species to which it belongs*** (Reg 34(1)(c)(i)). [added in 2007; numbering reflects 2009 amendment] (subject to defence of mercy killing (Reg 35(3))
4	Disturbing bats (whilst rearing or caring for young)		to ***deliberately or recklessly*** disturb a wild ***animal*** of an EPS [note, wherever they are occurring] while it is rearing or otherwise caring for its young (Reg 39(1)(b)(iii)) (subject to defence of mercy killing (Reg 40(1))	
5	Disturbing bats (whilst occupying a structure or place used for shelter or protection)	to ***intentionally or recklessly*** disturb any wild Sched 5 ***animal*** [which includes all species of horseshoe bat and all typical bat species] while it is occupying a structure or place which it uses for shelter or protection (s.9(4)(b) W&CA (subject to defence when within a dwelling house s.10(2) W&CA (when bats, must notify first s.10(5) W&CA)) (subject to the incidental result defence s.10(3)(c) W&CA (when bats, must notify first s.10(5) W&CA))	to ***deliberately or recklessly*** disturb a wild ***animal*** of an EPS while it is occupying a structure or place which it uses for shelter or protection (Reg 39(1)(b)(ii)) (subject to defence of mercy killing (Reg 40(1))	***deliberately*** to disturb such an animal while it is occupying a structure or place which it uses for shelter or protection (Reg 34(1)(b)). [added in 2007; numbering reflects 2009 amendment] (subject to defence of mercy killing (Reg 35(3))

A detailed review of the implications of Morge v Hampshire County Council

Although Morge[6] is a pre-Brexit case, it still applies to the interpretation of the domestic legislation which derives from Article 12 of the Habitats Directive (i.e. mainly the disturbance offences in the Habitats Regulations). This does not include disturbance offences that have their root in domestic legislation only, i.e. those that refer to disturbing a bat in its place of shelter (see **APPENDIX 1: Table A1.1**). *Morge* is still at present binding and, because *Morge* is a Supreme Court case, it is binding throughout the United Kingdom.

Meaning of the term 'deliberate' for Article 12 Habitats Directive-derived criminal offences

The disturbance offences which derive from Article 12 of the Habitats Directive include the word 'deliberately' and therefore they are not strict liability offences.

'Deliberately' is a term found in the Habitats Directive and is difficult to define. The CJEU case law is also not clear on this point. In the UK, the Supreme Court in *Morge* has provided some helpful clarity on what the term 'deliberately' means. The Supreme Court said:

> *"As stated by the Commission in para 33 of their Guidance:*

> *"'Deliberate' actions are to be understood as actions by a person who knows, in light of the relevant legislation that applies to the species involved, and the general information delivered to the public, that his action will most likely lead to an offence against the species, but intends this offence or, if not, consciously accepts the foreseeable results of his action."*

> *"Put more simply, a deliberate disturbance is an intentional act knowing that it will or may have a particular consequence, namely disturbance of the relevant protected species. The critical, and altogether more difficult, question is what precisely in this context is meant by 'disturbance'" [see para 14].*

This means that where a person carries out the prohibited act contained in the offence but does not do so 'deliberately', the person has not committed an offence. It follows from the meaning of 'deliberate' that where an activity is judged unlikely to lead to bat disturbance (i.e. the risk of disturbance occurring is low, based on survey data and (perhaps) proposed mitigation (avoidance) measures), then if disturbance does unexpectedly occur, it is unlikely that that disturbance can be said to have occurred 'deliberately'. It also follows that if, following completion of a development (such as an onshore wind farm), it becomes clear that bats are being disturbed by the development then the operator may well be said to be deliberately disturbing the bats by allowing that activity to continue in the same manner.

The 2021 Guidance, which is very similar to the 2007 version of the guidance in this regard, also states that:

> *"… the term 'deliberate' is interpreted by the CJEU as going beyond 'direct intention'. 'Deliberate' actions are to be understood as actions by a person or body who knows that their action will most likely lead to an offence against a species, but intends this offence or, at least, consciously accepts the foreseeable results of his action" (page 24).*

The 2021 Guidance confirms the meaning of 'deliberate' which appears in the Reg. 43 offences of deliberate capture, killing and injury and deliberate disturbance. It quotes CJEU case C-221/04 at para 71 where the Court said:

> *"… for the condition as to 'deliberate' action in Article 12(1)(a) of the Directive to be met, it must be proven that the author of the act intended the capture or killing of a specimen belonging to a protected animal species or, at the very least, accepted the possibility of such capture or killing" (page 24).*

The 2021 Guidance concludes:

> *"In other words, the provision applies not only to a person who fully intends to capture or kill a specimen of a protected species but also to a person who is sufficiently informed and aware of the consequences his or her action will most likely have and nevertheless still performs the action, which leads to the capturing or killing of specimens (e.g. as an unwanted but accepted side-effect) (conditional intent)" (page 25).*

In practice this term 'deliberate' is about conscious risk-taking and ignoring a recognised risk of a prohibited act where the risk is 'most likely' or perhaps merely 'possible'. Going ahead in those circumstances would be regarded as 'deliberate'.

The way to avoid acting 'deliberately' is to reduce the risk of the prohibited act to something less than 'most likely' (although CJEU case law does suggest that even if the prohibited act is merely 'possible' then the act could still be said to have been done deliberately).

***Meaning of the term 'disturbance' in relation to offences deriving from Article 12 of the Habitats Directive*[122]**

The Supreme Court in *Morge* also gave its views on the meaning of the "*disturbance*" prohibition in Article 12 of the Habitats Directive. The Supreme Court agreed that this relates to protection of the species (not specimens of the species) and that the disturbance does not have to be "*significant*" to come within the prohibition. However, the Supreme Court departed from the 'high bar' threshold set by the Court of Appeal that "*deliberate disturbance*" requires an impact "on the *conservation status of the species at population level"* or an impact which "*affects the survival chances of a protected species"*. Whilst it departed from these 'high bar' thresholds, the Supreme Court was reluctant to state what the minimum threshold for *"deliberate disturbance"* of the species would be, although it did cite the European Commission's 2007 guidance referring to the need for the disturbance to be "*harmful*". It is, of course, very difficult for a Court to set a 'one size fits all' threshold for disturbance. There is, therefore, no threshold set for how many individuals need to be affected for an Article 12-derived disturbance offence to be committed.

The Supreme Court in *Morge* did, however, provide some guiding principles including:

- each case has to be judged on its own merits, and a species-by-species approach is required;
- even with regard to a single species, the position might be different depending on the season or on certain periods of its life cycle;
- consideration should be given to the rarity and conservation status of the species and the impact of the disturbance on the local population of a particular protected species – the implication of this is that for a rare species of bat, for example, disturbance of just a few individuals (or even one individual) might be enough to trigger a disturbance of the bat species;
- individuals of rare species are more important to a local population than individuals of a more abundant species;
- disturbance to species that are declining in numbers is likely to be more harmful than disturbance to species that are increasing in numbers;
- disturbance during the periods of breeding, rearing, hibernation and migration is more likely to have a sufficiently negative impact on the species to constitute disturbance, but the offence leaves open the

122. i.e. this does not apply to the s.9(4)(b) W&CA 1981 offence in England or Wales; the Reg. 39(1)(b)(ii) offence in Scotland) nor the Reg. 34(1)(b) offence in Northern Ireland.

possibility that disturbance at other less sensitive periods could still potentially amount to 'deliberate disturbance'; and

- the Court strongly supported the European Commission's 2007 guidance on the issue. The implication of this is that the 2021 Guidance would be given similar weight.

The 2021 Guidance summarises the position as follows by stating that:

> *"Any deliberate disturbance that may affect the chances of survival, the breeding success or the reproductive ability of a protected species, or that leads to a reduction in the occupied area or to relocation or displacement of the species, should be regarded as a 'disturbance' in line with the terms of Article 12" (page 26).*

The 2021 Guidance also says that:

> *"… any activity that deliberately disturbs a species to the extent that it may affect its chances of survival, breeding success or reproductive ability, or leads to a reduction in the occupied area or the relocation or displacement of the species, should be regarded as a 'disturbance' under the terms of Article 12" (page 26).*

Therefore, the disturbance offences derived from Article 12 of the Habitats Directive are directed at disturbance ***"of the species"*** (not specimens of the species) but the 2021 Guidance makes the point that in some limited circumstances, disturbance of a single individual could potentially still trigger the offence.

It is also noticeable that, in Scotland and Northern Ireland, the Regulations refer to 'an animal', so appear to be more strict than Article 12 of the Habitats Directive (see **APPENDIX 1: Table A1.1**).

The meaning of the terms 'intentionally' or 'recklessly'

Unlike the Habitats Regulations (which mainly use the word 'deliberately' in the offences so as to reflect Article 12), the W&CA uses the terms 'intentionally' or 'recklessly' in the offences applying to bats. 'Recklessly' is, however, also used in the Scottish Habitats Regulations.

'Intentionally' is a well understood English law term. The definition of 'intention' under English law is twofold and is as follows:

1. *A result is intended when it is the actor's actual purpose (e.g. a person sets out to kill a bat and does so though, in practice, a wildlife conviction under this meaning of intention would be very rare).*

2. *A court may infer that a result is intended, though not desired, when: (i) the result is a 'virtually certain' consequence of the act; and (ii) the relevant person knows/appreciates that it is a virtually certain consequence (e.g. using explosives at a quarry to quarry stone and knowing, with 'virtual certainty', that hibernating bats will die in so doing).*

In practice this means that ignoring a recognised risk of a prohibited act occurring, which is known to be a 'virtual certainty', and going ahead anyway would be regarded as 'intentional'. Therefore, the higher the risk being run, the nearer to the 'virtually certain' threshold a person will be, triggering this offence.

Given this high threshold it difficult for a prosecutor to prove in practice that a person has acted 'intentionally'. For this reason, the word is often combined with the word 'recklessly'. This has the effect of lowering that threshold.

'Recklessly' is an English law term whose interpretation has been the subject of much debate and change over the years by the judges who decide caselaw. The current definition under English law is set out below, but this may alter in the future. A person acts 'recklessly' where he:

- is aware of a risk that a circumstance exists or will exist; or
- is aware of a risk that a result will occur,

and (in either case) it is, in the circumstances known to him, objectively unreasonable to take that risk.

Please note that this definition does not depend on a certain threshold of likelihood of risk being met (as with intention – 'a virtual certainty'). Instead, any level of risk will suffice (whether high, medium or low) and the key issue is 'whether taking the risk is unreasonable'. It is not a question of whether the accused thought the risk was reasonable; rather it is a question of whether an ordinary and prudent person would have been prepared to take the risk. This will depend on a number of factors such as (i) the probability of the risk occurring; (ii) the nature and gravity of the harm being risked; (iii) the value and likelihood of achieving what the accused was trying to do whilst running the risk (was there social value in it?).

When the Law Commission carried out its 2015 review of wildlife law in England and Wales it found that the "concept of 'recklessness' covers a wider range of knowledge and attitudes than the term 'deliberate' as defined by the Court of Justice in Commission v Spain".[123] This means that 'recklessness' could "criminalise all instances where it was established that the defendant knew about a risk of harm to a species and carried out an activity despite that knowledge, in circumstances where the court considered that it was unreasonable for the defendant to do so".[124]

Note that the accused must himself perceive the risk in order to act 'recklessly'. An accused would not be convicted of a reckless offence if he had not perceived the risk himself even if that risk would have been obvious to a reasonable person. However, in practice, it would be very difficult for, say, a professional ecological consultant to try to persuade a magistrate or a jury that he did not perceive a risk which would have been obvious to others.

Therefore, ignoring/discounting a recognised risk of a prohibited act (no matter how certain it is to arise) and going ahead anyway would be regarded as 'reckless', where it was 'unreasonable' to do so.

The way to avoid acting 'recklessly' is to ensure that any actions taken are *reasonable*. Since one of the things to consider is the 'probability of the risk occurring' (see (i) above), reducing the risk to 'unlikely' or 'very unlikely' is part of a*cting reasonably.* However, factors other than likelihood are also relevant (see (ii) and (iii) above). There may still be cases (e.g. where large numbers of a rare bat species will be disturbed) where an action could be considered reckless even where the risk being run is 'very unlikely'.

For practical purposes, adopting a precautionary method of working helps to reduce the likelihood of an offence being committed as it allows practitioners to make the case that they had not acted 'deliberately' or 'intentionally/recklessly' with regard to the disturbance of bat species.

Advice should always be taken from an ecologist to determine whether an offence would be triggered in a particular circumstance. Given the complexities of the law, advice may also be needed from a specialist lawyer to determine whether an offence would be triggered in a particular circumstance.

Bat licences under the Habitats Regulations

It is an important principle in wildlife licensing that licensed action will not have an adverse effect on the conservation status of any species or habitats (though there have been licensing cases where this issue has arisen[125].

The 2021 Guidance states that derogations under Article 16 of the Habitats Directive must be interpreted restrictively and that *"derogations must be a last resort"* (page 46). In addition, the concept of 'proportionality' should be applied across each of the three licensing tests. Broadly, this means that the greater the potential harm to bats, the greater the rigour with which the three tests should be applied. This concept is discussed in the 2021 Guidance, which reaffirms the proportionality prin-

123. Wildlife Law Report Summary (2015) LC362, para 1.67
124. Wildlife Law Report Summary (2015) LC362, para 1.67
125. Two examples are: The Royal Society for the Protection of Birds, R (On the Application Of) v Natural England [2021] EWCA Civ 1637 in respect of Hen Harrier Brood Management, and Langton, R (On the Application Of) v The Secretary of State for Environment, Food And Rural Affairs & Anor (Rev 1)[2019] EWHC 597 (Admin) in respect of badger disease control licences.

ciple in connection with species licences. This means that "*as a general rule the severity of any of the conditions or tests will increase with the severity of the potential impact of a derogation on a species or population*" (page 47).

This following provides more information on two of the three derogation (i.e. licensing) tests applicable to Habitats Regulations bat licences that are set out in **Section 2.6.**

Test 2 – no satisfactory alternative (NSA)

- For this test, it is necessary to look at the problem or specific situation that needs to be addressed. Are there any other solutions that would not require a licence, or which would have less severe impacts on the bat species and which would still address the relevant problem for which a licence is sought?
- The 2021 Guidance states that:

> *"The analysis of whether 'there is no other satisfactory alternative' presumes that a specific problem or situation exists and that it needs to be addressed. The competent national authorities are called upon to solve this problem or situation by choosing, **among the possible alternatives,** the most appropriate that will ensure the best protection of the species **while solving the problem/situation.** To ensure the strict protection of species, the alternatives must be assessed against the prohibitions listed in Article 12. For example, they could involve alternative locations of projects, different development scales or designs, or alternative activities, processes or methods" (page 61).*

- The English case *Prideaux, R (on the application of) v FCC Environment UK Ltd* [2013] EWHC 1054 (Admin)[126] provides helpful clarity on the interpretation of this test. Lindblom J (as he was then) took a dismissive view of the 2007 version of the European Commission guidance and stated:

> *"… the advice given in the European Commission's guidance document … that derogation 'must be a last resort'. **But the guidance is not the law.** The law is to be found in the relevant provisions of the Habitats Directive and the 2010 regulations, and in any jurisprudence that sheds light on their meaning. Para 37 of the guidance enjoins the competent national authorities to select from the **'possible alternatives' the one that will ensure the best protection of the species 'while solving the problem …'.** But this does not* **require a** ***comparative assessment of the possible effects of each suggested alternative on the European Protected Species.*** *Article 16 of the Habitats Directive does not provide that a licence must be refused if an alternative emerges with no foreseeable impact on European Protected Species, or an impact less harmful than that of the project in hand. And I do not accept the suggestion that an alternative must be regarded as satisfactory – or can only be satisfactory – when that is so… (para 112)*

> *As is clear from the European Commission's guidance, **other considerations other than the effects of European Protected Species can and will come into play.** Physical, planning and timing constraints are germane to the question. Any or all of these may prove decisive. To be satisfactory an alternative has to be a real option, not merely a theoretical one… (para 113)*

126. R (on the application of Christopher Prideaux) v Buckinghamshire County Council Fcc Environment Uk Ltd (Interested Party) - Case Law - VLEX 792877721.

- The 2021 Guidance also states that:

> *"Only when it is sufficiently demonstrated that potential alternatives are not satisfactory, either because they are not able to solve the specific problem or are technically unfeasible, and when the other conditions are also met, can the use of the derogation be justified.* ***However, if a measure is partially satisfactory even if it does not sufficiently address the problem, but it can still reduce or mitigate the problem, it should be implemented first.*** *Derogations for lethal intervention may only be justified for the residual problem, if no other methods are possible, but must be proportional to the problem remaining after non-lethal measures are taken" (page 62).*

> *"The process to ascertain whether another alternative is unsatisfactory should be based on a well-documented assessment of all possible available options, including in terms of their effectiveness, based on the best available facts and data. The assessment of alternatives must be balanced in light of the overall objective of maintaining or restoring the favourable conservation status of the species of Community interest concerned (it must therefore take into account the conservation status, the impact of additional incidental or illegal removal of specimens and prospects of the population concerned). The assessment may also take into account proportionality in terms of cost. However, economic cost cannot be the sole determining factor when analysing alternative solutions. In particular, satisfactory alternative solutions cannot be rejected from the outset on the grounds that they would cost too much" (page 62).*

- With regards to the application of the proportionality principle in these circumstances, the 2021 Guidance states that:

> *"The Advocate General in Case C-342/05 clarified the proportionality principle, according to which a 'measure may not be implemented if its objective can be attained by* ***less drastic means****, that is to say by means of a satisfactory alternative within the meaning of Article 16(1) of the Habitats Directive'. 'An alternative is satisfactory not only if it would attain the objectives of the derogation equally well, but also if the disadvantages caused by the derogation would be disproportionate to the aims pursued and the alternative would ensure proportionality'." (page 63)*

4) **Test 3 – Favourable Conservation Status (FCS)**

The following provides more information on the application of the FCS test (as set out in **Section 2.6**);

- Under Article 2 of the Habitats Directive, measures taken pursuant to the Directive are designed "to maintain or restore, at favourable conservation status, natural habitats and species of wild fauna and flora of Community interest". This means that the purpose of the Directive is to ensure that habitats and species are robust and that their survival is not jeopardised by anthropocentric activities. This concept at a European level is derived from the purposes of the Bern Convention at an international law level.
- The test applies to 'protected species' and not 'specimens of the protected species'. The English case *Keir v Natural England*[127] provides helpful clarity on the interpretation of this test. In this case, involving potential impacts on barbastelle bats in the vicinity of development work on HS2, Holgate J concluded that:

127. Keir, R (On the Application Of) v Natural England [2021] EWHC 1059 (Admin)

*"It is important to note that regulation 55(9)(b) focuses on **the conservation of the species, not individual members of that species.** That has to be so because in an appropriate case a licence may authorise even the killing of a wild animal belonging to a protected species (see regulation 43(1) (a))". (para 39)*

"… These tests or considerations are concerned with a much broader perspective than the effects of the development or an activity on the individual specimen or specimens of a protected species on a particular site". (para 40)

"… it is relevant for a decision-maker to consider degrees of likelihood or confidence … that approach must accord with the precautionary principle. In other words, levels of confidence, or likelihood, or risk, may be judged to be acceptable if the decision-maker does not consider that there is a reasonable scientific doubt about whether an action authorised by a licence would be detrimental to the maintenance of the population of a species at a 'favourable conservation status in their natural range'." (para 41)

More information on use of the 'incidental result' defence

As noted in **2.6.10** to **2.6.16,** in England and Wales, the 'incidental result' defence can be used in a limited set of circumstances, i.e. the two offences relating only to disturbing a bat while it is occupying a place of shelter, or obstructing access to that place. The statutory defence relies on three things, outlined in **2.6.13**; in relation to the third item (that the unlawful act which took place could not reasonably have been avoided), the following would be relevant to consider, for example:

- Could the planned activity be timed differently to avoid the two offences above?
- Could the planned activity follow a different methodology to avoid the two offences above?
- Could the planned activity be at a **different location** to avoid the two offences above?
- Could **more money** be spent to avoid the two offences above?

For each of these elements, if there is more that could reasonably be done in terms of the **timing/methodology/location/cost** to avoid the activity that contravenes one or more of the two offences above, then the words 'could not reasonably have been avoided' will not be met and the legal defence will not be available.

In terms of the **timing** issue specifically, this essentially means that where an activity which contravenes one or more of the two offences above could reasonably be delayed to avoid the offence, then it should be delayed. To go ahead anyway and to commit the offence in those circumstances (hoping to rely on the defence) would be very risky. By contrast, if delay is not reasonable in all the circumstances (e.g. perhaps if there is an emergency and delays would therefore threaten public health or safety; or if delays would lead to a large and disproportionate expenditure of public money), then the activity (which contravenes one or more of the two offences above) could go ahead and seek reliance on the defence (as long as the other two defence elements are also met).

No commentary such as is set out here can give full guidance on this defence for all factual scenarios. Reliance on this defence is a matter of judgment, particularly as regards what is reasonable, based on the individual facts of each case. Reliance on this legal defence is inherently risky as only a criminal court can decide ultimately if the defence is or is not available in a specific factual situation. Obtaining a licence, by contrast, is a much more legally secure way of proceeding.

There are also notification requirements, as set out in **2.6.14**. If seeking to use this defence, the precise wording of the law should be carefully reviewed. A court would need to decide whether the defence has been applied properly, and it is recommended that professional legal advice is sought before relying on this defence.

Additional information on Article 6 of the Habitats Directive and HRA

To reflect the requirements of the precautionary principle, Article 6(3) adopts a strictly step-wise process of decision-making for derogations in respect of protected sites (in the UK, 'the national site network').[128] This is described by the EC *Managing Natura 2000 Sites*[129] as follows:

a) The first part of this procedure consists of a pre-assessment stage ('screening') to determine whether, firstly, the plan or project is directly connected with or necessary to the management of the site, and secondly, whether it is likely to have a significant effect on the site; it is governed by Article 6(3), first sentence.

b) The second part of the procedure, governed by Article 6(3), second sentence, relates to the appropriate assessment and the decision of the competent national authorities.

The applicability of the procedure, and the extent to which it applies, depends on several factors and, in the sequence of steps, each step is influenced by the previous step. The order in which the steps are followed is therefore essential for the correct application of Article 6(3).

The precautionary principle is an important concept in HRA. In *Landelijke Vereniging Tot Behoud van de Waddenzee and Nederlandse Vereniging to Bescherming van Vogels v Staatssecretaris Van Landbouw, Natuurbeheer en Visserij* (C-127/02) [2005] 2 C.M.L.R. 31 ("***Waddenzee***")[130], the CJEU provided authoritative guidance on how the precautionary principle applies in this context. First, the trigger for an appropriate assessment is a mere probability of a significant effect on a site [paras 41, 44]. Accordingly, a risk is sufficient. It was also established that such a risk exists if it cannot be excluded on the basis of objective information that the plan or project will have significant effects on the site concerned [para 44].

If a likely significant effect cannot be excluded then an appropriate assessment is required which is capable of providing "complete, precise and definitive findings and conclusions capable of removing all reasonable scientific doubt as to the effects of the plans or the projects proposed on the protected site concerned"[131]. In light of this assessment, the competent authority is only able lawfully to grant planning permission for the proposals after having ascertained that they will not adversely affect the integrity of the sites concerned.

A third part of the procedure (governed by Article 6(4)) comes into play if, despite a negative assessment, it is proposed not to reject a plan or project but to give it further consideration. In this case Article 6(4) allows for derogations from Article 6(3) under certain conditions.

The competent authority can then decide as to whether, a negative assessment notwithstanding, it is satisfied that there are no alternative solutions and that the plan or project must be carried out for imperative reasons of overriding public interest (IROPI). If it is so satisfied then the plan or project may proceed as long as compensatory habitat measures are secured.

128. Article 7 of the Habitats Regulations applies the derogations process under the Habitats Directive to Special Protection Areas. Sites designated under the Ramsar Convention (Ramsar sites) are afforded the same consideration, but are unlikely to have been designated for bats in the UK.
129. See European Commission Guidance: Managing Natura 2000 sites (page 39) Available at https://ec.europa.eu/environment/nature/natura2000/management/docs/art6/Provisions_Art_6_nov_2018_en.pdf
130. https://uk.practicallaw.thomsonreuters.com/6-382-1762?contextData=(sc.Default)&transitionType=Default&firstPage=true
131. Case C-293/17 Cooperatie Mobilisation for the Environment UA, Vereniging Leefmilieu v College van Gedeputeerde Staten van Limburg [2019] Env LR 27, at para 98.

APPENDIX 2: Valuation exercises

Table A2.1 Example 1: Large footprint development on the east coast of England.

The site boundary has been amended to avoid the most valuable habitats; much of the proposed development is currently arable land.

Species [Table 3.1]	Importance of roosts (summary of justification only) [Table 3.2]	Importance of commuting and foraging habitat (summary of justification only	Importance of assemblage [Table 3.3]
Widespread Common pipistrelle Soprano pipistrelle Brown long-eared	Limited evidence of roosts on site for either pipistrelle species (though smaller roosts undoubtedly exist). Maternity colony of 50 soprano pipistrelles in a bat box within 200 m (outside) of site boundary. **Does not exceed District importance** Maternity colony of 20 brown long-eared bats (average for region) within 100 m of site boundary. **Does not exceed District importance**	The habitats combined in and around the redline boundary meet the definition of 'high potential value' as defined in Collins (2016). - High relative levels of bat activity in many areas of the site, indicating reliance. - Woodland is an uncommon feature in East Anglia, and the diverse pockets of woodland across and around the site form a relatively rare resource, enhanced by wetter habitats in several areas. - Those areas of woodland are well used across the year by a diverse assemblage including breeding barbastelle and the edge-of-range Leisler's bat - Other breeding roosts are known (Natterer's bat, brown long-eared bat) in different locations. - Radio-tracking indicates core areas centred on the site for several species, including barbastelle. - Woodlands and other habitats of value are well connected, but with relatively few regularly used commuting routes apparent. However, there are links with woodlands to the north, as determined by radio-tracking. - The woodlands are very likely to support hibernating tree-roosting bats, thus providing a winter foraging resource. Taking the above into account, the mosaic of habitats within the Zone of Influence is considered to be of Regional importance. However, the area to be developed comprises largely arable areas which are of much lower value. 1 point per species	*1 point per species* Score 3 for this part of the assemblage (of a maximum of 3)
Widespread but not as abundant in all geographies Daubenton's bat Natterer's bat Noctule	Maternity colony of Natterer's bat using complex of sites (counts 50+). Identified roosts were all off-site, but the small number of individuals radio-tracked had home ranges overlaying suitable habitats within and adjacent to the site, indicating other roosts likely to be present. **Does not exceed County importance** No evidence of roosts for Daubenton's bat or noctule, though smaller tree roosts undoubtedly exist. **Site importance**		*2 points per species* Score 6 for this part of the assemblage (of a maximum of 6)
Rarer or restricted distribution Serotine Leisler's bat Nathusius' pipistrelle	**Leisler's**: Very uncommon; assessed as very low numbers; however, this species is edge-of-range. **District importance, because edge-of-range** No evidence of roosts of other two species, though likely within ZoI. **Would not exceed District importance**		*3 points per species* Score 9 for this part of the assemblage (of a maximum of 15)
Rarest Annex 2 species and very rare Barbastelle	Breeding colony of **barbastelle** centred on and extending beyond site; individuals also likely to hibernate. **At least Regional importance** (no SAC).	Score 3 for this part of the assemblage (of a maximum of 3)	*4 points per species* Score 4 for this part of the assemblage (of a maximum of 4)
Overall score: Assemblage score 22/28 = 78.5%; meets threshold for **National importance.**			

Table A2.2 Example 2: Large site, major infrastructure.

<table>
<tr><th>Species
[Table 3.1]</th><th>Importance of roosts (summary of justification only)
[Table 3.2]</th><th>Importance of commuting and foraging habitat (summary of justification only</th><th>Importance of assemblage
[Table 3.3]</th></tr>
<tr><td>Widespread
Common pipistrelle
Soprano pipistrelle
Brown long-eared</td><td>Many buildings within the red line boundary contain individual roosting bats and/or non-breeding day roosts. A single building has been recorded supporting a small maternity roost of approximately 30 soprano pipistrelles Does not exceed District importance
Several buildings within the red line boundary support individual or small non-breeding roosts for brown long-eared bat.
Site importance</td><td rowspan="4">The habitats in and around the red line boundary meet the definition of ‘moderate potential value’ as defined in the Bat Survey Guidelines. Areas of woodland, rare for this area of north-west Wales, provide sheltered foraging alongside the exposed coast in poorer weather. There are some hedgerows and ditches, but much of the rest is grazed.
- The Natterer’s bats from the maternity roost are heavily dependent on the woodland due to its isolated nature; significant activity for the species was recorded via transects and static detectors in the wooded areas of the site
- Similarly, small numbers of brown long-eared bats (~10) regularly use the isolated woodland within the red line boundary.
- High activity levels for common and soprano pipistrelles were recorded on static detectors in areas of habitat of higher foraging value for bats.
- Noctule were recorded only irregularly during transects and static detector monitoring.
- Only a single occurrence of Nathusius’ pipistrelle was recorded on static detectors survey.
- Whiskered/Brandt’s bats regularly used the site in small numbers.
Taking the above into account, the habitats within the red line boundary, and particularly the woodland, are considered to be of District importance. Habitats elsewhere within the county are of higher value and support a greater diversity and abundance of species.</td><td>1 point per species
Score 3 for this part of the assemblage (of a maximum of 3)</td></tr>
<tr><td>Widespread but not as abundant in all geographies
Natterer’s bat
Whiskered/Brandt’s
Noctule</td><td>Several buildings within the red line boundary support individual or small non-breeding roosts for Whiskered/ Brandt’s.
Site importance
No noctule roosts detected within the red line boundary.
Maternity roost for Natterer’s bat containing 40 bats located on site. This is a rare occurrence within the county. County importance</td><td>2 points per species
Score 6 or 8 (of a possible 10)
for this part of the assemblage (possible both whiskered and Brandt’s bats present)</td></tr>
<tr><td>Rarer or restricted distribution</td><td>N/A</td><td>3 points per species
Score 0 for this part of the assemblage (of a maximum of 3)</td></tr>
<tr><td>Rarest Annex 2 species and very rare
Nathusius’ pipistrelle</td><td>Despite absence of prior evidence from numerous emergence surveys, a single Nathusius’ was located during the supervised demolition of a building within the red line boundary. This was assumed a transitory animal and the roost therefore of low significance.
Site importance</td><td>4 points per species
Score 4 for this part of the assemblage (of a maximum of 16), noting that barbastelle are patchily distributed and not thought to be present here, so discounted.</td></tr>
<tr><td colspan="4">Overall score: Assemblage score 13 (or 15). Range for importance is because whiskered/Brandt’s not distinguished, illustrating the issue of undistinguished Myotis. 13 (or 15)/32 = 41-47%. This site would therefore meet the threshold for County importance only if both whiskered/Brandt’s were present, which is considered unlikely.</td></tr>
</table>

Table A2.3 Example 3: Linear infrastructure scheme in Snowdonia.

<table>
<tr><th>Species
[Table 3.1]</th><th>Importance of roosts (summary of justification only)
[Table 3.2]</th><th>Importance of commuting and foraging habitat (summary of justification only</th><th>Importance of assemblage
[Table 3.3]</th></tr>
<tr><td>Widespread
Common pipistrelle
Soprano pipistrelle
Brown long-eared</td><td>No pipistrelle roosts have been identified within the red line boundary; however, there are records of maternity roosts within 500 m of the boundary.
Do not exceed District importance.
No brown long-eared bat roosts have been identified within the red line boundary; however, there are records of non-breeding day roosts within 500 m of the boundary. [Site] importance – noting location is off-site</td><td rowspan="4">The habitats in and around the red line boundary meet the definition of 'high potential value' as defined in Collins (2016). There are areas of mixed woodland to the east of the scheme, including components of an SAC, and a tree-lined river network. Much of the land within the red line boundary is grazed, with a limited hedgerow network.
The area does not stand out as exceptional for the county.
- High levels of Natterer's activity at certain times/ locations were recorded during static surveys indicating high reliance on the habitat by the species.
- High levels of Whiskered/Brandt's activity at certain times/locations were recorded during static surveys showing high reliance on the habitat by the species.
- Moderate activity levels of lesser horseshoe bat frequently recorded at multiple locations within the red line boundary; however, this species is not as common as elsewhere in the county.
- Regular occurrence of small numbers of brown long-eared bat recorded through static surveys
- Semi-regular occurrence of small numbers of noctules recorded through static surveys.
- Irregular recordings of greater horseshoe bat in low numbers via static surveys. Occasional passes of barbastelle, serotine and Nathusius' pipistrelle similarly detected.
- High levels of common and soprano pipistrelle activity were recorded during static surveys showing high reliance on the habitat by the species.
- Caves and mines are available for hibernation in the vicinity.
Taking the above into account, the habitats within the red line boundary are considered to be of County importance.</td><td>1 point per species
Score 3 for this part of the assemblage (of a maximum of 3)</td></tr>
<tr><td>Widespread but not as abundant in all geographies
Natterer's bat
Whiskered/Brandt's
Noctule</td><td>No roosts have been identified within the red line boundary; however, there are records of non-breeding day roosts within 500 m of the boundary.
[Site] importance – noting location is off-site</td><td>2 points per species
Score 6 or 8 (of a possible 10)
for this part of the assemblage (possible both whiskered and Brandt's bats present)</td></tr>
<tr><td>Rarer or restricted distribution
Lesser horseshoe bat</td><td>No roosts have been identified within the red line boundary however there are records of maternity and non-breeding day roosts within 200m of the boundary for lesser horseshoe. District – noting location is off-site, but pretty close to redline boundary</td><td>3 points per species
Score 3 for this part of the assemblage (of a maximum of 3)</td></tr>
<tr><td>Rarest Annex 2 species and very rare
Greater horseshoe bat
Barbastelle
Serotine
Nathusius' pipistrelle</td><td>No records of roosts</td><td>4 points per species
Score 16 for this part of the assemblage (of a maximum of 20).</td></tr>
<tr><td colspan="4">The assemblage score is at least 28, possibly 30 (range for importance is because whiskered/Brandt's not distinguished, although highly likely both were present). 28 (or 30)/36 = 78-83%, confirming an assemblage of National importance.</td></tr>
</table>

Table A2.4 Example 4: Swale creation for flood alleviation, north Gwynedd.

<table>
<tr><th>Species
[Table 3.1]</th><th>Importance of roosts (summary of justification only)
[Table 3.2]</th><th>Importance of commuting and foraging habitat (summary of justification only</th><th>Importance of assemblage
[Table 3.3]</th></tr>
<tr><td>Widespread
Common pipistrelle
Soprano pipistrelle</td><td>A non-breeding roost of 2 soprano pipistrelles was located within a tree inside the red line boundary.
Site importance</td><td rowspan="4">The habitats in and around the red line boundary meet the definition of 'moderate potential value' as defined in the Bat Survey Guidelines. They include mixed wooded copses/patches and small areas of wet meadow,
- Regular use by low numbers of lesser horseshoe bats throughout all surveyed seasons was recorded.
- Observation of the known Natterer's bat roost and connecting hedgerow showed high reliance on a hedgerow within the red line boundary. The roost identified is of county significance and therefore the commuting value should reflect this. Irregular usage by small numbers of other Myotis (unspecified) noted from static detector surveys.
- During some static detector survey sessions, activity was very high for noctules, but timings and vantage-point surveys suggested usage by lower numbers of bats.
- High levels of common and soprano pipistrelle activity regularly recorded as habits offered high value foraging potential.
The assemblage is not unusual for the area. Taking all the above into account, the habitats within the redline boundary are considered to be of District importance.</td><td>1 point per species
Score 2 for this part of the assemblage (of a maximum of 3)</td></tr>
<tr><td>Widespread but not as abundant in all geographies
Natterer's bat
'Myotis spp'
Noctule</td><td>A roost of approximately 30 Natterer's bats has been identified in a building within 50 m of the red line boundary
County
No roosts have been identified for any other species in this category.</td><td>2 points per species
Score at least 4, possibly 6 for this part of the assemblage (of a maximum of 10)</td></tr>
<tr><td>Rarer or restricted distribution</td><td>No lesser horseshoe roosts have been identified within 500 m of the red line boundary</td><td>3 points per species
Score 3 for this part of the assemblage (of a maximum of 3)</td></tr>
<tr><td>Rarest Annex 2 species and very rare
n/a</td><td>n/a</td><td>4 points per species
Score 0 for this part of the assemblage (of a maximum of 20).</td></tr>
<tr><td colspan="4">Assemblage score unlikely to exceed 11 (11/36 = 31%), so does not meet the threshold for County importance.
[It is possible that one or more of the rarest species could be discounted (reducing the theoretical maximum from 36), but this site would need to be outside of the range of at least three of the rarest species to be ranked of County importance.]</td></tr>
</table>

Table A2.5 Example 5: Moderate sized greenfield development site.

<table>
<tr><th>Species
[Table 3.1]</th><th>Importance of roosts (summary of justification only)
[Table 3.2]</th><th>Importance of commuting and foraging habitat (summary of justification only</th><th>Importance of assemblage
[Table 3.3]</th></tr>
<tr><td>Widespread
Common pipistrelle
Soprano pipistrelle</td><td>A maternity roost of 40+ common pipistrelles in a house adjacent to the site. 5+ common pipistrelles identified in a tree within the red line boundary Do not exceed District importance</td><td rowspan="4">The habitats in and around the red line boundary meet the definition of ‘low potential value’ as defined in Collins (2016).
Habitats comprise farmland (low value rye grass grazing for the most part) with two nearby water bodies and small-scale light industrial use. Site is 5 km from a major river, with little or no woodland and poor quality hedging.
Soprano pipistrelle: low number of passes recorded long after emergence times, indicating an infrequently used flight-path along one boundary.
Common pipistrelle: high numbers of passes recorded, widespread around the site, higher in habitats to be retained within ZoI.
Moderate Leisler’s bat activity in vicinity of roost tree; regular passes recorded elsewhere.
Early whiskered bat activity adjacent to roost building, but limited passes recorded within site boundary.
Overall levels of bat activity do not suggest high reliance on the site. There are no obvious/known modifying factors that would make this site of higher value than the above would suggest.
Taking the above into account, the habitats within the red line boundary are considered to be of Local importance.</td><td>1 point per species
Score 2 for this part of the assemblage (of a maximum of 3)</td></tr>
<tr><td>Widespread but not as abundant in all geographies
Leisler’s bat</td><td>An ash tree had previously been identified as a non-breeding Leisler’s bat roost. Site importance</td><td>2 points per species
Score 2 for this part of the assemblage (of a maximum of 8)</td></tr>
<tr><td>Rarer or restricted distribution
Whiskered bat</td><td>Small whiskered bat maternity roost recorded in building just outside the site boundary. County importance</td><td>3 points per species
Score 3 for this part of the assemblage (of a maximum of 6)</td></tr>
<tr><td>Rarest Annex 2 species and very rare
n/a</td><td>n/a</td><td>4 points per species
n/a</td></tr>
<tr><td colspan="4">Assemblage score 2+2+3 = 7. Maximum score in Northern Ireland = 17. Percentage score for assemblage: 41%, therefore does not meet the criteria for County importance.</td></tr>
</table>

APPENDIX 3:
Forms of legal agreements

Mechanisms to ensure post-development habitat management, site maintenance and population monitoring

Schemes with a requirement to secure post-development works through a separate legal agreement (in addition to any EPS licence in force) could use one of the mechanisms in **Table A3.1**. Note that they may not all be available in all four countries of the UK, and this does not represent a detailed assessment of the legislation through which these different options may be achieved.

Table A3.1: Legal mechanisms to ensure post-development habitat management, site maintenance and population monitoring

Mechanism	Description	Note
Section 106 Agreement	Developer pays sum to fund an agreed programme of works.	Most common mechanism for assuring medium- to long-term management and monitoring plans in England and Wales. Commonly used to fund activities for compensation measures in (or due to come into) Local Planning Authority (LPA) ownership. Useful for establishing management frameworks. Functions in same way in Scotland, guided by Planning Circular 3/2012 (revised 2020)
Natural Environment and Rural Communities (NERC) Act 2006 Agreement with Natural England	Under the NERC Act, Natural England has the power to enter into an agreement with a person who has an interest in land about the management of the land, if doing so appears to Natural England to further its statutory general purpose to conserve and enhance nature in England.	NERC agreements are often used by Natural England to secure mitigation or compensation; however, only Natural England can create these agreements and they often rely on chains of novation agreements against successors in title.
Management agreement under s.15 of the Countryside Act 1968	Under the Countryside Act, NRW or NatureScot "may enter into an agreement with the owners, lessees and occupiers of any such land … which imposes restrictions on the exercise of rights over land by the persons who can be bound by the agreement."	Relevant in Wales and Scotland
Management agreements under s.16 of the National Parks and Access to the Countryside Act 1949.	A Welsh local authority or NatureScot "may enter into an agreement with every owner, lessee and occupier of any land, being land as to which it appears to [the Welsh local authority or (as the case may be) NatureScot] expedient in the national interest that it should be managed as a nature reserve, for securing that it shall be so managed"	Relevant in Wales and Scotland
Commuted sum	Developer provides lump sum payment to the LPA (or another body) to fund works. Commuted sum and interest must be ring-fenced for management and monitoring.	Best applied to larger developments, or to medium- to long-term management and monitoring plans.
Service charge	Owners/occupiers pay a service charge, collected annually, and index-linked. Must be ring-fenced for management, wardening and monitoring as appropriate, and agreed in writing.	Best applied to larger developments, or to medium- to long-term management and monitoring plans. May be possible to set up to last 'in perpetuity'. In Scotland, these are likely to be more effective once NPF4 is adopted, as (draft) Policy 3 requirements would mean that it should be easier to include measures within a service charge and see them delivered.
Legal agreement with local conservation organisation	Developer enters legally binding agreement, and sets up fund arrangements, to allow post-development activities to be undertaken by a local organisation.	May be used to fund management and monitoring by Wildlife Trusts etc., and can be independent of any planning approval. An example would be where a Trunk Road Agency has responsibility for an enhancement area, but contracts the local Wildlife Trust to actually manage and/or monitor the work.
Conservation covenant	Defined in Part 7 of the Environment Act 2021, this is an agreement between a landowner and a responsible body which has a conservation purpose, and is intended by the parties to be for the public good.	The definition of a responsible body is set out in the Act.

Post-development site safeguard

Table A3.2 below shows some mechanisms which could be used to provide site safeguard. Consultants and developers should choose mechanism(s) which are appropriate to the circumstances. Some must be finalised as part of planning determination and therefore require early consideration. Not all options are available in all four countries of the UK.

In particular, stand-alone bat houses and bat lofts created for high conservation status roost loss must be safe from foreseeable future development and habitat management threats, and should be proposed for the highest-impact cases.

Table A3.2: Mechanisms to secure long-term site safeguards

Mechanism	Description	Note
Restrictive covenant	Restricts the use of land; binding upon the current owner and any future owners of the land. Used mainly to prevent damaging activities, including future development or destruction of habitat features.	n/a
Clause to relinquish future development options in s.75/106 Agreement	Prevents further development within area covered by s.75/106 Agreement.	Can be permanent or time-limited.
Explicit recognition of site importance in local planning documents (e.g. Local Plans).	Ensures consideration in future planning decisions.	This may be more suitable for stand-alone compensation roosts than buildings which also function as private residences.
Legal agreements	Typically, such an agreement will transfer a landholder's obligations when an asset is sold, and give the SNCB powers to ensure the roost (compensation measure) remains protected.	Can be made under the NERC Act in England, between the SNCB and the licensee. These types of NERC Act agreements will be expected where a licensing proposal results in a high negative impact to a high conservation status roost.

APPENDIX 4: Case studies

Case study number	Reason for inclusion
Case study 1: Fron Haul, Flintshire, North Wales	A successful replacement roost for brown long-eared bats
Case study 2: Sherwood Hideaway, Ollerton, Nottinghamshire	Creation of a new roost for brown long-eared bats
Case study 3: Durslade Farm, Somerset	Creation of a bat loft and associated enhancements
Case study 4: Use of screening to reduce disturbance	Use of screening on a large site used year-round by different species of bats
Case study 5: Stables at Croxteth Park, Liverpool	Successful mitigation for brown long-eared bats
Case study 6: Peckforton Castle, Cheshire	Modification of a Natterer's bat breeding roost
Case study 7: Holiday Inn Hotel	Creation of soprano pipistrelle maternity roost
Case study 8: Primary School, Forest of Dean, Gloucestershire	Retaining access points in modified roosts
Case study 9: Stately home repairs, Worcestershire	Re-instating roosts and access points as closely as possible during repair and refurbishment works
Case study 10: Barn re-roof, Lancashire	Maintenance of functionality in a Daubenton's bat roost
Case study 11: Building reconstruction and bat barn construction, Lancashire	Compensating the loss of a roost for a range of bat species
Case study 12: Modern roofing systems	Including bat access within modern dry-roof systems
Case study 13: Creating a roost behind a fascia board	Plans and photographs for creating a roost behind a fascia board
Case study 14: Bat access slate (Option 1)	Plans and photographs for installing bat access
Case study 15: DIY construction of the 'Morris' Bat-slate (Option 2)	Plans and photographs for installing bat access
Case study 16: More access options	More examples of access points in place
Case study 17: Re-roofing Hugh Sexey C of E Middle School, Somerset	Accommodating mobile day-roosts within re-roofing
Case study 18: Eaves access for lesser horseshoe bats	A low-level eaves access point which reduces heat loss compared to a dormer
Case study 19: Providing additional microclimates for horseshoe bats	Low-cost enhancements to existing roosts to add additional microclimates
Case study 20: Modification of pedestrian subway to create lesser horseshoe bat roost	Conversion of an existing structure into a multi-purpose roost with varying microclimates
Case study 21: Triple ridge system roosting opportunity	Creation of additional crevices during a renovation project
Case study 22: Replacement roost using an 'American style' bat box	Successful use of an 'American style' bat box for a roost lost in renovation work
Case study 23: Conflict resolution: relocating a soprano pipistrelle maternity colony from a building's interior to artificial roosts	Successful artificial roost provision on a northern elevation and resolving bat-human conflict within a shared space. Also demonstrates the value of providing artificial heat.

Case study 24: Tree-marking protocol	An example marking scheme for wide-scale tree removal
Case study 25: Tree-removal protocol for large numbers of trees	An example protocol for wide-scale tree removal
Case study 26: Examples of tree mitigation	Examples of veteranisation
Case study 27: Creation of PRFs in 'habitat poles'	Retaining habitat poles as a means of compensating habitat loss through tree crown removal
Case study 28: Placement of standing deadwood (monoliths)	Translocation of monoliths
Case study 29 : Re-use and creation of potential bat roost features	Examples of re-used and created PRFs
Case study 30: Silverton Mill, Devon	Working around multiple constraints, notably a culvert; also the importance of habitat improvements
Case study 31: Kingfishers Bridge hibernaculum, Cambridgeshire	Successful creation of a bespoke artificial hibernaculum
Case study 32: Middleton Upper Quarry mine-workings, Midlothian	An innovative approach to maintaining access to a hibernaculum which was threatened with loss
Case study 33: Two Mile Bottom artificial hibernation tunnel, Thetford Forest	Successful creation of a bespoke artificial hibernaculum
Case study 34: Denbury Lime Kiln	Successful creation of a bespoke artificial hibernaculum
Case study 35: Exclusion of bats from an inaccessible mine adit using smoke	A novel approach to bat exclusion in a constrained situation
Case study 36: Working around asbestos	An approach to bat exclusion in a situation limited by H&S considerations
Case study 37: Urban riverside lighting	A sensitive approach to lighting
Case study 38: Noise measurements of construction activities	Samples of unweighted high-frequency noise recordings of construction activities
Case study 39: Barbastelle tree roost, Somerset	An example of buffers applied to a development site to protect an important tree roost.
Case study 40: Management of disturbance	An approach to managing disturbance
Case study 41: Use of a s.106 agreement to secure long-term funding for management	Protection and sympathetic management of a strategic flyway with secured funding achieved through a s.106 agreement
Case study 42: A487 Porthmadog, Minffordd and Tremadog Bypass	An example of a successful dedicated 'bat bridge'
Case study 43: Maes-yr-Helmau to Cross Foxes Improvement Scheme	Use of bollard lighting in reducing bat casualties
Case study 44: Example large-scale monitoring protocol for tree clearance	Example of a large-scale monitoring protocol subsequent to tree clearance over a wide area

Case study 1

Fron Haul, Flintshire, North Wales

Reason for inclusion: to demonstrate a successful replacement roost for brown long-eared bats.

A derelict house required demolition to accommodate a quarry expansion for a site in North Wales. Historically, the property had been a brown long-eared maternity roost (pre-1999, one of the largest recorded in N. Wales), so a replacement bat roost structure was required in compensation.

Overview of mitigation

The replacement structure was completed in June 2011.
The original roost was a derelict farmhouse with stone walls and slate roof located on a former track close to broad-leaf woodland, and enclosed by more- recently planted conifer (screening to quarry). It was demolished in October 2011.

State of property before works

Design principles

- 6m (l) x 4m (w) x 6m (h) gable-ended stone barn with cavity walls and earth floor
- underground chamber created from cast concrete rings
- ground floor divided into three sections by block walls with half-doors
- insulated ceiling to create warm loft
- modified trussed roof to create open central space
- steeply sloping slate clad roof with two gabled dormers
- external roosting opportunities for crevice-dwelling bats

Replacement roost July 2011 (south-eastern elevation).
Located adjacent to quarry access road on woodland edge set into a steeply sloping bank, 150 m from the original roost.
By setting it into the bank, it enabled the northern gable end to be partially buried and ensured suitably cool and humid conditions for transitional and hibernation use.

Replacement roost July 2011 (south-western elevation)

Replacement roost July 2014 (South-eastern elevation), three years later

A modified open-plan trussed roof was used with a rough timber ridge board inserted at the apex and an additional false purlin inserted 600 mm above floor level

Overview of monitoring results

Prior to demolition, the house had deteriorated and was being used (2008) as a:

- transitional and hibernation roost by small numbers of brown long-eared bats;
- mating and transitional roost by small numbers of lesser horseshoe bats;
- day/transitional roosts for small numbers of common and soprano pipistrelle bats.

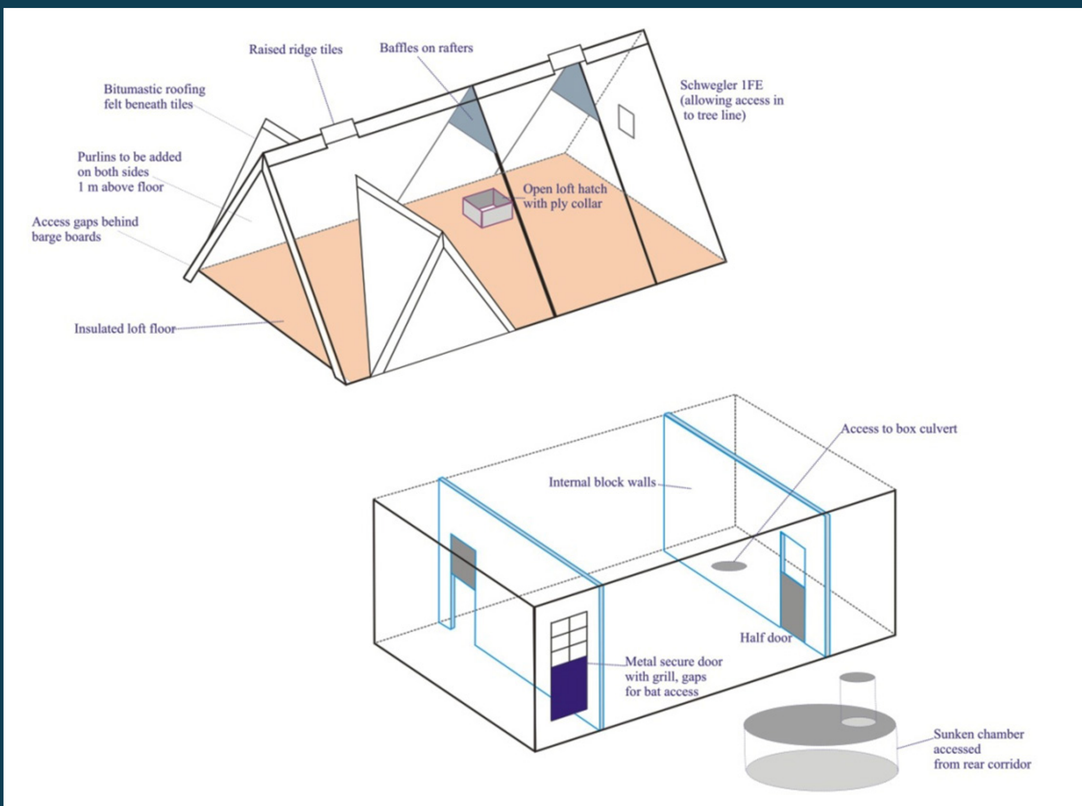
Replacement roost (completed October 2011):

- use of replacement structure by small numbers of brown long-eared and lesser horseshoe bats confirmed in June 2012;
- evidence of hibernation by small numbers of lesser horseshoe bats noted in winter 2012;
- breeding by lesser horseshoe bat confirmed in summer 2014;
- hibernation by brown long-eared bat confirmed in winter 2014;
- increasing numbers of both species recorded year on year - latest count in July 2021:
  - 60+ lesser horseshoe bats (approx. 30 juveniles)
  - 27 brown long-eared bats (approx. 15 juveniles).

Replacement roost July 2011 (south-eastern elevation).

Located adjacent to quarry access road on woodland edge set into a steeply sloping bank, 150 m from the original roost.

By setting it into the bank, it enabled the northern gable end to be partially buried and ensured suitably cool and humid conditions for transitional and hibernation use.



Thanks to David Lewns, Protected Species Ecology Ltd, in conjunction with Wardell Armstrong, for case study and photographs, and to Marshalls (now Breedons) (client).

Case study 2

Sherwood Hideaway, Ollerton, Nottinghamshire

Reason for inclusion: to demonstrate the creation of a new roost for brown long-eared bats

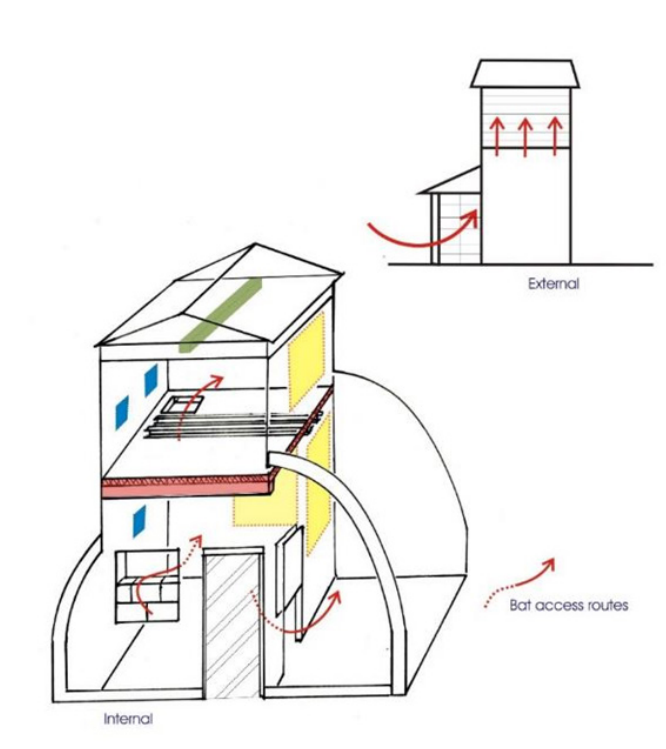
A former Territorial Army camp, with over 130 buildings within a forested site, obtained planning permission to create a holiday park with log cabins/chalets. Most buildings offered low suitability for bats; however, the site included a number of veteran trees and was adjacent to an SSSI and SAC. Transects of the site confirmed a wide range of bat species present (barbastelle, Natterer's bat, *Nyctalus, Pipistrellus*).

Overview of mitigation

To compensate for the loss of roosting opportunities, two of the redundant buildings on the edge of the site were retained and modified to create dedicated bat roost buildings, each approx. 5m (l) x 3m (w) x 4.8m (h).

Building modifications included

- Demolishing part of the building to leave just the water tower section, and stripping out all internal pipe work and tanks
- Adding a pitched roof on top of the existing flat roof and inserting a ceiling with 150mm insulation 1.5 m below the roof to stabilise internal temperatures in the loft
- Partially blocking the existing window to create a bat access point 400mm by 900mm
- Adding hanging tiles inside the building (yellow squares), bat boxes (blue squares), and a rough timber beam (green rectangle) for additional roosting opportunities
- Adding timber cladding to all external elevations
- Adding a lean-to porch to cover bat access points



Schematic diagram showing bat access points (external) and bat features (internal) – NB porch omitted from internal diagram

Building prior to start of works

Conversion – December 2009

Completed conversion – 2009. Timber wedges (right) were added to create gaps behind the timber cladding

Internal – ceiling inserted 1.5 m below flat roof

Bat boxes and hanging tiles were added to the internal walls – although these do not appear to have been used

August 2012 – vegetation surrounding the bat structure – this required regular strimming to ensure that access was not blocked

August 2012 – vegetation starting to encroach on bat structure

Overview of monitoring results

- Most buildings offered low suitability for bats; the roost resource was in the adjacent habitat.
- Modifications occurred December 2009
- July 2010 - pipistrelle spp. droppings below access points on external cladding;
- August 2012 – brown long-eared bat droppings noted inside buildings;
- 2015 confirmed maternity roost of brown long-eared bats (13 bats including 6 juveniles).

Thanks to David Lewns, Protected Species Ecology Ltd, in conjunction with Wardell Armstrong, for case study and photographs, and to Proteus Park LLP (client).

Case study 3

Durslade Farm, Somerset

Reason for inclusion: to demonstrate the creation of a bat loft within the main roost building and associated enhancements, originally used by multiple species in small numbers.

This site was a traditional 1800s Grade II listed farmstead that had been abandoned and not worked for several decades. The buildings comprised a farmhouse with separate wash-house, a threshing barn, stables and pig stalls, constructed of stone with pitched, tiled roofs. A separate timber granary was also present. The buildings were all in a poor condition.

Overview of mitigation

Bat surveys of all buildings on site undertaken in 2010 and 2012 identified small numbers of roosting common pipistrelle, soprano pipistrelle, serotine and brown long-eared bats. Surveys in 2010 also identified night roosts for greater and lesser horseshoe bats. A building inspection in April 2013 recorded a brown long-eared bat day-roosting in the piggery. The building renovation resulted in the loss of these roosts and disturbance to bats during the works.

Mitigation comprised the creation of a bat loft in the farmhouse for serotine, pipistrelle and long-eared bats, and restoration/modification of a derelict wash-house to provide roosting opportunities for horseshoe, long-eared and pipistrelle bats.

Western view of the farmhouse (mitigation roof void roost on the right of the photo)

Wash-house before it was renovated and converted into a bat roost

Bat access tile installed within the farmhouse roof

Design principles

Roost height/volume: The dimensions of the farmhouse bat loft were 6.5 m along the length of the ridge by 4.3 m width to the eaves, with a height at the roof apex of 2.5 m.

The dimensions of the wash-house were approximately 4.9 m long (including former WC) by 2.6 m wide. The internal rooms (approximately 2 m high at the eaves and 3.5 m to the roof apex) are available for use by bats.

Access points: Farmhouse bat loft: a bat access tile was inserted on the north-east-facing aspect of the tile-covered roof, approximately 2 m from the north-west gable end. A cut approximately 60 mm x 30 mm was made in the bitumen underfelt to allow bats to access the roof void. The bat loft includes a second access point under the rear eave of the same section of roof, providing bat access to the wall top.

Wash-house and adjoining former WC roost: two fly-in access points for bats were created above the tops of doors to the wash-house and WC (for the whole width of the doors and each measuring at least 200 mm deep). The buildings were roofed using bitumen underfelt beneath slates, and an internal window was created approximately 400 mm x 400 mm to allow internal flight access between the two rooms. The windows were boarded over internally to create dark internal conditions during daylight hours. Two crevice roost sites were provided on internal walls of the wash-house, using ply-board constructed boxes. These measured 500 mm x 500 mm and were made of 12 mm marine ply.

Thermal regime: Not known, but the farmhouse roof void was very similar in materials and dimensions to before, so it is assumed the conditions following repairs are very similar to the original conditions.

Perching opportunities: The rafters and central ridge beam were retained, so numerous perching locations were present. Gable stone walls also offered perching potential.

Roofing membranes: Type 1f bitumen felt was used. Any new timbers (battens) were treated with chemicals approved for use in bat roosts.

Location and connectivity; external environment: mature trees close to the immediate west of the buildings provide good connectivity between roosts and foraging/commuting habitat.

Orientation: the farmhouse roof void ridge line is east to west. The wash-house ridge line is north to south.

Protection against vandalism: The roosts are in private ownership and are not accessible to the general public. Risk of vandalism is extremely low.

Long-term security: good.

Overview of monitoring results

Low numbers of common and soprano pipistrelle, brown long-eared, serotine and horseshoe bats were recorded roosting within the site during the 2010 surveys.

During the roof stripping and renovation works in 2013, the following bats were found:

- 9 brown long-eared (different roosting locations)
- 1 serotine

The renovations and roost creation roofing works were completed in 2014.

Monitoring following the works comprised daytime inspections only.

21 August 2014

- Farmhouse roof void – c. 35 serotine and/or long-eared bat droppings scattered throughout the mitigation roof void and a concentration of c. 15 serotine droppings at the south-eastern end of the void. An adjacent roof void contained c. 15-20 droppings attributed to serotine. No bats seen in either roof void.
- Wash house – bat feeding remains found comprising 6 small tortoiseshell butterfly wings in two groups (no bats or droppings seen).

19 August 2015

- Farmhouse roof void – c. 350 serotine droppings in several piles in the mitigation roof void and a concentration of c. 50 serotine droppings at the south-eastern end of the void. One serotine bat was present at the apex of the roof void (against central ridge beam). The adjacent roof void contained c. 15 droppings attributed to serotine and potentially long-eared species (no bats seen in that roof void).
- Wash house – 3 bat droppings found attributed to long-eared species. Occasional old bat feeding remains found comprising butterfly wings (no bats seen).

25 October 2016

- Farmhouse roof void – c. 1,500 serotine droppings on the floor of the roof void. The bats appeared to be using the north-west gable to access the void (as opposed to the bat access tile – not confirmed). The adjacent roof void contained c. 10 droppings attributed to serotine and long-eared (no bats were seen). The number of droppings had decreased.
- Wash house – 6 bat droppings found attributed to long-eared species (no bats seen).

Challenges

The monitoring surveys comprised day-time inspections only; dusk/dawn or static surveys would have been useful in determining species and numbers to be sure of success for each species affected by the works.

Contractors repeatedly used the wash-house to store equipment and caused regular disturbance, and the client would not provide a lock for the door. This is likely to have deterred any bats from day-roosting in this building.

Ideally, monitoring would have been undertaken over a longer period to determine the success of the mitigation. The monitoring was sufficient to show use by two species (noting that all species had only used the site in small numbers originally, and the buildings had been in a poor condition). For serotine, use had increased.

Lessons learned

Seek up-front agreement to place locks on mitigation roosts to reduce disturbance.

Undertake more detailed monitoring surveys (as allowed for in the licensing requirements now).

Thanks to Tom Clarkson, Clarkson & Woods Ltd, in conjunction with Wardell Armstrong, for case study and photographs

Case study 4

Use of screening to reduce disturbance

Reason for inclusion: to demonstrate screening works for a roost occupied all year round.

A listed large timber-frame barn in rural North Hampshire suffered major damage from winter storms in 2015/16, necessitating structural repair works and complete re-roofing of its southern half.

The barn was known (from unsuccessful development proposals) to support barbastelle (day roost, males); common and soprano pipistrelle bats (day and hibernation roosts); brown long-eared bat (satellite maternity roost); and Natterer's bat (day/hibernation roosts). It was used by bats all year round in multiple sites (timber frame, ridge tiles etc) as well as supporting an active barn owl nesting site.

Note – this building has always had particularly high light levels internally and licence trainees assessing the site often judged it to have a lower potential than proved to be the case.

Outline mitigation strategy

- Commence direct works following the breeding season and before hibernation.
- Retain and protect roosting opportunities in the northern section of the barn and manage indirect noise, dust and disturbance by installing protective sheeting between north and south parts of the site.

Northern part of the barn prior to screen installation

Implementation

- Works commenced autumn 2016 under licence (purpose: public safety) and continued through winter 2016/17.
- No bats encountered in southern half of the barn during works following checks.
- Protective sheeting remained in place during the entire works period.
- Monitoring during and post works confirmed the continued presence of all species and roost types as well as further evidence of barn owl nesting.

Pre-works inspections for bats

Outcome

Subsequent surveys also found whiskered bats had started using the barn as a day roost.

Screening in place

Completed works

Thanks to Ian Davidson-Watts for text and photographs.

Case study 5

Stables at Croxeth Park, Liverpool

Reason for inclusion: to demonstrate successful mitigation for brown long-eared bats

A daytime assessment in 2012 found evidence that a brown long-eared bat maternity roost was using a loft space which opened up into the adjacent upper floor of a stable. Proposals involved complete re-roofing, work to timber beams, timber-treatment to eliminate woodworm and the installation of a fire wall which would reduce the available free-flight area by approx. 50%.

Overview of mitigation

Due to the work and building requirements, notably the installation of a dividing fire wall, it was not possible to maintain the roost in its entirety. However, gaps were provided above the fire wall that would still allow bats to access both areas. In addition, a heater was installed and the existing access points were retained.

Design principles

Roost height/volume: the free-flight area was reduced; however, the loft where the majority of droppings were located measures approx. 18 m x 7 m x 4 m, with a link to the adjacent upper floor of the stables maintained.

Access points: existing access points at eaves level were retained to the east and west aspects and to the north elevation through a window opening.

Thermal regime: temperatures in original roost: minimum 11°C and maximum 33.9°C; average reading 21.4°C.

Current temperatures within the roost now average 23.6°C, with the heater set at 30°C.

Perching opportunities: original timbers were retained and additional pre-treated rough sawn planks (150 mm wide x 25 mm thick) were affixed to the rafters from the ridge beam down to a distance of 600 mm. These were designed to encourage the bats away from the breathable membrane (BRM) and provide a localised and constant heat source.

Roofing membranes: Originally there was no roof lining; however, securing funding for the work depended upon the contractor guaranteeing the work for 10 years. They would not provide that guarantee using bitumen felt, only with a BRM. A scheme was required that Natural England would be able to approve. The above method was a compromise designed by the ecologist to meet the different parties' stipulations. Whilst imperfect, it was approved by Natural England.

Dotted line shows loft space above the property which connects to the upper floor of adjoining stables

All existing timbers were maintained and droppings retained in the loft space. Interior of roost has additional timber provision and a heating panel (droppings present below this feature).

Location and connectivity; external environment: The roost was in the same location, but during emergence and re-entry the bats were heavily dependent on the dark shelter provided by a yew tree. The importance of this feature was emphasised to the Local Authority to ensure it remained.

Protection against vandalism: The building is within the grounds of council-owned land and is secured from the general public.

Long-term security: The council has a long-term obligation to maintain the building which is Grade II listed. Notices have been provided at loft hatches to ensure no unauthorised access.

Overview of monitoring results

In May, June and July 2012, numbers prior to the work comprised 8 emergent brown long-eared bats, with 17 and 18 brown long-eared bats respectively re-entering during the two dawn surveys.

Monitoring was undertaken in line with the terms of the licence during 2013, with 30 individuals recorded; 2014 saw an increase to 68 individuals, with large accumulations of droppings clearly demonstrating that the mitigation was successful.

In 2021, a daytime inspection revealed droppings had increased significantly, especially in the location of the heating panel. Additionally, levels of droppings in the upper floor of the stables saw a large increase, notably where the fire wall divides the main roost. This indicates the bats are using both areas, possibly at different times of the active season (they are still able to access and utilise both areas without restriction).

On 25 July 2022, Merseyside & West Lancashire Bat Group monitored the mitigation roost. The weather was not optimal (light rain and breezy); nonetheless, 49 brown long-eared bats were recorded emerging.

Challenges

The main challenge with this site was the use of the BRM; the council would have lost the grant for the works without the guarantee secured by the use of a BRM.

Had the work not taken place, there would have been a rapid deterioration in the roof, more woodworm damage and, as a consequence, the loss of the roost.

It was important that the bats were discouraged from coming into contact with the BRM; this was achieved by offering alternative roosting opportunities in the form of extensive rough-sawn timbers and a localised heat source. The reduction in the size of the loft space and of the associated draughts increased mean temperatures within the roof and was achievable without compromising the roost because the initial space was so large.

Lessons learned

The reduction in the size of the loft space and of the associated draughts increased mean temperatures within the roof and was achievable without compromising the roost because the initial space was so large.

It may have been possible to challenge the use of BRM more strongly so that traditional bitumen was used, but the council were keen to use the appointed contractors who stipulated BRM, and it was not possible (or appropriate) to influence that choice.

The BRM has been closely inspected and has not to date revealed any wear or droppings to suggest the bats are roosting on it or in close proximity.

NOTE: this case study is for illustrative purposes only. It should not be taken as an endorsement of the use of any roofing felt other than bitumen 1F or (as of August 2022) certified NBCRMs (see 6.3.29 et seq), nor should it be used as a precedent to indicate that the use of uncertified NBCRMs (formerly referred to as BRMs) is acceptable (nor licensable) should the measures described above be adopted.

Thanks to Kylee Wilding, Tyrer Ecological Consultants Ltd, for text and photographs

Case study 6

Peckforton Castle, Cheshire

Reason for inclusion: to demonstrate the modification of a Natterer's bat breeding roost

A daytime survey of the castle, now a hotel, revealed evidence of a Natterer's bat breeding roost within stone wall cavities in a room in the west wing, which was unused at the time. Proposed plans to refurbish this area as additional guest accommodation would therefore have resulted in the loss of a roost for over 60 bats.

Overview of mitigation

Originally there was no viable alternative to keeping the room that contained the roost; the hotel were adamant that they needed to provide their guests with additional accommodation. A proposal was negotiated that would retain the roost by reducing the height of the ceiling within the new guest room but still allow free flight by the bats. The existing access/ingress was also retained.

Design principles

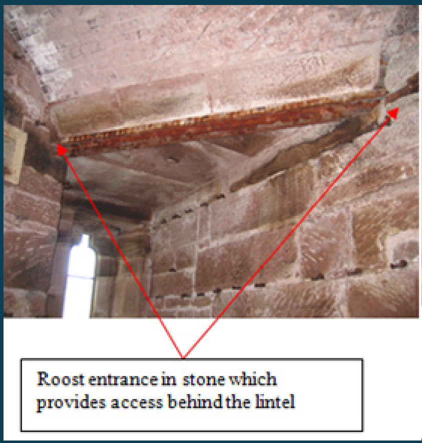
Roost height/volume: The existing area previously available for bats was c.36 m2; after the room was converted with a corridor construction, this was reduced to c.27 m2.

Access points: The bats left the building via a window opening. The lower section (within in the hotel room used for guests) could be glazed while the unchanged upper section adjacent to where the bats were located was retained.

Thermal regime: Previous temperatures of the roost were not taken as the West wing was highly exposed. Thermal recording of the new roost area showed an average temperature of 21.1°C. The ceiling that partitions the roost area and the guest room was thermally and acoustically insulated to avoid transfer of heat or noise.

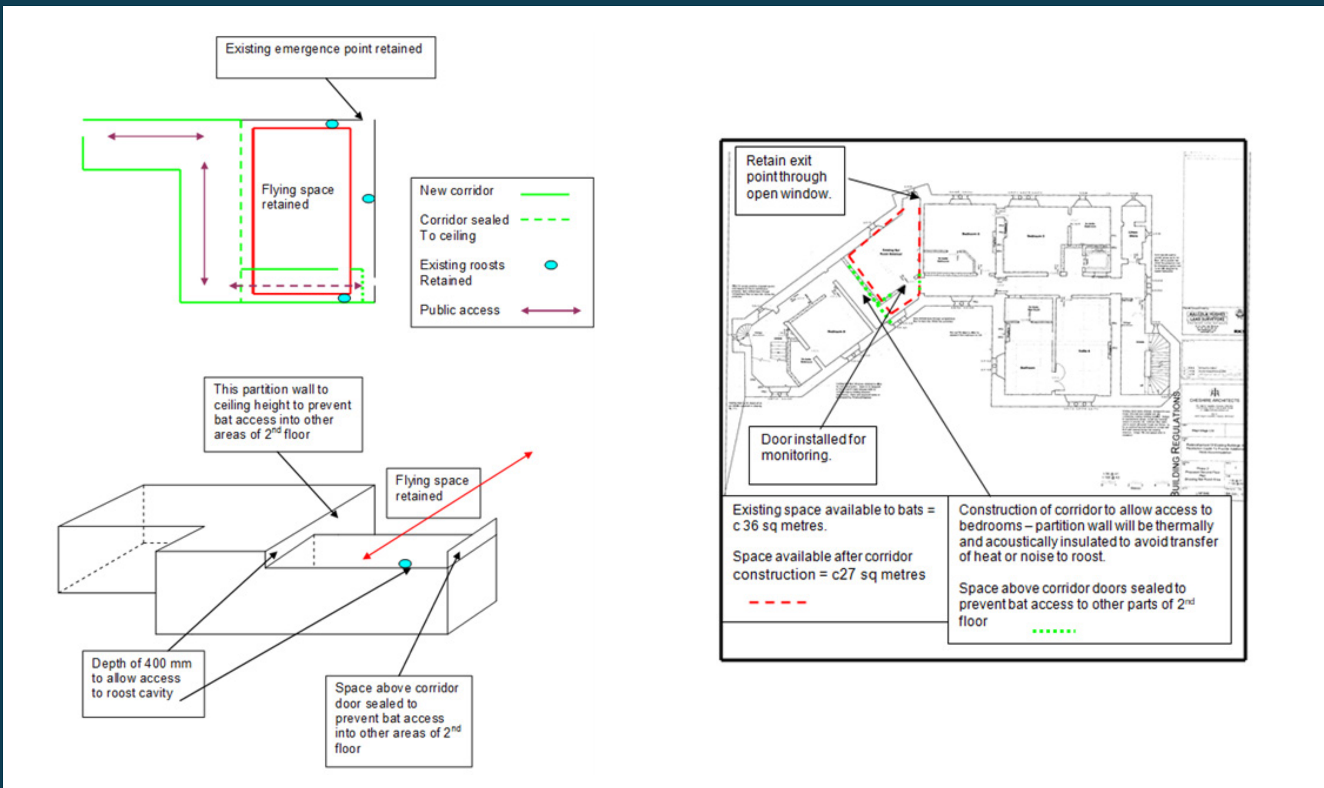
Perching opportunities: original features and roost locations retained.

Roofing membranes: n/a - original wall cavities retained.



Existing and retained roost locations in wall cavities

Exterior of Peckforton Castle



Summary of the provision and retention of the roost with reduced area for free flight prior to emergence

Location and connectivity; external environment: All maintained and unaffected

Protection against vandalism: the loft hatch is not accessible to the public

Long-term security: The roost is well documented and under the protection of the hotel.

Overview of monitoring results

During the initial surveys in 2009, a maximum of 61 Natterer's bats were identified as roosting within the castle room. During subsequent monitoring at the new roost in 2010, 81 Natterer's bats were observed emerging from the roost at the beginning of August, with 25 emergent bats towards the end of September. However, in 2013 the numbers observed emerging showed a slight decline, with 57 in June, 0 in July and 42 in August. These results demonstrated the roost continued to be used with bats still in situ until late September. There was some suspicion of roost obstruction in 2013 which could account for the reduction; however, this was discussed and rectified and the bats were still using the property in August.

Challenges

It was difficult to persuade the hotel to keep the roost in situ as they were initially keen to take over the roost space in its entirely to accommodate additional guests. However, the proposal outlined above meant they were happy to keep the roost at the castle even though it resulted in a reduced height within the new guest rooms.

Lessons learned

Try wherever possible to retain existing roost features and work with site owners to achieve the best results for bats, but also consider their commercial operations.

Thanks to Kylee Wilding, Tyrer Ecological Consultants Ltd, for text and photo-

Case study 7

Holiday Inn Hotel

Reason for inclusion: to demonstrate the creation of a soprano pipistrelle maternity roost.

During a daytime assessment and following dusk surveys, a large soprano pipistrelle roost was identified. The hotel was receiving complaints about odour caused by the bats as the roost was located within a void above an external staircase with the smell permeating into the corridor and hotel rooms, especially in hot weather. If a solution hadn't been provided, this roost would have been excluded as a number of rooms could not be used (a direct financial impact).

Overview of mitigation

Under licence and outside of the maternity season, the roost as dismantled and a new void constructed above the existing staircase void. Droppings were collected and transferred into the new void, and measurements replicated what was currently being used by the bats. Access points were provided within the same locations as previously identified.

Holiday Inn Hotel

Design principles

Roost height/volume: New void above the existing replicating the dimensions: i.e. flat roof (top of the staircase) 1 m x 1.5 m x 150 mm, and 4 m x 1 m x 150 mm deep (running down the staircase) – see photograph showing access points.

Access points: Several access points with a gap approx. 15-18 mm wide x 200 mm long were located behind the barge board providing access to the roof void approx. 13 m above ground level. These replicated the emergence locations identified from the dusk surveys.

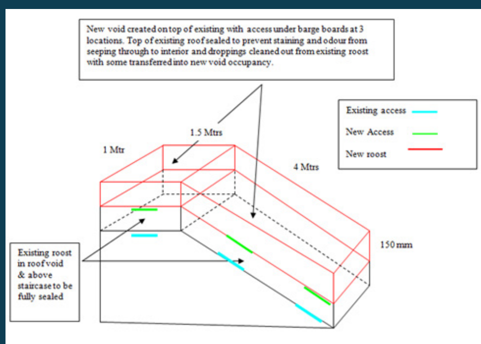
Identified emergence points by S. Pipistrelle

Thermal regime: n/a

Perching opportunities: The roost was replicated above the original roof void.

Roofing membranes: New flat roof covered in bitumen with three layers of felt (the standard procedure for these systems).

The existing roost was covered in bitumen and green mineral felt to seal the roof and internal ceiling from the new roost to prevent seepage and odours into the hotel. Droppings were collected and transferred into the new roost and existing barge boards were re-used at the newly created loft void.



Newly constructed loft void above existing roof – area sealed and purely dedicated for the soprano pipistrelle

Location and connectivity; external environment: n/a - roost modified in situ.

Protection against vandalism: The area in which the roost is located cannot be accessed by the general public.

Long-term security: The hotel needs to stay in a good state of repair and the roost is well documented with the hotelier.



Overview of monitoring results

Before the works: soprano pipistrelle count

May 2009	199
July 2009	137
14 August 2011	225

After the works: soprano pipistrelle count

8 July 2010	140
16 August 2010	162
16 June 2011	214
14 August 2011	225
17 July 2012	422
14 August 2012	246

Long-term outcome: the mitigation was successful in addressing issues with smell and staining. An updated count undertaken in July 2022 recorded 451 soprano pipistrelles emerging, 241 of which emerged before sunset.

Challenges

Persuading the hotel owners not to request exclusion.

In 2022, a tawny owl was observed watching the roost and then actively trying to take a couple of bats during the survey whilst in flight.

Lessons learned

Innovative methods to secure the roost and alleviate the problems were possible by being mindful of the problems (and commercial impacts) the hotel were experiencing. This meant the 'easy option' of just providing external bat boxes (which may not have been as successful or have the same longevity) was not necessary.

Thanks to Kylee Wilding, Tyrer Ecological Consultants Ltd, for text and photographs, and to her team and the hotel for undertaking/ permitting a return visit in 2022.

Case study 8

Primary School, Forest of Dean, Gloucestershire

Reason for inclusion: to demonstrate the value of retaining access points in modified roosts

During repair works to the roof of a primary school in March 2009 a bat was found and works stopped. Subsequent surveys in summer 2009 identified a maternity colony of brown long-eared bats, along with non-breeding roosts of lesser horseshoe, common and soprano pipistrelle. The proposed works comprised replacement and re-lining of the roof, and replacement and repair of internal roof timbers, soffits and bargeboards due to rot and beetle infestation.

Overview of mitigation

The mitigation strategy was to retain the roosts in situ, avoiding disturbance to bats by timing works to avoid the maternity season. As the presence of hibernating bats was unlikely, work took place during December to March.

Design principles

Roost height/volume: Unchanged.

Access points: The access point used by brown long-eared bats was a gap between the stonework and bargeboard at the apex of a gable end. Bats crawled over the wall-top to gain access to the lofts. As existing purlins were retained, the spacing between bargeboard and wall, and spacing between wall tops and rafters remained unchanged.

Interior of building during works

Thermal regime: Unchanged.

Perching opportunities: Some rafters in poor condition required replacement, majority of timbers retained.

Roofing membranes: at the time the licence was granted, use of non-bitumen coated roofing membranes was still allowed although there were increasing concerns about its use in roosts. The re-roofing used non-bitumen coated roofing membrane but a single sheet of 1F underfelt was specified along each side of the ridge beam.

Bat access point at gable apex

Location and connectivity; external environment: Unchanged.

Protection against vandalism: Premises are fairly secure, as in active use as a school.

Overview of monitoring results

Pre-development surveys identified a peak count of at least 35 brown long-eared bats (end July count), plus up to six common pipistrelle bats, and one soprano pipistrelle bat.

Monitoring in mid-July 2011 (year 2 following works) recorded 31 brown long-eared bats emerging from the same access point, and four common pipistrelle bats emerging elsewhere on the building. Further surveys in 2016 (year 7) found peak counts of 35 brown long-eared bats (post-breeding), two common pipistrelle and one soprano pipistrelle emerging.

Challenges

Contractors failed to implement the required 1F, and due to restricted access to the building once re-occupied by the school, this was not picked up in time to correct it (though it has been done retrospectively during a subsequent phase of works). Fortunately, no evidence of fluffing or trapped bats has been found.

Lessons learned

Access should have been gained during replacement of the roof membranes, to check implementation of the 1F underfelt strip, but current best practice and licensing policy would in any case have required use of 1F or timber sarking throughout.

As of August 2022, the use of certified NBCRM would also be possible.

Thanks to David Wells and Rebecca Collins, Collins Environmental Consultancy, for text and photo-

Case study 9

Stately home repairs, Worcestershire

Reason for inclusion: to demonstrate the value of re-instating roosts and access points as closely as possible during repair and refurbishment works

Repair works were proposed to a Grade II* listed building in 2004, which was known to support a common pipistrelle maternity roost. Proposed works included strengthening roof timbers, repairing gutters, re-pointing chimneys and repairing brickwork. Bats were roosting in a soffit box supporting the lead gutter, in voids between the lead and the soffit box and, to a lesser extent, in the roof void.

Overview of mitigation

The mitigation strategy was to retain the roost *in situ*, avoiding disturbance to bats by timing works to avoid the maternity season. As the presence of hibernating bats was unlikely, work took place during October to March.

Design principles

Roost height/volume: Unchanged.

Access points: The access point used by bats was a gap between the wall top and the underside of the soffit, on either side of a gutter downpipe.

Thermal regime: Unchanged.

Perching opportunities: Some rafters in poor condition required strengthening, and much of the soffit timber needed replacing. A quantity of droppings was removed from the old soffit and spread in the replacement one prior to fitting the lead gutter.

Roofing membranes: As was common at that time, the 1F membrane present prior to works was replaced with non-bitumen coated roofing membrane, though dark-coloured membrane was specified, and the main roosting site was not in contact with this membrane.

Location and connectivity; external environment: Unchanged.

Protection against vandalism: The roost is fairly secure against vandalism, being at eaves height on a two-storey building.

Access point against wall top

Gutter with lead removed showing droppings

Overview of monitoring results

Pre-development surveys identified a peak count of at least 247 common pipistrelle bats (June count).

Monitoring in mid-July 2005 (year 1 following works) recorded 181 common pipistrelle bats emerging from the same access point.

Challenges

The contractors' programme was delayed due to poor weather so that works extended into April, when bats may have been wanting to re-occupy the roost. It is clear that bats did so almost immediately on completion of works.

Lessons learned

With hindsight, given the time of year and potential for weather-related delays, it should have been specified that the roost area was completed earlier in the programme, to avoid the risk of bats returning before works were complete.

Thanks to David Wells and Rebecca Collins, Collins Environmental Consultancy, for text and photographs.

Case study 10

Barn re-roof, Lancashire

Reason for inclusion: to demonstrate the maintenance of functionality in a Daubenton's bat roost

Work comprised the replacement of all roof coverings of a two-storey barn, leading to the temporary loss of roosting features for Daubenton's bats (including use as a maternity roost).

In 2016, when the licensed works took place, the roost had been counted for over 15 years, with a mean count of 31 bats during the maternity season. The highest number of Daubenton's bats counted at any time was 45. The specific location of the roost (deep vertical wall cavity) was unknown until it was uncovered during the works.

Overview of mitigation

- Close supervision of bat-related aspects by the Project Ecologist.
- Programming of works to avoid high-risk periods (summer and winter).
- Putting safeguards (bat boxes) in place before the start of proposed works and retaining these after development works. Bat boxes have been used (by pipistrelles) throughout the year, from one year after installation.
- Ensuring that the whole roof and associated area (potential roost sites) were carefully searched and dismantled to minimise impacts on bats, under the direct supervision of the Project Ecologist.
- Retaining the roost feature in the wall cavity, and providing a purpose-designed series of roosting features in the replacement roof structure.
- Monitoring of bat use of the development site during and after the period of development.

Bat access point at gable apex

Detail Photo

Design principles

Roost height/volume: new roost features at a variety of heights (increase from previous). Roost volume retained (wall) and increased (roof coverings).

Access points: existing access points retained via fascia board. New access points incorporated into roof coverings. Since mitigation work, bats continue to use their original access point. The specific roost area is likely to be the same as the original site in the wall cavity, though this is not visible as it is now fully covered.

Thermal regime: regime was maintained in wall roost as this was not disturbed. No other roost sites for Daubenton's bats have been found within this building. Regime improved in roof coverings due to materials and techniques used during construction.

Roofing membranes: Type 1 felt used to form all potential contact points for bats.

Orientation: no change to orientation

Location and connectivity; external environment: The barn lies within a small complex of stone buildings, part of a former farmstead (now workshops/offices). Immediate surroundings include parkland with amenity grassland, a freshwater lake, tree belts and small mixed woodlands. There is extensive artificial illumination, but undeveloped landscape features have a high degree of connectivity.

Protection against vandalism and long-term security: The building is situated on a university campus and lies on the route of regular security patrols. It is locked when not in use

Overview of monitoring results

Before works

Species/counts – Daubenton's bat (max 45); common pipistrelle (max 1)

Roost status – County importance (Daubenton's bat); site-level importance (common pipistrelle)

After works

Species/counts – Daubenton's bat (max 20); pipistrelle (not determined to species) – max count 2.

Roost status – County importance (Daubenton's); site-level importance (common pipistrelle)

Thanks to Pat Waring, Ecology Services UK Ltd, for text and photographs.

Case study 11

Building reconstruction and bat barn construction, Lancashire

Reason for inclusion: to demonstrate an example of the scope for compensating the loss of a roost for a range of bat species

The development involved the partial deconstruction and rebuilding of a group of derelict mill buildings in Lancashire. The buildings were used by soprano pipistrelle, common pipistrelle, brown long-eared and Natterer's bats (including use as brown long-eared and Natterer's maternity roosts). The development involved the complete destruction of all roost features, with potential disturbance to roosting bats. The buildings were unsafe for full inspection, so only some of the roost features could be examined initially.

Overview of mitigation

- Close supervision of bat-related aspects by the Project Ecologist.
- Programming of works to avoid high-risk periods (summer and winter).
- Mitigation (bat barn) in place before the start of proposed works.
- Ensuring that roost sites were carefully searched and dismantled to minimise impacts on bats, under the direct supervision of the Project Ecologist
- Monitoring of bat use of the bat barn during and after the period of development.

Design principles

Roost height/volume: large two-storey bat barn (approx. 8 m x 8m x 9 m)

Access points: multiple features, including beneath waney-lap, ridge tiles, fly-in over door, fly-in at first floor.

Thermal regime: design enables consistently cool ground floor and more fluctuating upper floor.

Perching opportunities: throughout interior and exterior, including roof felt, roof timbers, bat boxes, waney-lap, walls

Roofing membranes: Type 1 felt.

Location and connectivity; external environment: The bat barn lies within large private parkland estate, including freshwater lakes and woodland blocks. Immediate surroundings include broadleaved woodland, freshwater lakes, other buildings and hard standing. There is no artificial illumination in the immediate vicinity. Undeveloped landscape features have a high degree of connectivity.

Orientation: multiple orientations for potential roost features were created.

Protection against vandalism and long-term security: the building is on a private estate with regular security patrols and is locked at all times.

Overview of the original bat roosts, prior to deconstruction

Detail of the compensation building (bat barn)

Overview of monitoring results

Before the works

Species	• common pipistrelle, soprano pipistrelle, brown long-eared bat, Natterer's bat
Counts	• common pipistrelle - 2 • soprano pipistrelle - 3 • brown long-eared bats - 10 • Natterer's bats – 55
Roost Status	• County importance for assemblage and for brown long-eared and Natterer's bats • Local importance for pipistrelles

After the works

Species	• common pipistrelle and brown long-eared bats
Counts	• common pipistrelle - 2 • brown long-eared bats - 14
Roost Status	• County importance for assemblage and for brown long-eared bats • Local importance for common pipistrelle

One of the many bat boxes, of various designs, installed in the compensation building. This box was installed on the ground floor, attached to the interior of the internal porch (which was installed to minimise draughts and light incursion).

The two deeper cavities of the bat box illustrated here have been used during winter months, over two years, by up to three brown long-eared bats.

Challenges

- Limited initial access to carry out bat surveys and assessment due to significant safety concerns
- Large complex buildings with many potential roost features and access points

The roost compensation was only partially successful, as Natterer's bats have not returned.

Lessons learned

A substantial amount of work was achieved, but, as always, there was scope for more improved design and adjustment to the features provided. Since its construction, regular visits by licensed ecologists have enabled many adjustments to be made, and this is ongoing. For example, access points and flightpaths have been altered to minimise draughts and light incursion, and additional roost features have been provided (and adopted by brown long-eared and pipistrelle bats).

Thanks to Pat Waring, Ecology Services UK Ltd, for text and photographs.

Dry ridge and verge systems (1)

Reason for inclusion: to demonstrate how to include bat access within a dry ridge[132] and verge system

A dry ridge system is a method of mechanically fixing ridge tiles to the ridge of a roof without the use of mortar. The most popular system is to use 'ridge roll ventilation' which involves covering the roof batten with ridge ventilation roll and adhering it to the tile or slate. The ridge tiles are then installed over the ventilation roll to secure it in place, laying them across the apex of the roof using plastic unions, clips, clamps, screws and washers. The unions secure the tiles together with a small expansion gap while the clamps are placed between tiles and screwed down into ridge board or batten to provide a wind-proof fixing that allows roof movement.

Dry ridge systems are very common, especially on volume-roofing projects. Contract managers and contractors themselves can be reluctant to cut holes into dry ridge components (because they fear it will allow in water and/or invalidate their warranty), and unwilling to use a traditional wet ridge (i.e. using mortar) because of the additional time required and expectation of increased future maintenance costs. The following provides examples of where work-arounds have been found.

Gaps can be created by using two battens with spaces (below).

In this photo, the ridge roll was omitted (they often contain BRM) and the battens placed directly onto Type 1F 1F bitumen felt. Screws go through the clip/bracket and into the ridge board.

It is also possible to use a ridge roll (and Type 1F bitumen felt), and leave these intact by placing an access tile immediately below the ridge.

Note: the process of fitting an access tile below the ridge is the same with or without a dry ridge.

A hole has been cut in the felt below the access tile.

The roofer cut the felt and pinned it up (rather than down) so that if any water does get past the tiles the felt (as far as possible) will divert it to either side and run down the felt rather than into the roof.

Ridge tiles in situ showing an access gap

Ridge tiles showing tile and plastic union installed over batten

Gaps can be created by using two battens with spaces. In this photo, the ridge roll was omitted (they often contain BRM) and the battens placed directly onto Type 1F 1F bitumen felt. Screws go through the clip/bracket and into the ridge board.

It is also possible to use a ridge roll (and Type 1F bitumen felt), and leave these intact by placing an access tile immediately below the ridge

Dry verges are also used along the edges of roofs (again, instead of mortar), shown here without bat adaptations.

Original access point (above) for non-breeding individual/ small numbers of whiskered bats, and replacement (below) replicated as far as possible [as of 2022, not yet recorded as having returned.]

Thanks to Brian Armstrong, Armstrong Ecology Ltd., for text and photographs.

Dry ridge and hip systems (2)

Reason for inclusion: to demonstrate how to include bat access within a dry-roof system on a large-scale Sheffield County Council roofing project (approx 916 roofs in Year 1 of a five-year scheme). The project included both dry ridge128 and dry hips[133].

Overview of mitigation

All recorded roosts in Year 1 of the five-year scheme were associated with open eaves (the roof ridges were in good condition with few gaps), so mitigation was focused on retaining the existing gaps at the wall plate at the underside of the eaves[134], and re-lining all properties with Type 1F bitumen felt. This was supplemented by the installation of purpose-built bat access tiles to one quarter of the properties, typically positioned two or three tile courses from ridges and hips (to mitigate for the loss of features such as slipped tiles on the mid-pitch). The project was undertaken under the terms of a Natural England mitigation licence.

- Once stripped (using sensitive working practices under the guidance of a bat ecologist who attended site frequently) the roofs are re-felted in their entirety using Type 1F bitumen with new battens installed above.
- Some incisions into the bitumen using a Stanley knife are made at the ridge for ventilation.
- Ridge roll is used above, made from Ethylene Propylene Diene Monomer, EPDM. It is a synthetic rubber that is extremely durable and waterproof, it doesn't contain any materials used in roof membranes and has no fibres.
- There is also a requirement for an approx. 1 m length of plastic membrane at the wall plate which is sandwiched between two sheets of marine ply in place of the current asbestos cloaking boards (i.e. not accessible to bats). A length of non-woven plastic sheet is fitted to the rafters to prevent loft floor insulation from blocking the eaves. [Note this is associated with ventilation in relation to keeping the eaves open, as opposed to a dry system specifically.]


Stripped wall plate

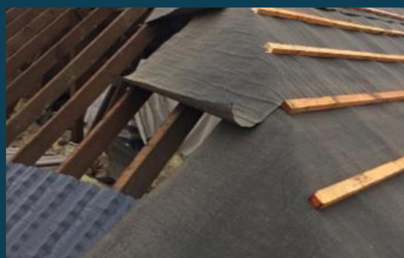

Eaves of completed roof


Wall plate access retained

Mitigation has been provided for PRFs (bat access tiles) as well as confirmed roosts (gaps at underside of eaves), and monitoring has yet to be undertaken. However, gaps at wall-plates have been retained like-for-like, the roofs are accessible to wildlife as before, and it would be surprising if these were not re-used by bats. Some that supported nesting birds prior to re-roofing saw the return of birds within the same season post-re-roofing.


Full bitumen Type 1F

Marley custom-built concrete bat access tile with a baffle covering the bat access gap and a roughened surface to the front for enhanced grip; and rear view of bat access gap.


Re-felting, also showing plastic sheeting which stops the loft insulation creeping over time, keeping the eaves ventilated.

Thanks to Daniel Best, Ecus Ltd, for text and photographs and to Sheffield City Council for their ongoing cooperation and support.

Case study 13

Creating a roost behind a fascia board

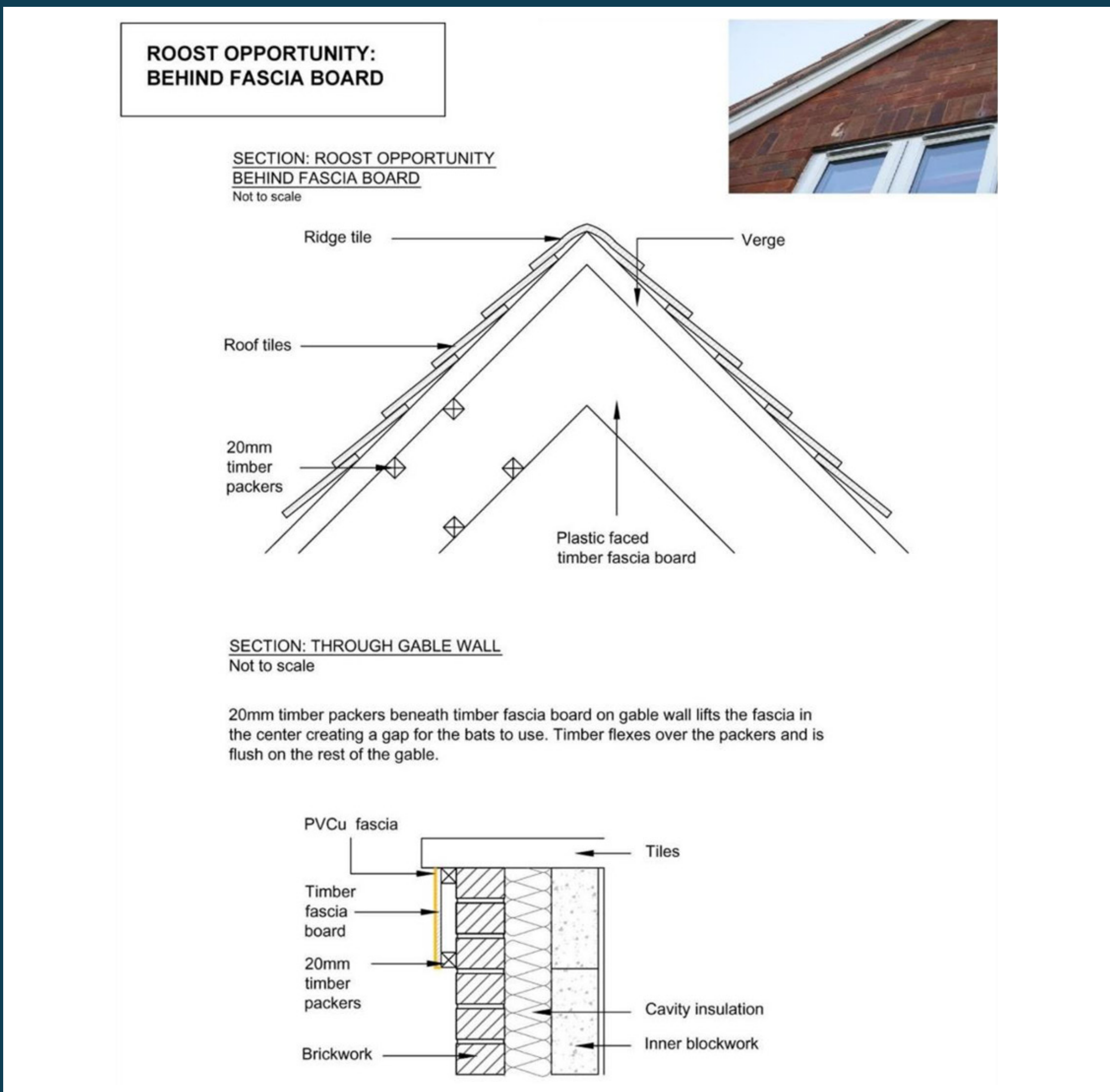
Reason for inclusion: plans and photographs for creating a roost behind a fascia board

Fascia board roost in practice (1)

Extension of semi-detached dormer bungalow on northern gable elevation (north-west Leicestershire).

Common pipistrelle bats were using the underside of the flat roof of the dormer windows as a maternity roost in the southerly part of the semi-detached property. Additional bat roosting features were installed in the extension to improve roosting opportunities for crevice-dwelling bats.

On the western gable elevation, when the property was being extended, an Ibstock Brick Built Bat Box was inserted into the gable wall apex. This was monitored for six months with weekly visits from March to the end of September. No bats were seen to use the bat box.



A barge board was required on the western elevation (as a local architectural feature, adjacent to the brick-built bat box, to be created in uPVC-faced timber.

In order to create access to the rear of the fascia board for crevice-dwelling bats, timber packers were inserted at the rear of the barge board. These resulted in the barge board being 'bowed' away from the brickwork in the parts of its length.

Common pipistrelle bats began to use the rear of the barge board within two months of completion of the work and individual common pipistrelle bats were recorded regularly using the feature throughout the six-month summer monitoring period.

NOTE: ideally, bat roost access points should not be placed above windows as a) if the roost is occupied, the window, which would be hard to reach to clean, would become marked with droppings and urine staining present; b) there is potential for bats to mistakenly enter the property through the window rather than entering the roost (especially juvenile bats); and c) light from the window may be sufficient to prevent use of the roost access point.

Fascia board roost in practice (2)

Refurbishment of a flat-roofed extension to a dwelling (North Warwickshire).

Replacement of the white uPVC fascia boards with brown/imitation timber fascia boards was undertaken at the same time as the flat roof was covered with a butyl sheet.

The original fascia boards were uPVC with no timber backing. When the fascia boards had been fitted, there was a gap of 20mm under the fascia board as it had been fixed to the roof joist ends. A single common pipistrelle bat was found under the fascia boards as they were being removed.

There was no access to the cavity wall, the wall plate closing off the cavity. The bat was found on the northern elevation at the end of February and was immediately returned when the flat roof was completed. The uPVC fascia board was replaced with the access for bats re-created. Individual common pipistrelle bats were recorded emerging from the feature during the spring of that year.

Thanks to Chris Smith, Tamworth Property Services, for text, plan and photographs.

Bat access slate (Option 1)

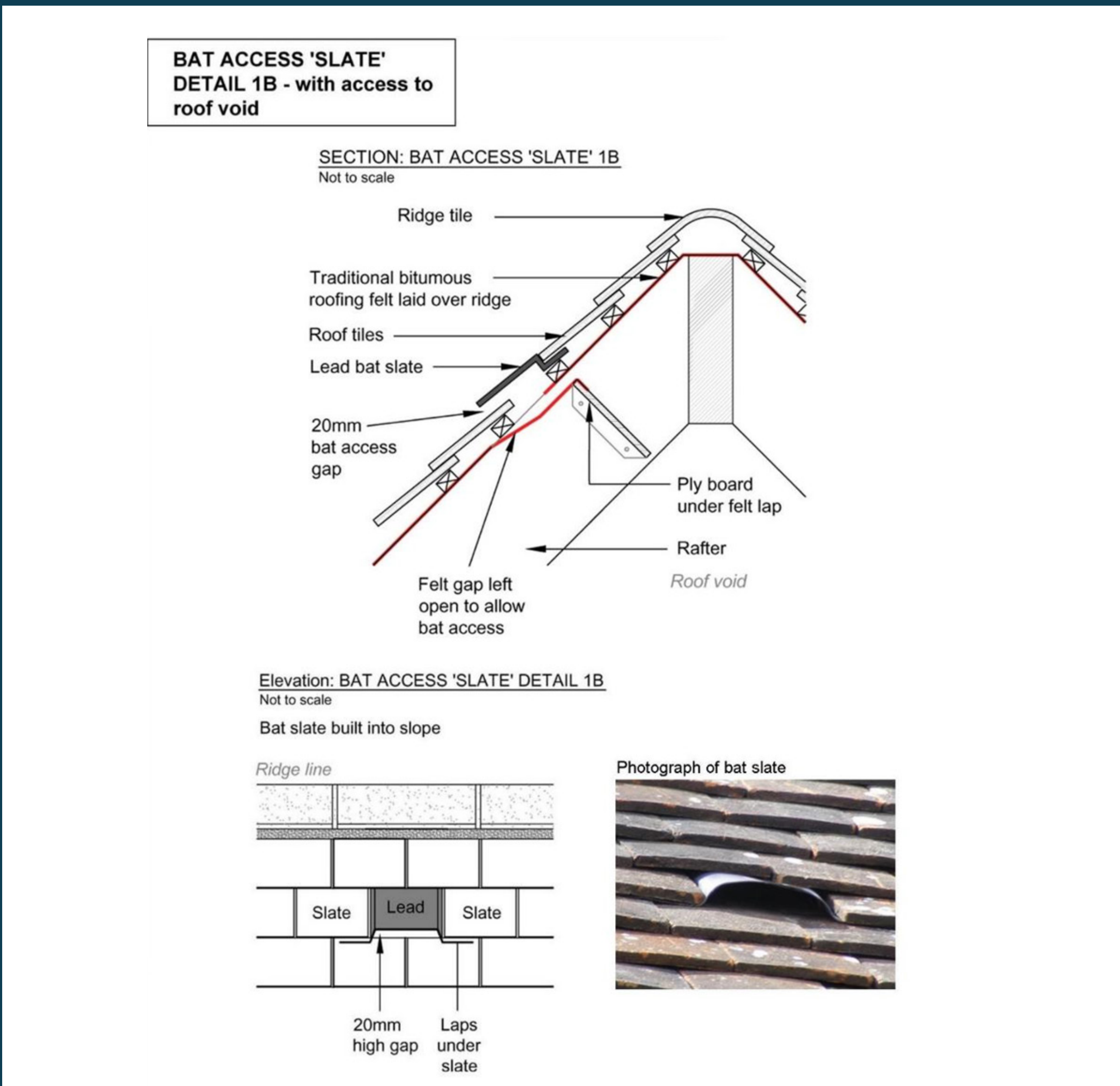
Reason for inclusion: plans and photographs for installing bat access

Bat access slate in practice

During roof repairs to a care home in Staffordshire, a maternity roost of brown long-eared bats was discovered. The roof spaces were complex with four interconnected roof spaces with different aspects.

There was water penetration through missing slates and, in the past, contractors had used a breathable roofing membrane when undertaking repairs on a part of the roof.

The proposal was to replace the breathable roofing membrane with a bitumous type 1F underfelt and to install lead bat slates, one on each external face of the roof where bats had been seen emerging and commuting to adjacent woodland.



The roof works were undertaken one roof section at a time after the maternity roost had dispersed so that repairs would minimise any disturbance (should any bats remain), and before the hibernation period so that there was no likelihood of disturbing hibernating bats.

Lead bat slates were installed and the maternity roost of brown long-eared bats was recorded back in the property in the following summer, using the bat slates as access to the roof spaces.

To aid bats accessing the roof space, a timber platform was constructed internally so that the bats could fly and land on the platform before emerging through the bat slate.

23 Brown long-eared bats at the ridge

Bat slate in position (neat and unobtrusive).

Note that the overall dimensions are dictated by the tiles to either side. The method of attaching the plyboard for lapping the underfelt is down to the roofing contractor and roof structure, and several different approaches would work.

Extensive bat droppings under the ridge board

Thanks to Chris Smith, Tamworth Property Services, for text, plan and photographs.

Case study 15

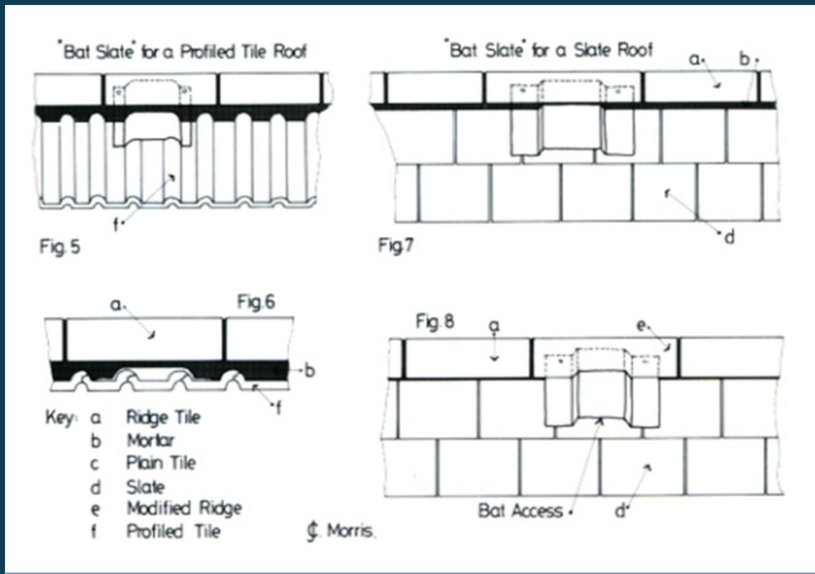
DIY construction of the 'Morris' Bat-slate (Option 2)

Reason for inclusion: plans and photographs for installing bat access

This provides instructions for creating a bat access point. On a refurbished building, stripped lead from the old roof, such as from a valley, wide chimney flashing or a hip can be used. A 300 mm square of lead will be enough to construct all types of Bat-slate, and can be reduced as tile size/type dictates.

The lead used should be at the very least Code 6. A lower code lead will sag after a very short time, blocking the bats' access. The Bat-slate can be quickly made and fitted during the normal re-roofing process with minimal disruption to the roofer.

On a plain tile roof, the Bat-slate can be fitted anywhere. The 'wings' of the Bat-slate should go under the adjacent tiles – a welt on each wing will further reduce the likelihood of water ingression.



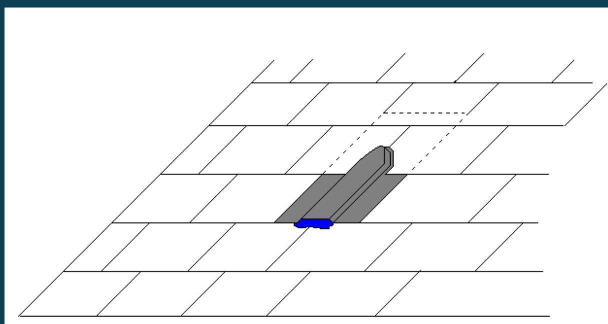
Installation on a profiled roof

On a profiled roof, the tile needs to be fitted under the ridge, as shown in *Installation on a profiled roof.*

For species of bats that use the inside of the attic, a hole will need to be established in the felt to allow bats free access in and out of the loft. The hole needn't be large – 75 mm x 30 mm is more than ample, but it is very important to establish it immediately adjacent to a rafter or wall to allow bats to climb back out. A hole in the middle of the felt will be difficult to find, difficult to land near, and unlikely to be used. Some species of bat use the cavity wall, and may require access to there from the loft.

Steep pitched roofs

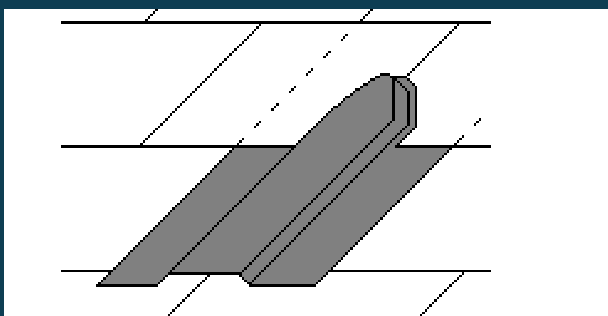
On a roof with a steep pitch, it is important to give the bats an area of grip, otherwise they would simply slide down the roof. An ideal material is readily available from builders' merchants - 100 mm wide Scotch™ anti-slip tape or similar. Alternatively, a rough material should be applied just below and under the raised section of the bat-slate. It is vitally important to continue the rough surface right up to the top edge of the lower slates. PVA adhesive or weatherproof Mastic with a 'drying' surface could be used to fix a suitable material, e.g. fine gravel or rough/coarse sand are a couple of options that might be used; these can be dyed to match the colour of the slates to make it less obvious from the ground.



Steep pitched roofs

Shallow pitched roofs

On a lower pitched slate roof, the bat-slate can be extended down the roof to lessen the chance of water ingression.



Shallow pitched roofvs

Fabrication and fitting of a Bat-slate in a plain-tiled roof – in pictures

The Bat-slate can be made from second hand lead, such as from a valley, hip, ridge, or wide cover flashings, and has the advantage of already looking 'weathered' and is usually free. It will need to be 'dressed' until it is flat.

Cut the lead to the length of one of the plain tiles to be used.

Cut the lead to the length of one of the plain tiles to be used.

Dress the lead over suitable sized timber. The finished depth should be 17-20 mm.

Use one of the tiles to form the correct width for the second 'wing' of the Bat-slate.

The second wing is complete

How the completed Bat-slate will fit amongst the tiles.

The Bat-slate is fitted alongside a rafter, allowing bats to land and crawl out. On a new or re-furbished roof, a hole will need to be established in the felt. The Bat-slate shown here is fitted so that a whole tile will fit alongside it. Where this isn't possible, the tile(s) will need to be cut. The Bat-slate is nailed (x2) to the batten and the tiles refitted around it.

The Bat-slate with all the surrounding tiles replaced. From the ground, it's almost invisible.

Fitting a bat-slate in a plain tile roof near the ridge tiles – in pictures

A hole is cut in the roofing felt when the Bat-slate is fitted near the ridge tiles. This will allow bats access into the loft/attic area. The Bat-slate is fitted in the same way as the previous one, being the same length and width as a plain tile and nailed twice into the top batten. Note: The Bat-slate is above the hole in the felt and a rafter. The top 'eave' tiles are fitted in the normal way.

The Bat-slate can also be fitted by replacing one of the shorter eave tiles (the Bat-slate's length should be adjusted accordingly.)

Here, the ridge tiles are being bedded on. If the mortar joint in the ridge-line is directly above the Bat-slate, material such as a broken tile or piece of slate should be placed on top of the Bat-slate and between the opposite top eave. This will ensure the mortar doesn't block the bats access. This could be done at every joint, allowing bats access to the underside of every ridge tile. Final photo shows the Bat-slate in place of the top eave tile.

Monitoring: it is difficult to determine the use of access tiles fitted for day-roosts because bats move between locations. On big roofing projects where bats are found beneath tiles (pers. obs.), there is often limited evidence of use. For the access tiles described here, 'dozens' were fitted, but as an enhancement, i.e. usually in places where bats had not been found but the owners of the properties were nonetheless happy to accommodate them. They replicated lead flashing with a gap underneath.

However, one was fitted on a ridge-line where whiskered bats were roosting under a ridge tile with some missing side-mortar. When these suffered storm damage, on returning to re-fit the ridge tile over the 'bat slate', a large heap of bat droppings was found, confirming use (C. Morris, pers. comm.)

Thanks to Colin Morris for all text and photos

Case study 16

More access options

Reason for inclusion: more examples of access points in place

Cut battens for access under the ridge (P. Waring)

Ridge access, wet ridge (P. Waring)

Ridge access feature (P. Waring)

Access to wet-ridge site (P. Waring)

Access at end of ridge (P. Waring)

Ridge tile (D. Wells)

Case study 17

Re-roofing Hugh Sexey C of E Middle School, Somerset

Reason for inclusion: to demonstrate the mobile nature of day roosts, and how to accommodate these during re-roofing

The school comprised several Victorian buildings along with modern structures. A grant was obtained to re-roof the main two-storey Victorian building, which had a multi-pitched roof with dormers, covered in double Roman tiles, and was approximately 36 m long and 12 m wide at its widest point (7.5 m at its narrowest). Bats were only discovered once the roofers had started stripping tiles from the eastern end of the building. Surveys then identified roosts used by five bat species (whiskered bat, serotine, brown long-eared bat, common and soprano pipistrelle) using 12 roost locations within the roof. All roosts were reinstated during the roofing works; a licence was obtained for their temporary loss.

Overview of mitigation

All roosts identified during the surveys were replaced/reinstated like-for-like and several additional features were included. Only Type 1F bitumen felt was used.


Southern view of the building

- The roof voids used by the whiskered bats and the brown long-eared bats were retained and a number of access points were created at the ridge and roof tiles providing access into the voids.
- Crevice roosts were reinstated by providing gaps of various sizes to suit the species concerned (pipistrelles, serotine and long-eared bats) under ridge and roof tiles over the entire roof.
- Locations where bats or droppings were found were recorded and access points were also created in those areas so there was no loss of access points or roost habitat within the repaired roof structure.

The usual mitigation was carried out, such as pre-works inspection, tool-box talk to contractors and ECoW during the roof strip.


Crevice access created by cutting a notch in the tile to create a gap (20 mm wide and the length of the tile)

Design principles

Roost height/volume: all roof voids were retained in their original condition and size.

Access points: A total of 27 replacement and new bat access points were created in the repaired roof, as follows:

- Four access points were created into the whiskered bat roost and another four into the brown long-eared bat roost (separate roof voids) where the original access points were identified. These measured 20 mm x 20 mm for whiskered bats and 70 mm x 30 mm for brown long-eared bats. A wet ridge system was used and the bat accesses were created by leaving gaps in the mortar securing the tiles to the ridge. These gaps lead to holes (offset to each other by c.100 mm) in the felt, which were positioned alongside rafters or the central ridge beam, to enable bats to access the roof voids.
- A further 19 ridge and roof tile crevice roost access points were created over both pitches of the roof for pipistrelle, serotine and brown long-eared bats. The ridge access tiles were created as described above but led to small cavities under the tiles. These gaps measured 20 mm x 20 mm or 70 mm x 30 mm to provide access for a range of bat species.
- The roof tile bat accesses were created by cutting a notch from the new tile to create a gap under the tile, which lead to the narrow space between felt, timbers and tiles. Notches were also cut out of battens in some areas to enable the bats to move more easily up and down the roof under the tiles. These access points measured 20 mm x 20 mm or 70 mm x 30 mm.

Thermal regime: the roof voids were reinstated and very similar materials were used in the repairs so it was assumed the conditions following repairs are similar to the original.

Perching opportunities: The rafters and central ridge beams were retained, so original perching locations were not affected.

Roofing membranes: Type 1f bitumen felt was used. Any new timbers (battens) were treated with chemicals approved for use in bat roosts.

Location and connectivity: the building is close to mature trees to the north and a line of poplars to the west, forming good connectivity between roosts and foraging/commuting habitat.

Orientation: all roosts are located in their original positions.

Protection against vandalism: The roosts are not accessible to people (other than the caretaker who lives below one roof void). Risk of vandalism is extremely low.

Long-term security: good.

Overview of monitoring results

Prior to works

- common pipistrelle (11 bats using 8 roost locations)
- soprano pipistrelle (2 bats using 2 roost locations)
- brown long-eared (4 bats using one roof void)
- serotine (1 bat)
- whiskered (assumed 5 bats using 1 roof void)

The roofing works were completed in April 2019.

Following completion of works

The dusk emergence monitoring survey was undertaken on 15 August 2019. The following roosts were recorded:

- Common pipistrelle x 7 bats (one roost location used by 2 bats, one roost used by a single bat, and third roost used by 4 bats, so 7 bats in total recorded using the newly installed bat access tiles)

In the adjacent Victorian buildings (not affected by works), common pipistrelle and serotine likely maternity roosts were recorded during this dusk survey, and a soprano pipistrelle bat was recording using another building. None of these roosts were present during the 2018 summer surveys.

The dusk emergence monitoring survey undertaken on 6 August 2020 recorded:

- common pipistrelle x 2 bats emerged from different locations;
- brown long-eared x 1 bat emerged from a ridge access tile over the long-eared roof void roost.
- A soprano pipistrelle bat also emerged from an adjacent building.

Challenges

- The initial surveys were carried out after roof stripping had commenced, which inevitably removed roost habitat, so the numbers of bats were not confirmed in parts of the building (DNA analysis of droppings confirmed which species were present where bats were absent).
- The monitoring surveys were carried out too soon after completion of the roof works, as it seems likely that bats will take at least a few seasons/years to return to the roosts.
- The August 2020 monitoring survey was carried out during a spell of very hot weather, which may have influenced bat use. of the roof structure. Covid-19 has also limited monitoring to a dusk survey only (the whiskered bat roost could not be checked internally).

Lessons learned

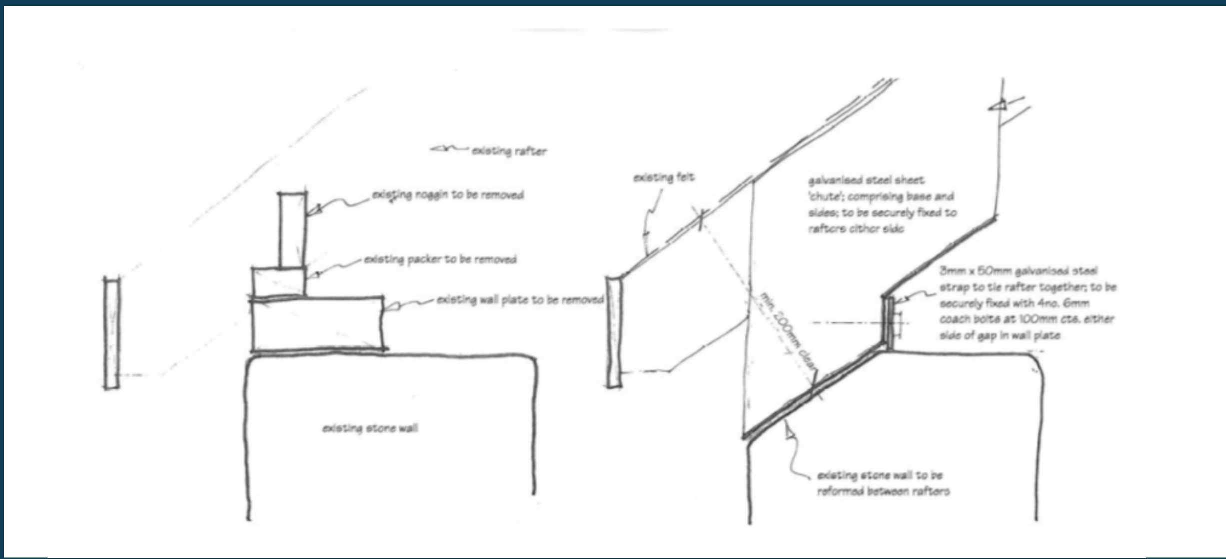
- Ideally all relevant preliminary surveys would be undertaken before roof works commence.
- It is important to record where all evidence of bat roosting is found during the roof strip so access points can be reinstated during the repair work, and ensure no loss of roost habitat.
- Working closely with the roofers was key to ensuring all the roost features were installed correctly. Their ability to be flexible and willingness to assist with the design of the access features was invaluable.
- The bat colonies using the buildings are evidently very mobile and more monitoring over the next 5 to 10 years would be very helpful in determining the success of the mitigation.

Thanks to Tom Clarkson, Clarkson & Woods Ltd, for plan and photographs.

Case study 18

Eaves access for lesser horseshoe bats

Reason for inclusion: to show a low-level eaves access point which reduces heat loss compared to a dormer



The access shown in the photographs was just under 400 mm when installed. The roost was used by low numbers of lesser horseshoe bats before and after the access was created, but similar access points (several gaps along the same eave) are in use at the roost described in Reason (2017), which supports large numbers of the same species.

Thanks to Richard Green, Richard Green Ecology, for plan and photographs.

Providing additional micro-climates for horseshoe bats

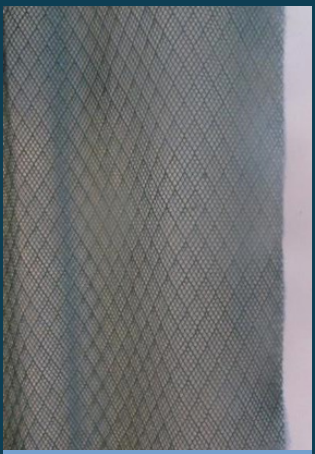
Reason for inclusion: to show low-cost enhancements to existing roosts to add additional microclimates

Made by Devon Bat Group, these boxes have fine greenhouse mesh sewn into them from which the bats hang. Both species of horseshoe bats use the small fish boxes (up to nine greater horseshoe bats have been recorded in a single box).

Around 70-80 individuals used the fibreglass pot

Avon Valley roost: a plant pot with greenhouse shading fixed inside and lined with expanding foam has been added. As the photo shows, many of the bats cluster together in the pot.

Kingsbridge: underground roost used by small numbers of greater horseshoe bats as a hibernation and day roost.



The greenhouse mesh: a solid fine mesh plastic which is available from garden centres.

Holne roost: these polystyrene food boxes were placed in the maternity roost. The concentration of droppings shows the boxes are well-used, which makes it easier to clear out any build-up.

Devon Bat Group provided funding for the materials.

Berry Head: a cave maternity site for greater horseshoe bats (part of a SAC). Numbers of pups have been declining over the years for several reasons.

A box was designed and fitted into the breeding chamber in March 2018. First recorded use was in 2019, with 6 pups, followed by 14 pups in 2020 and 22 in 2021.

This project was designed, built and installed by ecologists David & Colin Wills, with permission from Natural England.

Thanks to Sylvia Bevis, Colin Wills and David Wills (Devon Bat Group) for text and photographs.

Case study 20

Modification of pedestrian subway to create lesser horseshoe bat roost

Reason for inclusion: To illustrate the conversion of an existing structure into a multi-purpose roost

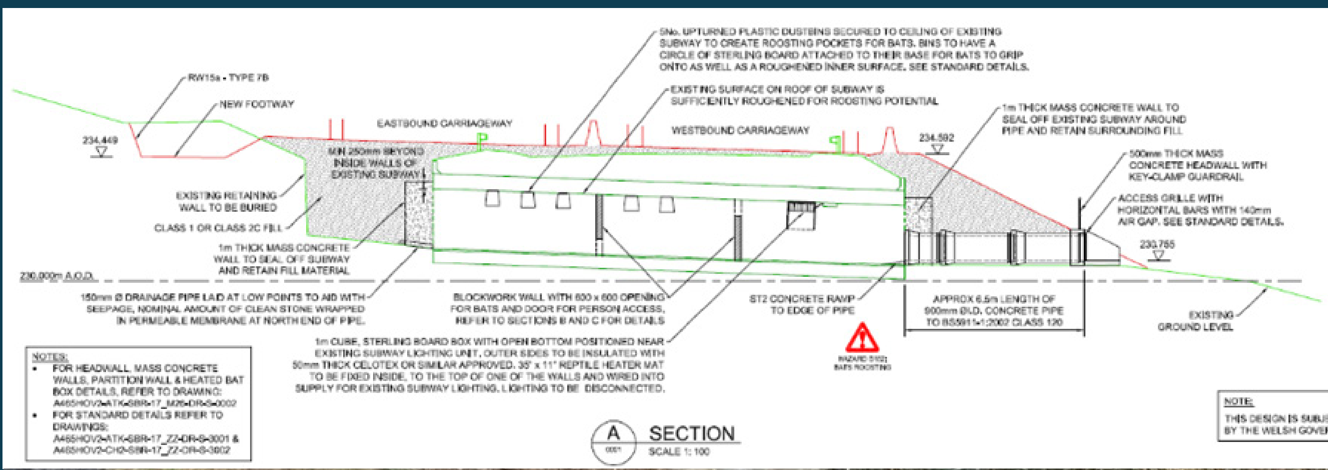
As part of bat mitigation works for the improvement (dualling) of the A465 Heads of Valleys Section 2, between Gilwern and Brynmawr (S. Wales), a pedestrian subway was converted into a bat roost, providing both warm conditions for breeding and cooler conditions for hibernation. The subway is adjacent to an extensive cave network within the Clydach Gorge, already used by lesser horseshoe bats for hibernation, and designated as part of the Usk Bat Sites SAC for that reason.

Overview of mitigation

An insulated 'hot' box, containing an infra-red heater mat, was provided at the southern end, near the entrance pipe, and two further chambers were provided in the northern half, to buffer air flow and provide stable cool conditions during the winter. The internal walls and ceilings were already pebble-dashed, providing suitable perching opportunities for lesser horseshoe bats. Upturned dustbins were fixed to the ceiling, with a disk of oriented strand board (OSB) for bats to hang from, creating 'avens' or 'chimney-like' roosting areas. A small amount of water flows through the culvert, from weep-holes in the northern end retaining wall. This helps to maintain humidity. A 1.2 m diameter culvert pipe was used to connect the buried subway to retained vegetation, and a locked metal grille prevents unauthorised entry.

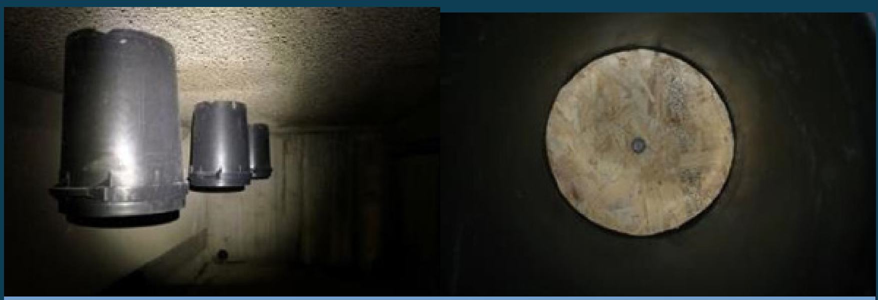
The subway was converted and the heater turned on in January 2019 but the final burying of the entrance culvert was not completed until September 2021.

Monitoring will continue for at least five years post-construction. In September 2021, shortly after completion, a single lesser horseshoe bat was present in one of the upturned dustbins, with droppings also found in several places within the subway. A single lesser horseshoe bat has since been present on all monitoring visits, i.e., in the cool part of the roost in February 2022 and January 2023, and in the hot box in May and August 2022.

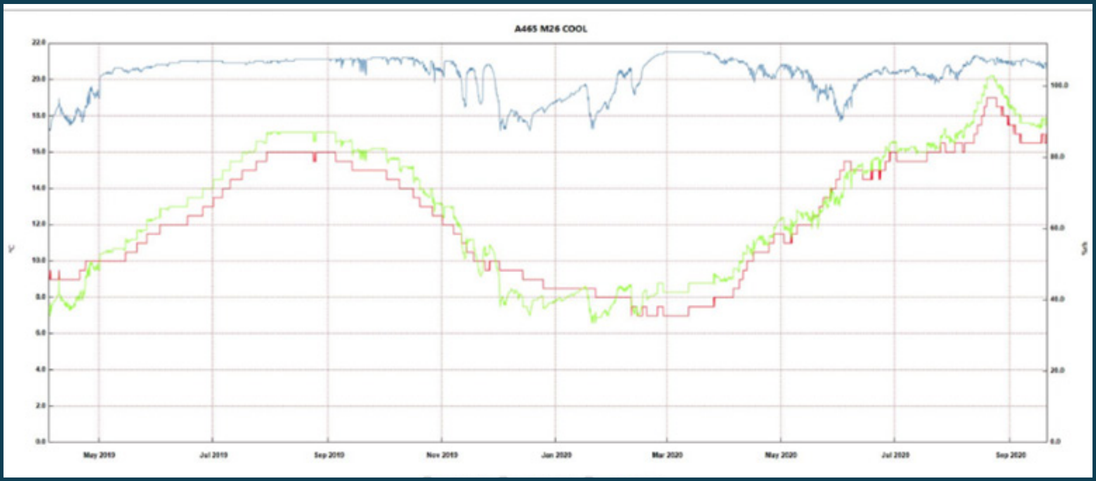


Heated hot box: infra-red heat matting provides heat from one side, offering a heat gradient across the box. The heating is powered from a nearby lighting column and the South-West Trunk Road Agency maintain/check that the power is on as part of their routine inspections.

A bat hanging directly from the OSB in the hot box.



Upturned dustbins fixed to the ceiling, with a disk of OSB for bats to hang from, create chimney-like roosting areas.



A data-logger placed in the cool part of the roost recorded continuous high humidity (blue line), and temperatures (red line) buffered between ~7-19 °C throughout the year. Temperatures of 7-10°C were recorded during the winter months in 2019/20 (before the earth bank was built at the southern entrance providing more insulation/buffering). [The green line shows the dew point, i.e. the temperature to which air must be cooled to become saturated with water vapour.]

Lessons learned

Still early days but lesser horseshoe bats will find new roosts relatively quickly, if well designed and located.

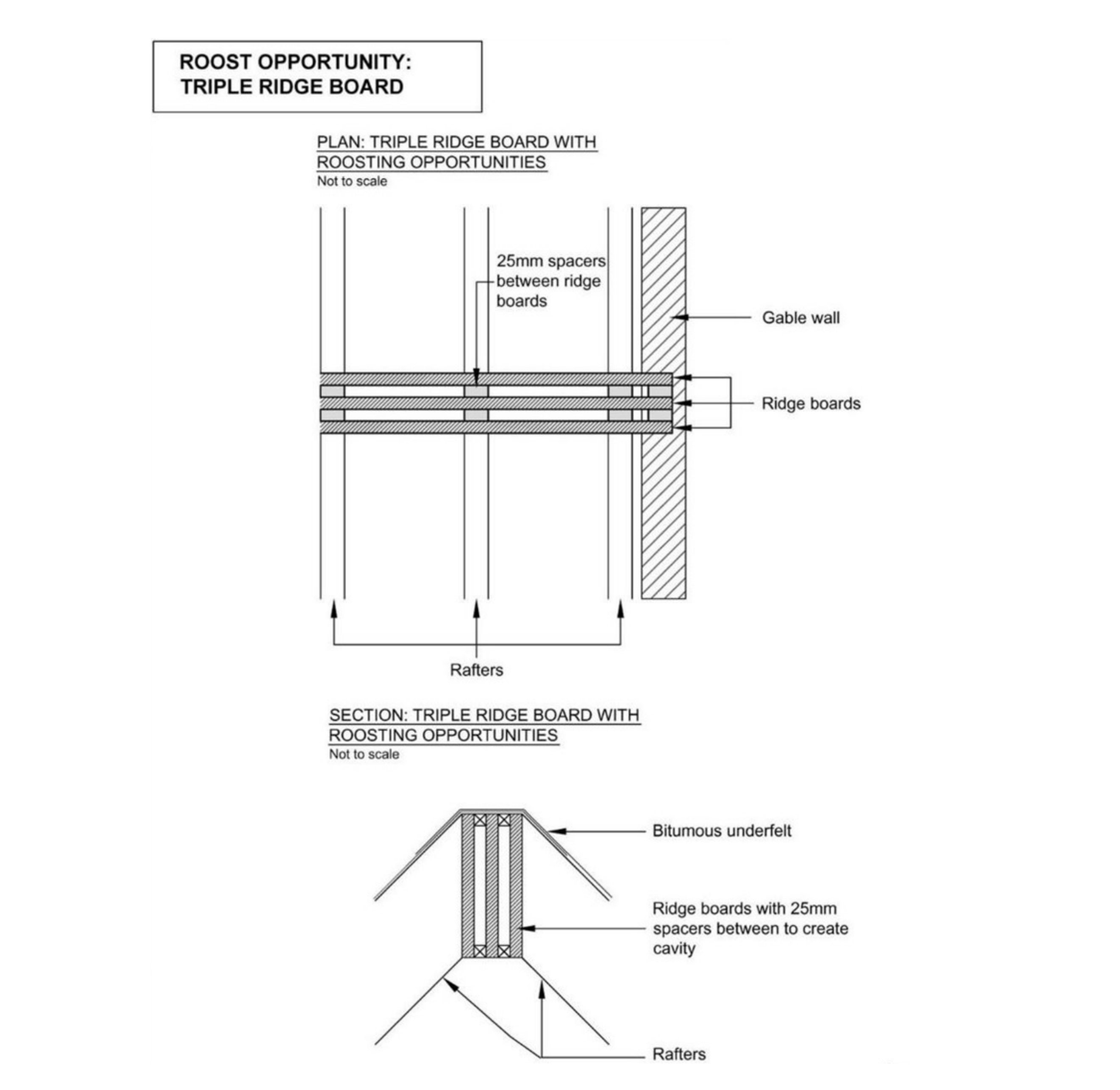
Finished structure

Thanks to Richard Green Ecology, RPS, Costain & Welsh Government for this case study.

Case study 21

Triple ridge system roosting opportunity

Reason for inclusion: to show creation of additional crevices during a renovation project



A sandstone store building annexed to a dwelling (Derbyshire) was to be re-roofed because of water penetration. Individual brown long-eared bats had been recorded using the building and the re-roofing was to be undertaken with the bats allowed back into the roof space. The rotten rafters were to be replaced but the method of construction was such that there was no ridge board.

A new ridge board was to be installed to strengthen the roof, helping to brace the rafters. The roof was then to be covered with a bituminous underfelt and the ridge tile access recreated.

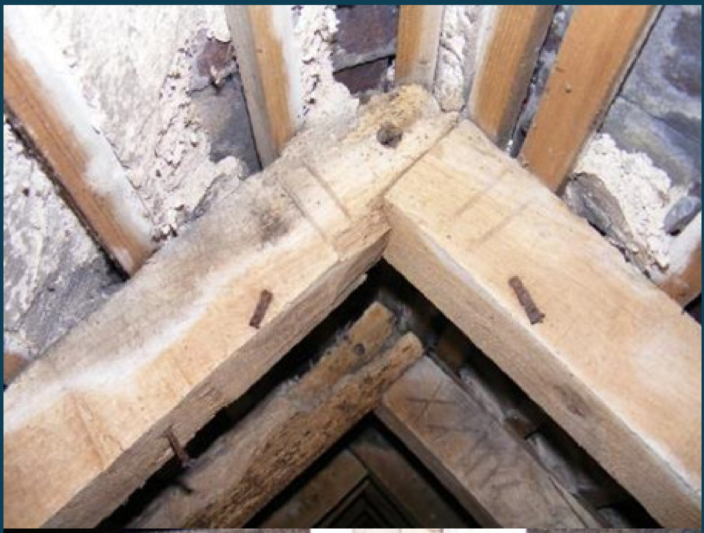
When the ridge board was installed, a triple ridge board was created so that there would be new crevices for the brown long-eared bats.

In one area, the bituminous underfelt was cut to allow the brown long-eared bats access to the underside of the ridge tiles. A ventilation ridge tile was then installed adjacent to this access, in the same place that the bats had originally emerged.

One brown long-eared bat was recorded using the roost again within six months when a monitoring visit was undertaken.

Thanks to Chris Smith, Tamworth Property Services, for text, plan and photographs.

NOTE: that this would not be a suitable solution where a ridge-board and rafters are already in place; it was designed for a situation where a new ridge board and rafters were required.



Case study 22

Replacement roost using an 'American style' bat box, Co. Cork

Reason for inclusion: to show successful use of an 'American style' bat box for a roost lost in renovation work

An extension to the east side of the main Mallow General Hospital, Co. Cork, was required. Before the development began, a maternity colony of soprano pipistrelles was found roosting within the building, and the roost access (a ventilation grille) would be lost, covered by the new extension.

Ventilation grille used by soprano pipistrelles

The grille allowed bats to enter the wall cavity

Work that did not impact on the roost began in July 2012 before the bats were excluded under licence in September 2012. An American-style bat box (supplied by Bat Roost Ireland) was recommended as it had been proven to be favourable for soprano pipistrelle use in similar situations in Ireland, is largely maintenance-free*, and is self-cleaning. This large box design offers bats a safe, dark and warm haven with a space large enough for 100 animals or more. The box was fitted on the south-facing gable end of an adjacent, older building outside of the area being developed, approximately 30 m from the existing roost. On the same day (mid-September 2012), the bats were excluded from the original roost using a one-way flap constructed of stiff plastic, secured by duct tape, over the ventilation grille. This flap, which allowed bats to leave the roost but prevented access on their return, was left in place for a period of seven days to ensure that all animals had vacated. The grille was then permanently sealed with concrete.

Mounting the American-style bat box on the adjacent building

The large bat box positioned high on the nearby building.

Overview of monitoring results

A dusk emergence survey in July 2012 recorded 72 soprano pipistrelles exiting the building via a ventilation grille.

Following completion of the extension, the box showed signs of bat use in spring 2014. That summer, 78 soprano pipistrelles were counted exiting the box, with 77 in 2015 and 74 in 2016.

Challenges

The recommended location for mounting the bat box was beneath the eaves of the main hospital building and as close as possible to the original roost entrance. However, due to the presence of windows at this location, it was decided to choose another site for the box to avoid the likelihood of bats entering the hospital wards when returning to their roost.

*In the longer term, the box may need attention, which would require a MEWP.

Thanks to Conor Kelleher, Aardwolf Wildlife Surveys, for case study and photographs.

Case study 23

Conflict resolution: relocating a soprano pipistrelle maternity colony from a building's interior to artificial roosts

Reason for inclusion: to demonstrate successful artificial roost provision for a soprano pipistrelle maternity colony, on a northern elevation, with exclusion of the colony from the building's interior

A large maternity colony of soprano pipistrelles were roosting inside a church. The colony was causing significant, long-term negative impacts on the use of the building (large amounts of droppings and urine, overpowering smell, hygiene concerns, substantial cleaning burden) and damage to historical artefacts (staining/bleaching from droppings and urine to floors, walls, pews, organ pipes, ledger stones, memorials, monuments etc). This resulted in significant human-bat conflict and negative attitudes towards the bats. Over a period of 10 years, various measures to reduce the impact of the bats on the church were trialled, unsuccessfully, and so partial exclusion of the bats (from the interior of the building only) was requested by the church and licensed by Natural England. Artificial roosts were provided and subsequently adopted by the maternity colony, as well as day, night and hibernation use, resolving bat impacts on the church and significantly improving attitudes towards the bats in the local and wider church communities.

Overview of mitigation

There was no viable option to retain the soprano pipistrelle roost at the existing (south aisle) location whilst preventing access to the building's interior. The southern aspect of the building would be preferable for maternity colony use but is highly visible and, as a Grade 1 listed building, provision of artificial roosts on this 'front' aspect would not have been acceptable from an aesthetic and heritage point of view. The bats' access to the church interior was (primarily) over the top of a seldom-used door on the northern aspect, therefore the preferred alternative option was to provide heated artificial roosts on the northern aspect, at the existing access area (increasing the probable speed of discovery and uptake), along with blocking potential/alternative access points. Radio-tracking data had provided a detailed understanding of how the colony utilised the church and linked maternity roosts, as well as key commuting routes and foraging areas. Roosting opportunities were also enhanced along the primary commuting route between the church and the main foraging area, by providing bat boxes.

Design principles

Roost height/volume: two large, bespoke artificial roosts were provided: one on the building's exterior, adjacent to the bats' main access into the church, and the other on the inside of the access point (over the door), to provide a range of roosting opportunities and variety of conditions, whilst blocking access through to the church interior.

1. Exterior artificial roost: height 1063 mm (plus 150 mm landing platform), width 690 mm, depth 320 mm. Nine internal crevices of varying depths (15-18 mm). Internal central baton dividing each crevice in half, but with gaps to allow passage between each side. Gaps at top and bottom of the box allowing passage between different crevices.
2. Interior artificial roost, connected to bat access over the top of the door: height 1215 mm (plus monitoring equipment storage area below), width 1100 mm, depth 340 mm. 'Attic' space at the top of the box, left section with vertical crevices, right section with horizontal crevices (angled at 15 degrees). 'No glow' infrared nest box cameras fitted to monitor usage.

The exterior artificial roost.

Additional roosting opportunities (a large wooden crevice bat box and six Schwegler woodcrete bat boxes) were provided on trees along the bats' main commuting route between the church and their main foraging area (see below 'location and connectivity').

Access points: over the top of the north aisle door. Access to the church interior was blocked with the interior bat box fitted to the back of the door. Access into the box was aligned with the over-door access point.

Access to exterior artificial roost is via a slot at the bottom of the box (width of box, depth of slot 15 mm). The bottom of the box is angled to help droppings roll out. Other known and potential access points into the church were blocked.

Location and connectivity; external environment: Adult female soprano pipistrelles were radio-tagged and tracked in 2014 and 2016 (prior to works), as part of research projects (Packman et al., 2015) (Packman et al. 2015 & Packman 2016): bats exit over the north aisle door into the adjacent tree cover, following the river corridor to commute north to a reservoir (main foraging area), approximately 1.5 km north-east of the church. There are three linked maternity roosts used by the colony, all in occupied houses, two approximately 100 m south-east of the church (neighbouring properties), the other around 3.5 km north-east of the church (the latter is c.1 km from the main foraging area).

The interior artificial roost installed, with false door open

Orientation: original church roost – south; artificial roosts – north (with heat mats provided to compensate for the northerly aspect); bat boxes on various aspects on trees.

Protection against vandalism: access to both artificial roosts are fitted with locks (and the interior artificial roost is secured with, and hidden by, a false door).

Long-term security: CCTV for security purposes and monitoring of bats.

Overview of monitoring results

Before works

The presence of a maternity colony at the church was first confirmed in 1981. Counts were undertaken periodically 2008–2012, with 100–357 soprano pipistrelles recorded in years when surveys took place. In 2014 the soprano pipistrelle maternity colony inside the church was monitored daily May-September as part of a University of Bristol research project (Packman et al., 2015); numbers through the maternity season fluctuated considerably on a day-to-day basis, from 86 to 677, with varying proportions of the colony split between the church and the linked maternity roosts. In 2015, two emergence surveys were carried out with a peak count of 588.

There is also a brown long-eared bat maternity colony in the roof void above the nave (bats rarely accessing the church interior).

After works

Bat boxes were erected on trees along the main commuting route in spring 2015 and the two artificial roosts were installed at the church in early spring 2016.

Uptake of the interior artificial roost was rapid, but initially by small numbers of soprano pipistrelles only (day and night roosting).

In 2019 the maternity colony took up residence in the exterior artificial roost, with a count of 307, followed by 436 in 2020 and 403 in 2021 (two counts per season only, in June and July).

Most of the colony is using the exterior artificial roost (maternity roost) with smaller numbers using the interior box (day, night and hibernation roosts). There has been continued use of the linked maternity roosts in houses throughout the monitoring period (assumed to be accommodating the church maternity colony bats 'full time' in 2016-2018).

Four of the seven bat boxes erected on trees along the main commuting route were used in year 1; usage in subsequent years has increased (primarily individual to small groups of soprano pipistrelles).

The brown long-eared bat maternity colony in the nave roof void was unaffected.

Brown long-eared bats and Natterer's bats have also been observed (on the roost monitoring cameras) visiting the interior artificial roost, as well as roosting blue tits and wrens (occupying at the same time as soprano pipistrelles).

Both hornet and wasp nests have been present in the interior roost in different years; the box continued to be used by bats despite this (the entrance to the artificial roost was 'guarded' by a wasp which would behave aggressively towards any bats getting too close, but providing a minimum distance was maintained, they appeared to coexist adequately).

The mitigation approach has succeeded in solving the problem of bat impacts on the building's interior and items of heritage importance. Individual bats still occasionally enter the church (brown long-eared bats and soprano pipistrelles), but impacts are minimal. The church is fully usable again and is not experiencing any adverse impacts from bats, while the church structure still hosts maternity, day, night and hibernation roosts of soprano pipistrelles (as well as a maternity roost of brown long-eared bats). The church and local community report being very pleased with the outcome which has transformed the inside of the church.

Challenges

The church was not a single roost, but many; the variety of conditions had to be recreated in a much smaller space, providing suitable maternity, day, night and hibernation roost provision for soprano pipistrelles.

Having to provide a suitable maternity roost space on the northern elevation was challenging, but achievable with the addition of heat. This will need to be carefully monitored, however, to ensure the heat mats continue to function long-term.

It was awkward to fit roost cameras into complex crevice-style artificial roosts; the cameras missed some early colonisers due to a restricted field of view and needed repositioning.

The door to which the interior roost was fitted was very old and irregular in shape, requiring a life-size trace of the door onto paper, to ensure that access points between the door and interior roost would align/connect without any gaps.

As with any blocking/exclusion work, ensuring all bats can and have exited the building is critical and can be challenging. The interior roost, which blocked the bats' access into the church, was fitted at night, post-emergence (following a daytime trial run). A one-way excluder was fitted to the inside of the interior artificial roost, at the same location as the original access, to help ensure any bats remaining inside the church could exit. The church interior was also closely monitored after the interior roost was fitted and, where needed, individual bats allowed to exit by opening the main (south) door (exit confirmed with infrared cameras). A static detector was left inside the church to check for any bat presence.

Lessons learned

Where possible, opt for a phased approach to exclusion/artificial roost provision, i.e. provide artificial roosts but, where these block access, allow one season for bats to continue to pass through artificial roosts to the building's interior, allowing the bats to find and become familiar with the artificial roosts before blocking.

Monitoring cameras showed bats spent a significant amount of time 'sniffing' the artificial roost when first erected, suggesting that olfactory cues are likely to be important. Both artificial roosts were 'seeded' with ground-up/powdered bat droppings from inside the church (ground-up so that droppings from colonisers would be evident).

It is important to understand a roost site in the landscape context; are the bats solely dependent on the roost site for maternity use, or is the roost part of a network of linked maternity roosts used by the colony (with regular switching between roost sites)? Research (Packman et al. 2015, Packman 2016, Zeale et al. 2014 & 2016) suggests the former is more common for Natterer's bats, whilst the latter is more common for soprano pipistrelles, which needs to be considered when designing mitigation measures and determining what approaches and outcomes are acceptable. It was predicted that the soprano pipistrelles would take several years to adopt the artificial roosts, but with knowledge of the linked maternity roosts this was considered acceptable.

The devil is in the detail – attention to the design and implementation details here were key to success.

Thanks to Dr Charlotte Packman, Wild Wings Ecology, for text and photographs.

Case study 24

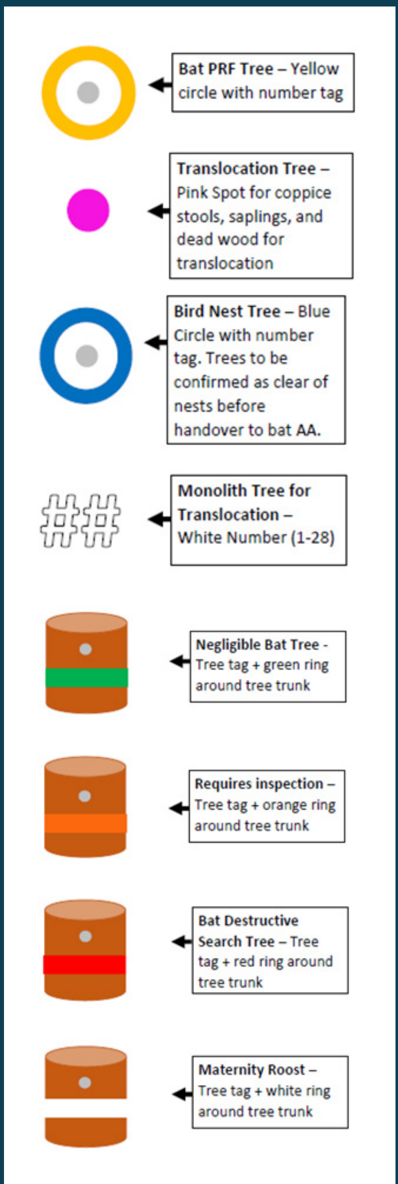
Tree-marking protocol

Reason for inclusion: a protocol for marking trees where a large number of trees are to be removed. It has been agreed for an infrastructure scheme (HS2), but could equally be applicable for other projects such as management of ash dieback.

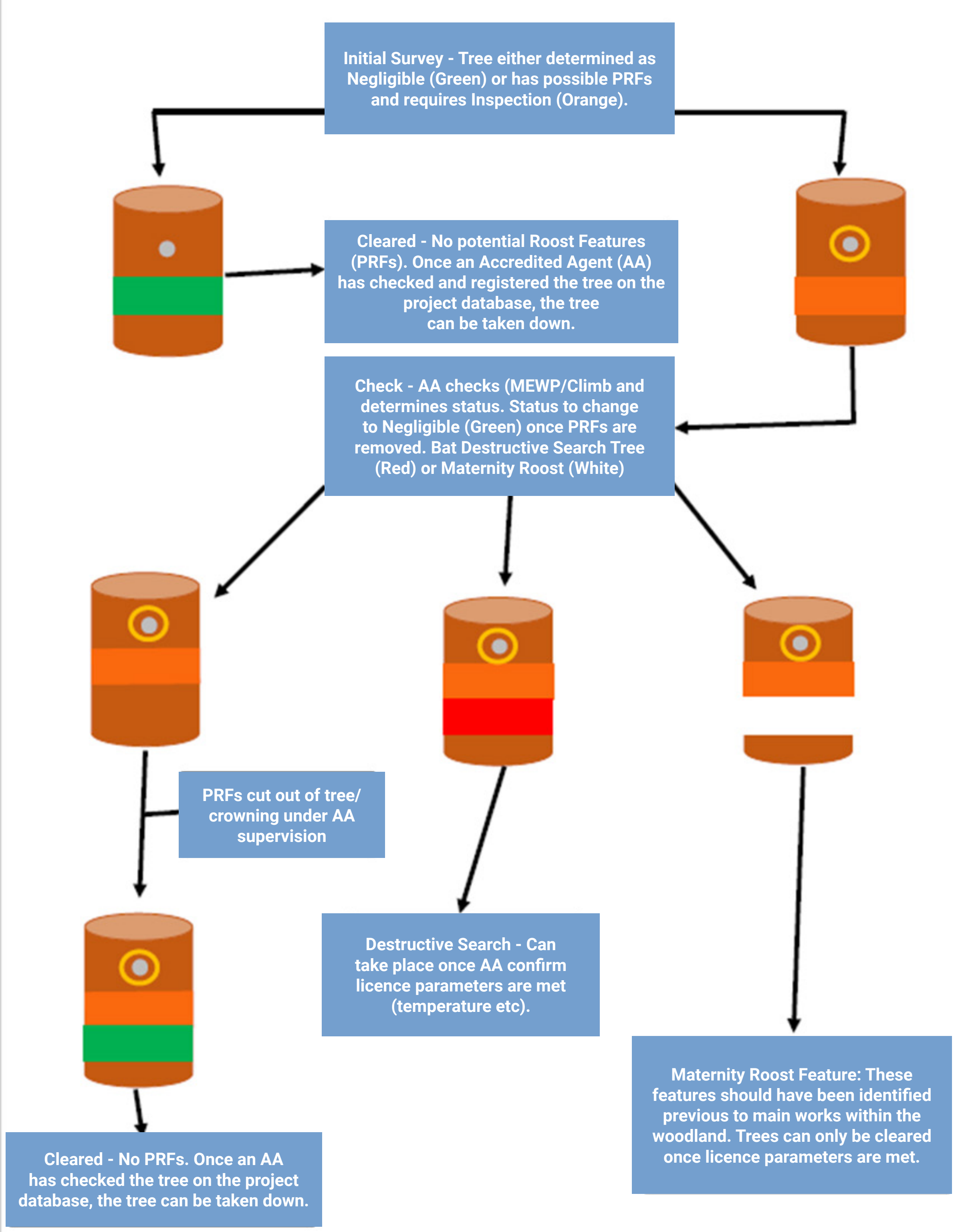
HS2 has a very large supply chain, with many bat consultants and tree surgeons working for different contractors across the route (often on more than one section of the route).

A review of incidents led to a system for consistently marking trees in relation to potential bat roost features before tree felling. This ensures all contractors working on a site, and across different project sites, can recognise what the markings mean. The system should reduce risk of misinterpretation and communication errors.

When adopting this system, be aware of staff with red-green colour-blindness.



The codes were included in a flow-chart detailing every step of the categorisation, inspection, and record-keeping process leading to pruning or felling.



The tree-marking system was developed by HS2 contractors LM JV, in association with their supply chain partners; with thanks to Kat Stanhope, HS2 Ecology Lead for providing this.

Case study 25

Tree-removal protocol for large numbers of trees

Reason for inclusion: outlines additional conditions/protocols for tree clearance over a wide area. It has been agreed for an infrastructure scheme (following extensive radio-tracking), but could equally be applicable for e.g. management of ash dieback.

This example was agreed in England and therefore the text refers back to Natural England licence terminology.

All bat related tree works within this licensable area will be undertaken by the Named Ecologist and/or the 'accredited agents' (AAs). AAs will be suitably experienced ecologists with Natural England Level 2 Class (CL18) licences, or similar demonstrable experience, who have been approved by and will be working under the direction of the Named Ecologist.

All works, actions and bats encountered will be fully documented.

Re-grading of the potential of trees within this licensable area to support bats (high/moderate/low) will be undertaken at the discretion of the AAs or the Named Ecologist. Any re-survey via ground-based inspection or tree climbing/aerial inspection will be documented and reported to Natural England as part of a licence return. The following protocol therefore applies to all trees subject to felling that are considered by the AAs or Named Ecologist to have potential to support roosting bats.

All trees declared clear of bats and approved for felling by the AAs or Named Ecologist will be positively marked for felling and recorded.

Additional non-standard protocols not covered by Natural England licence conditions a-h:

1. **For trees that are safe to climb and with Potential Roost Features (PRFs) that can be reached/accessed,** pre-felling climbing inspections will be undertaken on the same day as the planned tree felling where possible. All climbing surveys will be undertaken by AAs equipped with an endoscope (with 1 m minimum length cable).

2. **Where a PRF contains bats** they will be removed in line with Natural England capture and release procedures. The tree roost will be declared clear for felling by the Named Ecologist or AA. Felling will take place on the same day as the climbing inspection or the roost will be made permanently unsuitable for bats, via destruction, section-felling or exclusion of bats. The action undertaken will be recorded.

   In the unlikely event a maternity roost is discovered, the bats will not be removed from the roost. The Named Ecologist will be informed. A bespoke buffer of vegetation will be created around the roost that is specific to the conditions onsite, and left in place until the bat(s) have moved of their own accord and felling can take place The minimum buffer will be 10 m diameter but in practice the buffer may need to be 20 m or even more, depending on the location and thickness of surrounding vegetation, in order to be effective at preventing impacts (disturbance and change of environmental conditions) to the roost.

3. **Where a PRF contains no bats** the tree will be felled following confirmation by an AA or the Named Ecologist that no bats are present. Should there be delays to felling, the PRF will be made unusable for roosting bats via removal of the PRF (destruction, section-felling or exclusion of bats).

   In the event that exclusion of bats is not possible or is reported to be ineffective, the PRF will be re-inspected prior to felling.

4. **Where bats within a roost cannot be captured or excluded using one-way exclusion devices** the Named Ecologist or AAs will consider a range of available options to establish whether bats are present or absent and how best to fell the tree. The options include undertaking additional emergence/re-entry surveys, repeat climbing inspections, or section-felling. A decision on the approach to be taken will be based on the nature of the PRF, associated safety considerations, the anticipated effectiveness of emergence/re-entry surveys given the time of year, and the ability to section-fell safely.

   Where emergence/re-entry surveys are undertaken, these will make use of thermal imaging (TI) or Infra-Red (IR) cameras and in line with BCT Interim Guidance80.

5. **Where a tree cannot be climbed or inspected (i.e. MEWP) due to safety** the considerations and measures outlined in Point 4 above will be followed.

6. **Where section-felling is required as the presence of bats within a PRF cannot be determined,** the feature will be section-felled in conjunction with an experienced arborist. PRF sections are to be carefully cut away and

lowered to the ground (anchored from MEWP or adjacent trees) and inspected by an accredited ecologist or the Named Ecologist. Any bats found will be moved in line with Natural England capture and release procedures and consideration given to anchoring the section-felled PRF into a nearby suitable tree. PRFs will be left in situ on the ground within a 10 m exclusion zone for 24 hours.

7. **Following successful capture** the AA or Named Ecologist will undertake a health check of the bat. The bat will then either be transported immediately to a pre-installed bat box/roost mitigation feature in the same woodland parcel where access is possible, or kept in a suitable container until dusk and released near the site of capture. Bats kept in captivity and released at dusk will be cared for in line with the Bat Care Guidelines (Miller, 2016).
8. **All licensable works, bats captured and subsequent actions** will be recorded and documented by the AAs approved by the Named Ecologist.

In addition, heightened hygiene and disease control measures will be implemented in the light of the Covid-19 outbreak:

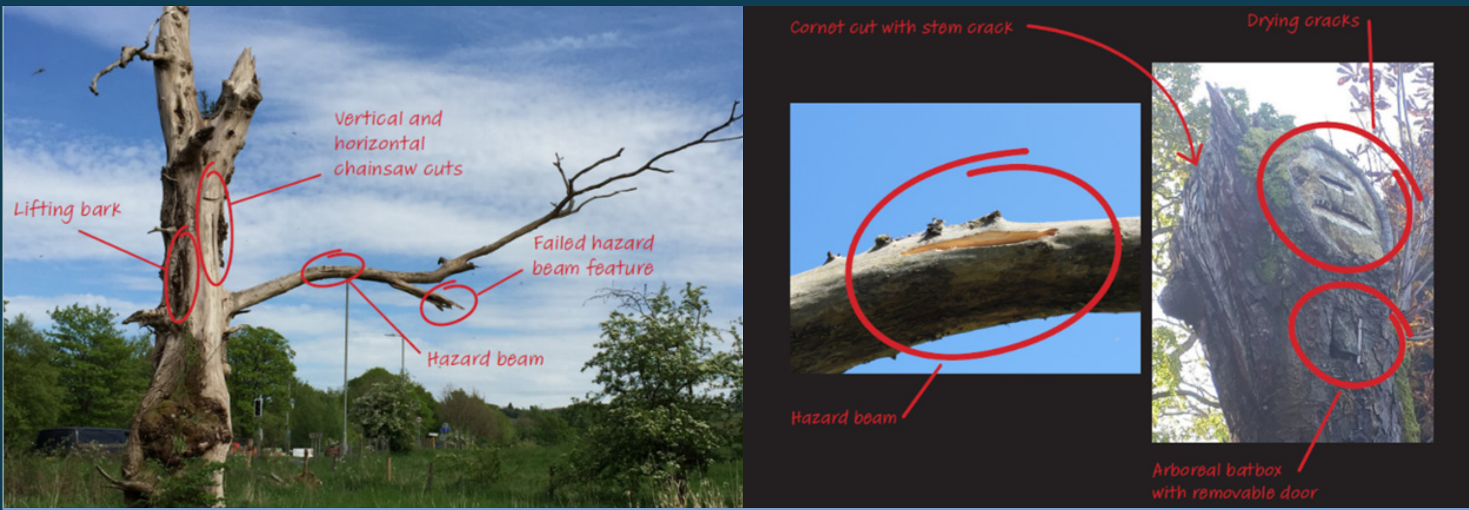
- Hands to be washed with soap or alcohol-based disinfectant hand gel prior to any surveys that may involve direct contact with bats.
- All equipment (e.g. endoscopes etc) which may come into direct contact with bats to be sterilised before and after use using a suitable disinfectant.
- A face mask and disposable gloves (over handling gloves) will be worn if the AAs or Named Ecologist are handling bats.
- One-use gloves to be used when handling different bats, one-use bags for housing bats while being transported.
- Gloves to be disposed of within sealed bags once a survey is complete.
- All handling bags, handling gloves or other soft equipment to be washed between surveys at least 60°C minimum.
- All hard equipment and PPE to be cleaned between uses using a suitable disinfectant.

With thanks to Ian Davidson-Watts, DWE.

Case study 26

Examples of tree mitigation

Reason for inclusion: examples of veteranisation



Examples of roost features on a tree, and recreation of some of these.

Veteranisation examples
Examples of roost features on a tree (top left), and recreation of some of these.
The chainsaw cuts in the tree shown (left) were adopted by at least one bat (inset).
Photos: David Whyte.

Case study 27

Creation of PRFs in 'habitat poles'

Reason for inclusion: to demonstrate the value of retaining habitat poles as means of compensating habitat loss through tree crown removal.

Overview of mitigation

Two dead elm trees (*Ulmus glabra)* were a potential safety risk to a road side and pathway. The recommendation was to remove the trees to ground level. An aerial inspection for a potential moderate PRF found no evidence of use by protected species. To compensate for the loss of habitat, standing stems were retained (no longer endangering the road or path). Chainsaw 'slit' features were created on both trees to provide future PRFs.

Design principles

Target species: *Pipistrellus spp.*

Roost height/volume:

- Tree 1 (T1): 4 vertical chainsaw slit features at 2.5 m-3 m, on an easterly orientation.
- Tree 2 (T2): one horizontal and one vertical chainsaw slit feature at 1.5 m. One horizontal and one vertical chainsaw slit feature at 2.5 m.

Feature description: All chainsaw slit features 30 mm (w) x 120 mm (l) x 300 mm (d). Created using a chainsaw 'boring technique'.

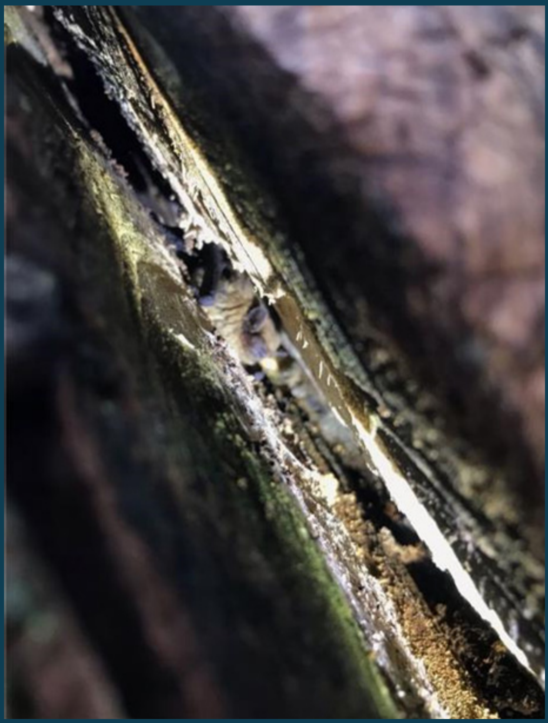
Location and connectivity; external environment: Scotland central belt. Approximately 500 m from the western coast line and sheltered water bays, and 50 m from rivers.

The local surrounding habitat is 85% open field, 10% semi mature-mature woodland cover, and 5% industrial.

Orientation: All features east-facing.

Protection against vandalism: Chainsaw slit features mimic natural cracks in drying wood, reducing the noticeability of the habitat.

Long-term security: Annual structural checks carried out on the standing stems to monitor decay.



Overview of monitoring results

Two standing dead elm trees with full crown. PRF on both trees was mainly flaking bark and drying cracks.

No evidence was observed in pre-work checks. The tree crowns were reduced with standing stems retained. Four PRFs were created on both trees in 2015.

Monitored annually.

Challenges

Single annual monitoring (limited by budget) does not provide an understanding of use by different bats in all seasons.

Lessons learned

A simple solution to compensate for loss of habitat that is immediate and highly effective.

Text and photos provided by David Whyte, Professional Tree Climbing Ltd.

Date	T1 results	T2 results
Aug 2016	Single soprano pipistrelle	No evidence
Sep 2017	Single soprano pipistrelle	No evidence
Jul 2018	Single soprano pipistrelle	No evidence
Aug 2019	Single soprano pipistrelle	No evidence
Sep 2020	No evidence	Single soprano pipistrelle
Oct 2021	Single soprano pipistrelle	No evidence

Case study 28

Placement of standing deadwood (monoliths)

Reason for inclusion: to demonstrate the retention of ancient woodland features by translocation where loss was judged to be unavoidable. This technique could be explored to supplement a replacement commuting route (again, not tested), or even a roost where the tree supporting it could not be retained. There are, however, limitations to the size of tree that can safely be treated in this way. Only limited monitoring has been undertaken to date, but at least one PRF has been used by bats.

During an Ancient Woodland Translocation Project, placement of existing deadwood at ground level was supplemented by use of live felled trees to create a new generation of standing 'green' deadwood.

Importance of aerial habitats

- Aerial habitats are very important; bats use trees as flightpaths to navigate while out hunting, and use other features such as holes or peeling bark as suitable roosting or hibernation places.
- Aerial habitats are used by birds as a vantage point to identify potential food sources/danger and for nesting.
- Large living trees cannot usually be translocated to become aerial habitats, as their root systems are too established to survive being disturbed during excavations; it is technically very challenging, though not impossible, to move a large tree safely.
- Using felled greenwood to become standing deadwood trees creates an aerial layer of habitat for the benefit of woodland bat and bird species.

Recreation of deadwood features

- Deadwood habitats are a critical component of a healthy woodland ecosystem, which should comprise deadwood of varying stages of decomposition to provide a range of functions.
- It is relatively easy to recreate most of the deadwood features found in a healthy woodland, since they are generally found at ground level; existing or new features can be placed into position by hand (for small sized features) or using heavy plant for larger features such as stumps or large limbs.
- Providing standing deadwood features is more problematic; large existing standing deadwood cannot be translocated because it is already decomposing so is fundamentally unsafe to move by machine.

Technical method for recreation of standing deadwood 'monolith' features

- Live oak specimens were straight felled/cut using an excavator and tree shears and the root balls removed.
- Once cut, the weight of the tree was calculated to determine its suitability to be placed as a standing monolith using the FISA industry standard method of calculation[135]. This involves taking the dimensions of the section (using the mean width) and multiplying it by the density. All specimens used for monolith creation were oak and handled immediately after felling, therefore the mass calculations for Lift Plans were based on the specific gravity of wet oak.
- Lift Plans for the plant machinery involved were calculated using an additional 50% Factor of Safety.
- An augered pit was prepared at a receptor site to approximately one third of the height of the tree. An excavator dipper was used to measure the depth to ensure it was deep enough.
- Once the pit was prepared, the specimen was moved used a forestry forwarding trailer and lifted into position with a 13 tonne (or larger) excavator and timber grapple.
- A second excavator was used to backfill and dynamically compact soil around the specimen once it was placed into the pit.
- Final soil compaction was carried out using hand tools/foot pressing to ensure the monolith was firmly in position.

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135. Forestry Commission Booklet: Forest mensuration handbook (forestresearch.gov.uk)

An auger attached to the excavator prepares the pit

Outcomes

- 31 monoliths were positioned within the newly created receptor site; they will be a very important component of the establishing woodland, until it reaches maturity and is capable of producing its own deadwood features. The monoliths were placed around the site in strategic locations, but concentrated along the central woodland ride to help create a future bat flightline.
- In May 2022, one bat was found roosting in a PRF feature (see Case study 29).

Text and photographs supplied by Jason Winslow and Rachel Quinn, RSK Habitat Management.

The monolith is lifted into position

The monolith is secured in the prepared position

Once secured, machines can work safely in close proximity

The monoliths in position, demonstrating how they add height diversity and ecological opportunities.

Case study 29

Re-use and creation of potential bat roost features

Reason for inclusion: to illustrate the use of different PRF mitigation techniques. Unlike most of the case studies included, the particular examples shown here have had limited monitoring for uptake/ occupation by bats (but use has been confirmed). If these techniques are used, monitoring must be undertaken.

Holes and crevices within trees, often used as roosting places by bats, were to be lost as part of a woodland translocation. PRFs from the donor woodlands were reused wherever possible at the new receptor site, to provide additional ecological enhancements. Additional PRFs were also created.

- Sections of branches/tree trunks containing PRFs were removed, under ecological supervision, and taken to a holding bay, for re-use as specific ecological features within the receptor site.
- A record of PRF height, orientation and location in the donor woodland was used to guide the spatial positioning of some PRFs on standing deadwood trees at the receptor site.
- Moving existing standing deadwood poses significant health and safety risks as it is already decaying; instead, suitable existing deadwood PRF features were used to provide microhabitat at ground level. These PRFs were assessed and placed in the most suitable location and orientation at the receptor site depending on the target species (not bats).
- The next generation of standing deadwood was created by re-using structurally sound timber from live trees, which would otherwise have been processed as commercial sawlog or biomass (see Case study 28).
- Tree limbs were cut to size, using specialist chainsaw techniques, to give the appearance of snapped branches rather than 'clean' chainsaw cuts.
- Artificial PRFs of varying sizes and types were then cut in to the monoliths, along with other 'veteranisation' cuts to speed up the process of decay and provide more PRF and bird-nesting habitats over time.
- A bat has been recorded using the artificially created PRF as illustrated below. Here, a chainsaw had made a simple vertical cut measuring approximately 500 mm to replicate a split, with a 300 mm long x 30 mm deeper void, created by inserting the tip of a chainsaw into the timber at an angle to create an 'upward' cavity once the monolith was erected.

Trunk with PRFs being moved to the receptor site

Trunk with PRFs being moved to the receptor site

Decaying trunk salvaged to provide shelter and habitat for ground dwelling species

Veteranisation of standing monoliths using chainsaw cuts to encourage faster decay & create new PRFs

A bat has been recorded using the artificial PRF in the monolith above - a vertical split approximately 2m above ground level

Text and photographs supplied by Jason Winslow and Rachel Quinn, RSK Habitat Management.

Case study 30

Silverton Mill, Devon

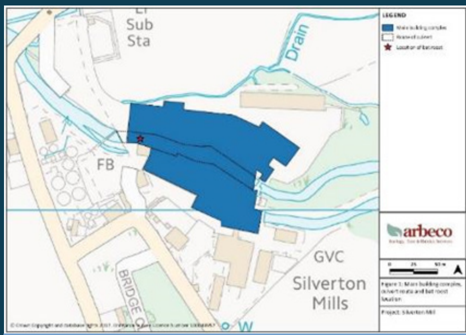
Reason for inclusion: to demonstrate the separation of bats from working areas; managing significant constraints (river diversion); the importance of environmental parameters (lighting); and the need to provide good quality habitat

A former paper mill in a derelict and contaminated state was to be demolished, which included the removal of a significant section of remaining concrete slab covering a culvert through which the River Culm flowed. The aim was to return the site to riparian habitat following over 100 years of industry. A Daubenton's bat maternity roost of at least 100 individuals used the culvert; historic records from 1992–1999 reported up to 200 individuals, making it one of the largest of its type known in the UK.

Overview of mitigation

The derelict buildings were removed along with most of the culvert. This resulted in significant roost modification and disturbance, but a 60 m section of culvert was retained to preserve the Daubenton's bat maternity roost. Several bat boxes were installed prior to the works.

The original mill dated back to 1897 but, whilst original parts remained, most of the site comprised modern industrial sections and buildings. These had been developed in a piecemeal fashion resulting in a very complex mix of interconnected sections and buildings. The River Culm flowed from east to west underneath the mill through a large concrete culvert. The Daubenton's bat maternity roost was recorded approximately 35-40 m from the western end of the culvert.



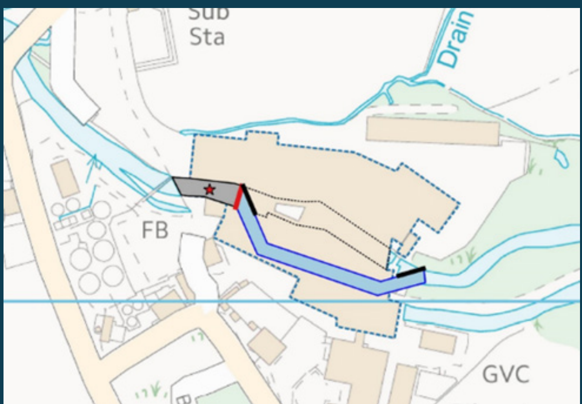
Red star shows location of the roost


Western end of culvert


Eastern end of culvert


Daubenton's bat maternity roost in the culvert in 2013

In order to demolish the eastern 140 m of the culvert, the River Culm needed to be temporarily diverted so the existing river bed could be drained. The roost was located at the western end of the culvert. However, activity surveys in 2014 recorded Daubenton's bats using the whole culvert and emerging from both the western and eastern entrances to forage. It was therefore



Diversion of river: plan


Diversion of river in place

necessary to prevent bats flying into the demolition area ahead of the river diversion.

The bats were separated from the works by cutting through the overlying slab with a diamond saw and installing a ‘bat curtain’ made from heavy-duty flexible plastic strips. The bat curtain allowed the river to flow and fluctuate in level whilst preventing bats flying into the demolition area, and created a 60 m long section of dark retained culvert for bats to continue roosting in.


Diamond cut through culvert slab


chematic of bat curtain installation


Bat curtain in situ

Pre-demolition inspections within the culvert slab demolition area were not possible due to structural instability. Therefore, after the installation of the bat curtain, 24-hour bat exclusion lighting was installed through holes at various points along the culvert slab demolition area. These lights were left in place for 3 days and nights before river diversion works commenced.

NOTE: this was requested by the SNCB licensing team at the time, but lighting is no longer recommended as a means of increasing the effectiveness of exclusions as it can have the opposite effect.

Re-directed River Culm (blue) and 60 m section of retained culvert (grey) housing bat roost location (star).

After successful diversion of the river, demolition of the culvert slab began. Following removal of all demolition debris from the original river channel, decontamination of the soil, and river bank re-profiling works, the river was re-diverted back along its original course. The bat curtain was removed after the culvert was demolished.

Monitoring

Monitoring to date has been undertaken in 2015, 2018 and 2021, comprising automated/static detector surveys, transect surveys, and dusk emergence surveys during pre-maternity, post-maternity and autumn dispersal periods. The culvert was also inspected from a boat, and the bat boxes checked.

Early monitoring results

Daubenton’s bats were not recorded roosting within the retained section of culvert during the boat-based inspections in 2015 and 2018.

Low numbers of Daubenton’s bats have, however, been recorded emerging from both ends of the culvert.

High foraging activity from Daubenton’s bats was also recorded at both ends of the culvert post-emergence, indicating that bats may have been roosting elsewhere but coming to the culvert to forage.

Automated static detector surveys also recorded high numbers of calls from Myotis species bats during 2015 and 2018.

Interventions

Following the 2018 surveys, it was considered that there was too much light ingress within the retained section of culvert, and that this was likely contributing to Daubenton's bat numbers not being at pre-demolition levels.

It was therefore decided to install a new bat curtain within the eastern end of the culvert (as shown right, during installation). This new bat curtain was not as tall as its predecessor, allowing bats to fly underneath it and into the culvert whilst providing a light-baffling effect.

Post-intervention monitoring results

In 2021, after the new bat curtain had been installed, dusk emergence surveys and bat activity transect surveys recorded higher levels of Daubenton's bats foraging, comparable to the baseline numbers. It has not yet been possible to determine numbers roosting in the culvert to see if these have recovered to pre-baseline levels. However a high level of foraging activity throughout the site, likely due to the site restoration and additional habitat improvements which are supporting the maintenance of the local Daubenton's population

Retained section of the culvert used by the colony

Improved habitat in the vicinity of the culvert

Case study and photographs provided by Nick Deykin and Dr Stephanie Murphy (who held the Natural England EPSML on behalf of RPS Group Ltd).

Case study 31

Kingfishers Bridge hibernaculum, Cambridgeshire

Reason for inclusion: to demonstrate a successful hibernaculum design.

Overview of mitigation

The Kingfishers Bridge 'cave' (overall dimensions 2 m x 2 m x 30 m long) is a trench dug into the underlying limestone with a pre-cast concrete roof containing elongated bat bricks (constructed 2004). The door (steel and oak boards) restrict the access of predators and humans. Slots at the top of the door allow bats to enter and fine wire mesh on the bottom allows air flow. The cave is used by brown long-eared bats and Natterer's bats each winter, either attached to the cave roof or in between the concrete cave roof sections.

Overview of monitoring results

The hibernaculum tunnel hosts a peak of 30-35 bats from December to February, averaging a 50:50 ratio of brown long-eared and Natterer's bats. The occasional Daubenton's bat is recorded, but most are believed to use the large mature willows on the north boundary of the reserve (considerable numbers of Daubenton's bats feed at the reserve over the wetlands).

There is a high-definition night-vision camera looking down the tunnel which provides valuable insight into the continued activity of bats using the hibernaculum throughout the year; in particular, unexpected high activity and feeding throughout the winter months.

Herald moths and small tortoiseshell butterflies also use the hibernaculum over winter with over 100 recorded when carrying out bat surveys in early winter. These can be almost completely predated over the course of the winter by roosting bats. Judging by the wings left on the floor of the tunnel, many more hibernating invertebrates are using the hibernaculum than are counted.

Challenges

Exceptionally high groundwater levels in 2012 led to excessive flooding in the tunnel; this could not be cleared by the original battery-powered sump pump. A physical drain was installed to a lower part of the reserve to mitigate against this in future. The drain was positioned so as to retain 150 mm of water at the bottom of the tunnel, thus maintaining humidity.

Lessons learned

Although the tunnel roof sections were constructed with bat bricks inset into them, the vast majority of roosting bats favour the gaps between the concrete roof sections in the mid to lower section of tunnel.

In tandem with the drain installation, the air vent at the far end of the tunnel was also removed and the hibernaculum now relies on the gentle upwards slope of the tunnel to clear warmer air. This has resulted in more stable winter air temperatures.

With thanks to James Moss, Kingfishers Bridge Nature Reserve Manager

http://www.kingfishersbridge.org/bat-cave.html

Case study 32

Middleton Upper Quarry mine-workings, Midlothian

Reason for inclusion: to demonstrate a successful hibernaculum design

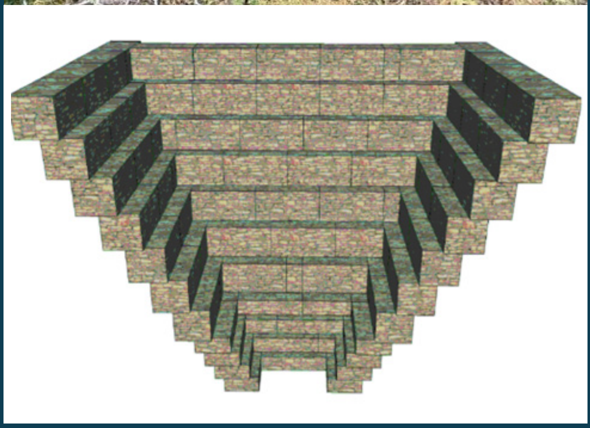
Mine-workings accessed from adits on the floor of Middleton Upper Quarry were known to be used by hibernating bats since the 1980s, with Daubenton's, Natterer's and brown long-eared bats regularly recorded.

A local authority enforcement notice required the owners to 'reinstate' the quarry as grassland, threatening the hibernaculum.

An innovative approach to maintaining access to the mine has been successful in allowing bats to continue to access the hibernaculum since its completion in 2014.

Overview of mitigation

Three adits were acoustically monitored in winter 2012-13, to identify which were most used by bats entering/leaving the hibernaculum. A 9 m high, steeply-sloping gabion basket funnel was constructed in front of the most-used adit, acting as a massive retaining wall when the quarry was filled with 750,000 tonnes of inert spoil. The cliff above the adit was retained, to sign-post bats towards it.



Design principles

Roost height/volume: Substantial underground limestone mine-workings.

Access points: Retained entrance and the section of cliff above it.

Thermal regime: The mine roof slopes up towards the retained entrance, allowing warm air to vent. An additional vent pipe was installed via another former entrance, to ensure warmer air can vent to the surface. The temperature has remained between 4 and 8°C throughout the mine, with a greater area around 6°C, leading to bats using more parts of the mine than previously.

Perching opportunities: Unchanged, as bats continue to have access to the underground adits.

Location and connectivity: external environment: Although the surrounding ground is significantly different, the section of cliff above the retained adit remains. A well-connected hedgerow 25 m from the retained adit was maintained, to assist bats in locating the entrance.

Orientation: The retained entrance faces south-east, with mine-working extending to north, west and south.

Monitoring access: The gabion funnel is 9 m deep and difficult to climb, so fall arrest blocks and safety harnesses are used to reach the adit. The adit is situated close to the roof of the mine. A steel ladder was fabricated and bolted to the wall, to allow safe descent to the mine floor, 6 m below.

Protection against vandalism: Security fencing with a lockable gate surrounds the gabion basket funnel.

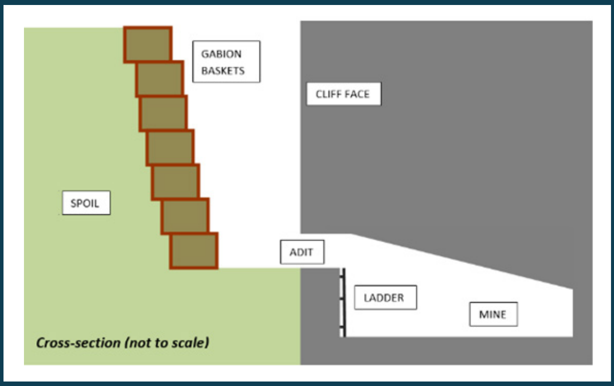
Long-term security: Licensed ecologists make regular inspection and survey visits.

Overview of monitoring results

- Winter monitoring of the mine uses a standardised search of a limited and safe section of the mine.
- 7 surveys over 3 years before infilling found a mean of 4.9 bats.
- 11 surveys over 8 years subsequently found a mean of 6.0 bats, with all three species remaining well-represented.
- Acoustic monitoring suggests that this is a small part of the population of bats using the mine.

Lessons learned

- It would have been useful to have control over vented warm air, in case the mine temperature strayed outside a suitable range for hibernation. Although the mine warmed slightly, this allowed hibernating bats to use areas closer to the entrances, which were previously too cold.
- Large clay berms had been in place in front of the in-filled entrances and it had been expected that they would hold back spoil when the quarry was filled. One gave way, allowing some spoil to enter. When a similar licensed closure was later carried out at Middleton Lower Quarry, an old shipping container was used successfully as blockage.



Case study supplied by David Dodds of David Dodds Associates Ltd

Case study 33

Two Mile Bottom artificial hibernation tunnel, Thetford Forest

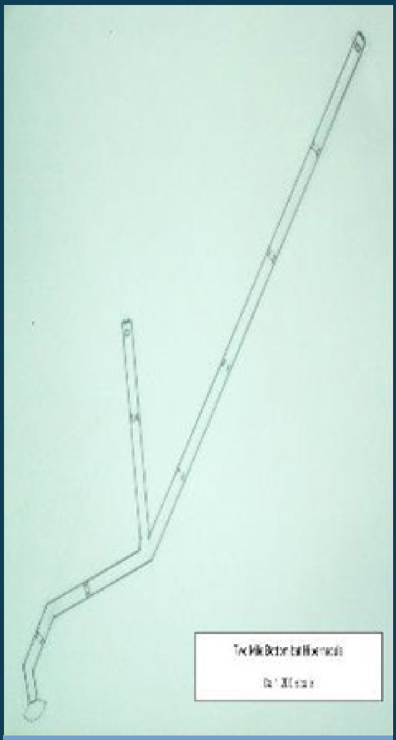
Reason for inclusion: successful creation of a bespoke artificial hibernaculum

This tunnel was designed by John Goldsmith and Nick Gibbons based on a similar extension to the bat hibernaculum at High Lodge (also in Suffolk). Since its construction in 2004, the use of this purpose-built hibernaculum by bats over the years has gone from strength to strength.

The Two Mile Bottom tunnel has proved to be a great success, undoubtedly the best purpose-built hibernaculum in the UK and a good general recipe for others to follow. The tunnel at Two Mile Bottom continues to provide a safe hibernation roost for Myotis bats – Daubenton's and Natterer's – as well as brown long-eared bats.

Overview of mitigation

The hibernaculum consists of a 95 m long asymmetrical Y-shaped concrete-block tunnel with an access grille, ventilation pipes, escape hatches and bat bricks built into the ceiling.



Tunnel plan (credit Nick Gibbons)

Design principles

Roost height/volume: 95 m tunnel constructed in a Y-shape with a long main stretch and a short spur, high enough for upright inspection.

Access points: Grille at north-eastern end facing north towards the river.

Thermal regime: For details see https://issuu.com/suffolknaturalistssociety/docs/tsns49a.

Perching opportunities: Numerous Norfolk bat bricks and modified London bricks were used. Both horizontal and vertical planks hang on the walls and slotted logs stand on concrete blocks on the tunnel floor.

Location and connectivity; external environment: the site was chosen where a small, shallow valley, possibly an area of old sand diggings, ran down almost to the Little Ouse river in the Thetford Forest. Key points were that the site was:

- near a river where there was lots of bat activity;
- north-facing;
- shaded;
- away from areas of disturbance;
- little light pollution.

Orientation: The tunnel was constructed in a Y-shape with a long main stretch and a short spur with ventilation shafts at the end of both, to provide a range of conditions within the site.

Protection against vandalism: Lock & bolt system to prevent unauthorised access via secure grille and post-and-rail fencing to prevent accidental damage from cyclists and forestry operations, with large brash placed on the track created over the roof on either side of the tunnel to dissuade cyclists. Damage was caused to the air vent when the grille could not be forced open by vandals.

Long-term security: Forestry England staff, particularly the Conservation Manager, make regular inspections.

Log (credit Sue Hooton)

Overview of monitoring results

The artificial hibernaculum was first used by one brown long-eared bat in January 2007, the third winter after it was built. In 2008, two brown long-eared bats were counted in the hibernaculum. From 2009 to 2013, three bat species were counted in the hibernaculum – brown long-eared bats, Daubenton's bats, and Natterer's bats, with the total number increasing each year (maximum numbers: 2009 – 16 bats; 2010 – 31 bats; 2011 – 31 bats; 2012 - 50 bats; 2013 – 62 bats). **In January 2019, a maximum total of 91 bats were recorded** (28 Daubenton's, 62 Natterer's and one brown long-eared bat). Following a Covid-imposed hiatus, monitoring will resume in the winter of 2022/23.

Lessons learned

- The original concept was to have one arm of the 'Y' sloping up and the other down but, due to the unstable nature of the sandy soil, digging down deeper to achieve this was not possible for safety reasons. As a result, both arms are almost horizontal.
- Ideally, a floated roof with reinforced concrete would have been better but not possible logistically.
- Using a beam and block roof meant the risk of the metal in the reinforced beams rusting. The ends of the beams were coated in bitumen and later encased in concrete to give some protection.
- Bigger air ducts in the initial stages, that could be adjusted down, would have meant fewer modifications later on to increase air flow.
- However discrete this location seemed at the time of its design, its location is not unknown and regularly attracts unwanted attention/vandalism. Better signage explaining what it is, its legal status etc would probably be beneficial.

Overview photo (credit Nick Gibbons)

Case study supplied by Sue Hooton, Suffolk Bat Group, with input from Forestry England as landowner (Neal Armour Chelu, District Ecologist, East England and Andy Palles-Clark, Conservation Manager, Thetford Forest) as well as Suffolk Bat Group stalwarts Arthur Rivett and Nick Gibbons.

Case study 34

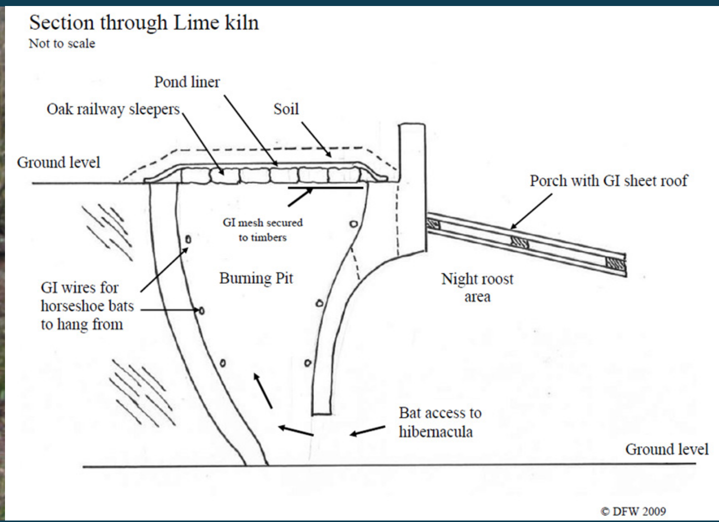
Denbury Lime Kiln

Reason for inclusion: successful creation of a bespoke artificial hibernaculum

Overview of mitigation

Hibernaculum designed for horseshoe bats as mitigation for a local road improvement scheme.

In 2010, prior to conversion, the front shelter was used as a night roost for lesser horseshoe bats and the 'burning pit' (see plan) was filled with soil and rocks.



Post-conversion monitoring:

8 October 2020: nine greater horseshoe bats;

25 November 2020: eight greater horseshoe bats;

26 January 2021: one greater horseshoe and two lesser horseshoe bats.

Inside lean-to showing the archway leading to the burning pit

Entrance to burning pit

Case study supplied by David Wills, Devon Bat Group.

Case study 35

Exclusion of bats from an inaccessible mine adit using smoke

Reason for inclusion: to demonstrate the process of exclusion from a winter site using unorthodox methods

Coal Tar Adit was one of a number of mines and caves along the Clydach Gorge used by roosting lesser horseshoe bats (maximum number: three). These underground sites are a qualifying feature of the Usk Bat Sites SAC. Coal Tar Adit was closed and filled in under NRW licence to enable construction of the A465 Heads of Valleys Section 2 Improvement Scheme.

Initially inspected internally (from 1994), a roof collapse in 2000 prevented human access, but would have allowed bats continued use (the extent of use, and of passageways, is unknown).

Monitoring using an Anabat Express detector inside the entrance confirmed its use by lesser horseshoe bats in early September 2015, despite dense bramble scrub growth over the grilled entrance which suggested it might be inaccessible to bats.

Measures to exclude any bats first involved clearing all vegetation around the entrance and continuing to monitor bat presence.

After bats were still recorded during the five following nights, the entrance of the adit was lit with tower flood lights. On the first night of deployment, the lighting was switched on at midnight (to allow any roosting bats to emerge without disturbance) and left on until after dawn.

On the second and subsequent nights, the lighting was turned on one hour after sunset, to allow any bats still roosting in the adit to emerge but reducing the risk of bats returning to roost before the light was switched on.

The entrance was also partially closed to further discourage bats from returning and to allow easy closure once it was confirmed that bats were absent.

Dense bramble scrub growth over the grilled entrance

Dense bramble scrub growth over the grilled entrance

Partial closure of the adit entrance

The smoker in situ

Anabat Express monitoring continued each night following installation of these measures but lesser horseshoe bats were still recorded using the adit, i.e., the measures had not dissuaded them from returning to roost.

After clearing the vegetation and lighting of the entrance had failed to exclude bats from the adit, the ecologists resorted to using smoke.

A 16-hour duration sawdust food-smoking tray was used to generate smoke in the entrance of the adit on 20 October 2015. The spirally arranged metal tray was filled with sawdust and lit one hour after sunset and left smouldering inside the entrance on an extendable piece of wood for the following 16 hours, i.e., until after dawn the following day.

Two lesser horseshoe bat passes were recorded shortly after the smoker was deployed on the first night. It was assumed that one or two bats emerged from the adit due to the presence of smoke. No further calls were recorded that night.

On the second night of smoker deployment, one lesser horseshoe bat pass was recorded in the middle of the night. It is possible that this bat was returning to the adit. It may have entered the roost or may have opted not to because of the smoke.

No further bat passes were recorded on the following three nights when the smoker was deployed. The entrance was therefore closed using a timber board over the entrance, enabling an Anabat Express detector to be deployed and collected from inside the entrance. Three further nights' monitoring was undertaken inside the adit after the entrance had been closed. The detector was analysed each day and no bats were recorded. It was therefore assumed that bats had successfully been excluded from the adit.

The adit was then dug back from the entrance during the day using a machine excavator under an ecological watching brief. No bats were encountered or seen to emerge during the excavation. The adit was excavated to its conclusion over several days, closing the entrance at the end of each day to prevent bats from returning overnight.

Take-home messages

Lesser horseshoe bats continued to use the adit despite the cluttered entrance and subsequent lighting, demonstrating high roost fidelity in the face of disturbance.

The adit was in use from early September (i.e. prior to the main hibernation season), underlining the need for confirmatory surveys of 'winter' sites outside of winter.

NOTE: the use of such an unorthodox method would need to be reviewed with the relevant SNCB, and may not be licensed, even as a last resort. It has been included to show that some exclusions can be complex and time-consuming, and to highlight the take-home messages.

Thanks to Richard Green for the case study, supplied with the permission of the Welsh Government.

Case study 36

Working around asbestos

Reason for inclusion: to demonstrate how impacts on bats can be minimised where there is a need to remove asbestos

Asbestos was identified in a 1970s detached chalet-style bungalow (Aldeburgh, Suffolk) scheduled for demolition. Asbestos was widespread: in the boiler chimney flue, fire barriers, artex ceilings, soffits and bargeboards, but a small number of brown long-eared bats were day-roosting around the chimney flue. Access to the roosts was covered by asbestos fire protection boards.

Overview of mitigation

The mitigation was driven by the need to i) enclose asbestos-containing materials within a negative-pressure chamber, ii) conduct a smoke test and iii) include a licensed asbestos worker in the enclosure.

The negative-pressure chamber works by removing the air (which is then filtered for asbestos), and replacing it with fresh air. There were concerns that the negative pressure atmosphere could be detrimental to the bats roosting in the asbestos boarding.

Ideally, bats would have been excluded prior to the works; however, tests found there was too much asbestos which could not be disturbed to effect a successful exclusion. The negative-pressure chamber could not be used as an exclusion device because too many access points remained despite the sealed chamber. Other than 'do nothing', the options were: to have a bat worker undergo full asbestos training to become a certified asbestos worker (this was possible, but cost and time prohibited) or to use CCTV and have an asbestos worker trained to carefully place the bat in a bag while guided by a licensed bat worker.

Precautions

Measures to protect the bats were a key factor in determining a robust methodology. However, the asbestos team were also concerned that the bats may have been contaminated by asbestos fibres which they could then spread into the wider landscape (that was, of course, happening prior to the identification of the roost). As a precaution, the bat worker was required to wear full asbestos PPE.

Prior to the sealed negative-pressure chamber being tested, the bat worker used a thermal-imaging camera to detect where the bats were located, and marked the areas of concern. CCTV cameras were then placed to view these areas of work and, on the outside of the enclosures, clear viewing screens were also installed. The project went to plan. All the bats were located by the trained asbestos-workers under the guidance of a bat worker using CCTV and walkie-talkies (placed in sealed bags so they could be subsequently washed). Captured bats were safely bagged and put into compensatory roost boxes, and the building was safely demolished with no bats in it.

> **NOTE:** the risk from rabies to the asbestos worker was assessed and deemed negligible, given the species involved and the extent of PPE worn, including doubled-pairs of protective gloves.

Challenges

PPE included: full face-fitted mask with asbestos rated filter; asbestos-grade disposable overalls and gloves; wellington boots which are taped and sealed to overalls (as were the gloves). This proved to be very hot!

Bat bags had to be destroyed because of potential contamination (so old ones were used).

Lessons learned

Clear project planning was essential to minimise any stress to the animals. Being prepared minimised the time the bats were in negative pressure, and the asbestos worker dismantled those sections first.

Good communication throughout was essential.


Overview of the building


Negative Pressure extractor pump and filter


Overview of the building


Negative Pressure extractor pump and filter

It is noted that the option to have a bat worker undergo full asbestos training to become a certified asbestos worker was considered impracticable here; however, a number of bat workers have already undertaken the relevant training and are certified to work around asbestos. While a work-around was used in this particular case, a licensed bat worker certified to work with asbestos would be the preferred option if available.

Thanks to Duncan Sweeting (now DCS Ecology Limited), for case study and photographs.

Case study 37

Urban riverside lighting

Reason for inclusion: to demonstrate a 'bat-safe' approach to lighting leading to a riverside walk

Background

A Green Infrastructure objective to reduce vehicular journeys into Worcester's city centre led to Worcestershire County Council upgrading the River Severn's network of footbridges and pathways. In its urban context, this Local Wildlife Site (LWS) links the wider countryside with Worcester's city centre.

Impact of the proposals

Flood-proof (IP68) bollard lighting was initially selected as it was considered a design least likely to contribute to skyglow or to illuminate the adjacent River Severn LWS. Bollards contain 180-degree LED arrays and are set at 12 m intervals, meeting BS5489. Subsequent monitoring by the Worcestershire Bat Group identified that bollard cowls were being vandalised, casting light on the river embankments.

An urban roost of lesser horseshoe bats in the nearby cathedral used a commuting route which threaded through partially illuminated gardens to reach the River Severn and wider countryside beyond the city's fringes. This traditional flightline was effectively being severed by the bollard lighting, as illumination was focused at 1.5m above ground level. This created a lit barrier between the roost and the river embankment; monitoring of the hibernation roost near the cathedral subsequently indicated a downward trend in numbers.

The challenge

Modifying the bollards would have compromised the housing's IP68 protection and external cowls were vandalised. Highways safety assessors deemed that removing the bollards to avoid impacting the horseshoe bats was an unacceptable departure from standards. Key concerns raised were increased risk of crime, and trips and falls along the river's steep embankments.

The solution

Working with the highway authority, street-lighting team, county/city councils, and a local charity 'Sightconcern' to understand what highway users with visual impairments would require from lighting schemes, a modified departure from standards was negotiated for highways authority adoption.

100 m of bollard lighting was programmed to independently turn off at sunset and fencing was installed at the river's margins. Within this 'dark corridor', ground-mounted solar-powered, cowled way-markers (Solareye's 'Solareye80 Bat Hat') were installed to demarcate the pathway.

The outcome

Post-installation monitoring by the local bat group and county council indicated preferential use of this new dark corridor by lesser horseshoe bats. Winter numbers in the nearby roost increased in the three years of post-installation monitoring. No accidents or uplift in crime in this area was reported to Worcestershire County Council, and the solar-powered waymarkers have subsequently been integrated into downstream developments to protect bat foraging habitats where these intersect with key green infrastructure components.

It is noted that the roost counts are an unreliable proxy for success, and that other factors may be involved. There have been a number of interventions at/around the roost: addressing vandalism (new grilles); tree felling/other vegetation loss; removal of connecting linear features; intensification of urbanisation on all three aspects, including high-power security lighting.

Conversely, lesser horseshoe bat numbers recorded in the county have increased as more roosts are discovered; the species seems to be moving northwards. All these variables could influence recruitment and maternity roost success, and subsequently the numbers counted in the hibernation/transition site. While it's not possible to disentangle these effects and directly point to the success of the lighting here, the bats are still present (three years after turning the bollards off), were heard and seen apparently making preferential use of the dark corridor, and the winter numbers have increased.

Case study supplied by Cody Levine, Ecology Team Leader, Worcestershire CC; Images supplied courtesy of SolarEye.

Case study 38

Noise measurements of construction activities

Reason for inclusion: to share unweighted high-frequency sound measurements from construction activities with a wide audience, as such data have been lacking to date. This work was carried out on behalf of HS2 Ltd.

Methods

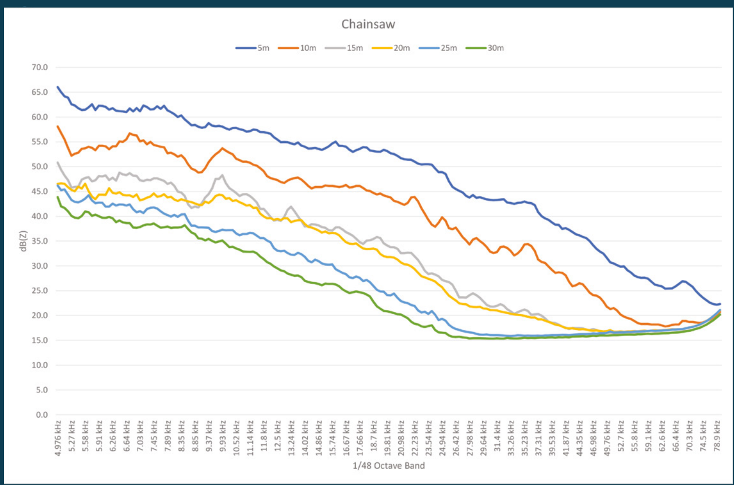
Measurements were made using an Apollo™ box frequency analyser (frequency range 8kHz-80kHz) at setback distances between 10m and 40m. Two 'Microtech Gefell MM 310' microphones with high-frequency measurement capacity were used. Measurements were taken at the nearest safe distance with clear line of sight to the activity. Measurements for the same activity were repeated at set back distances of 5m increments until a distance where the sound under measurement was no longer dominant, or until a point that the location of the measurements was unsafe. Measurement distances from the source are stated and represented as different coloured lines in the figures below.

Results are presented as an average Z-weighted sound pressure level at each 1/48th octave band from 5kHz to 80kHz, $LZ_{eq,}T$.

The preliminary data provided in this case study are presented as $LZ_{eq,}T$, but over short periods of time (~30 seconds), and in some instances, comparable with the LZ_{max} noise metric.

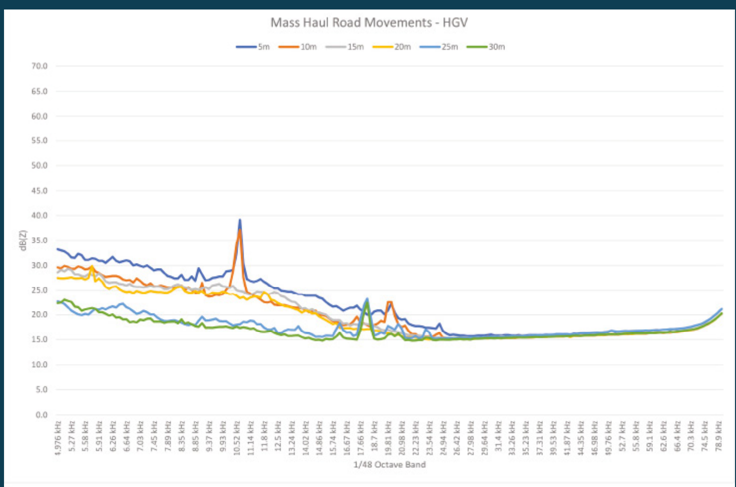
Caveats:

- Note that LZ_{max} (representative of the maximum level of noise from a source) may have a stronger relationship to a 'startle response' than the L_{Zeq} noise metric, which is more commonly used to represent the average sound level . See below for definitions.
- Noise measurements are site-specific (to an extent) and affected by environmental factors, however they can be used to guide an assessment for other sites and to determine if the impacts are such that an acoustician should be consulted.



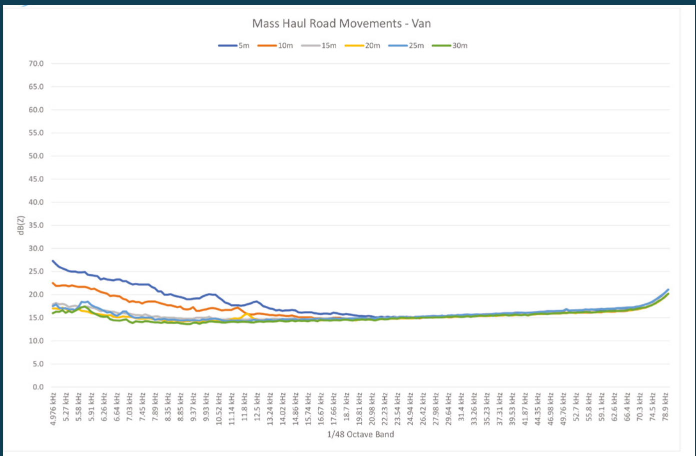
Chainsaw: measurement range 5-30m

- Measured levels do not exceed ~65 dB $LZ_{eq,}T$ at any frequencies, at distances of greater than 5m
- Measured levels do not exceed ~50 dB $LZ_{eq,}T$ at any frequencies, at distances greater than 15m



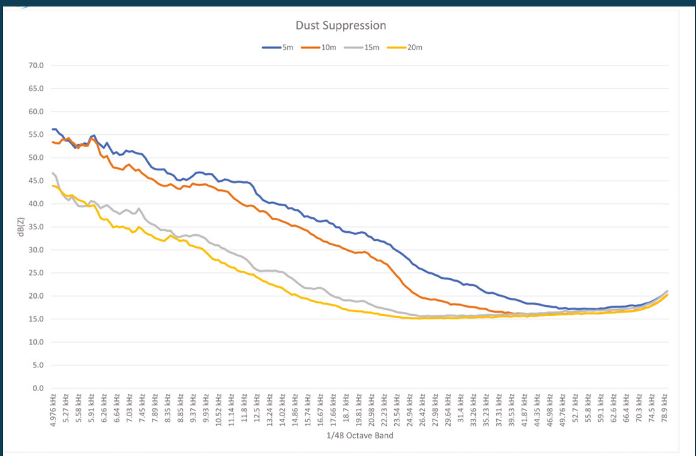
Vehicle movements on clay-surfaced mass haul road (HGV loaded with stone): measurement range 5-30m

Measured levels do not exceed~35 dB LZ_{eq},T at any frequencies, at distances of greater than 5m (beyond one small spike that reaches 40 dB LZ_{eq},T at distances equal to or less than 10m).



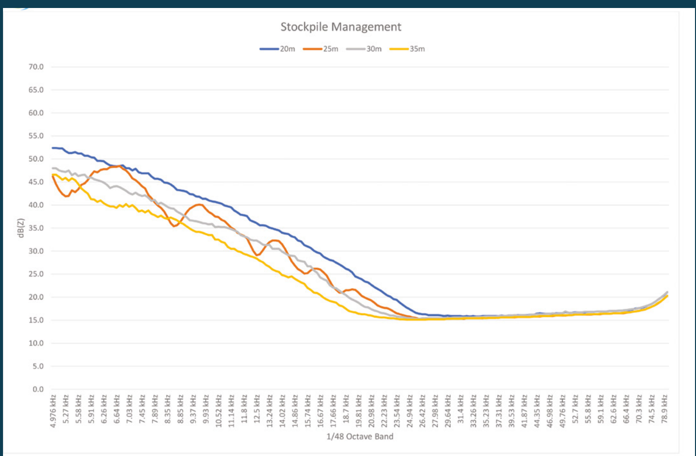
Vehicle movements on mass haul road (van): measurement range 5-30m

- Measured levels do not exceed 30 dB LZ_{eq},T at any frequencies, at distances greater than 5m



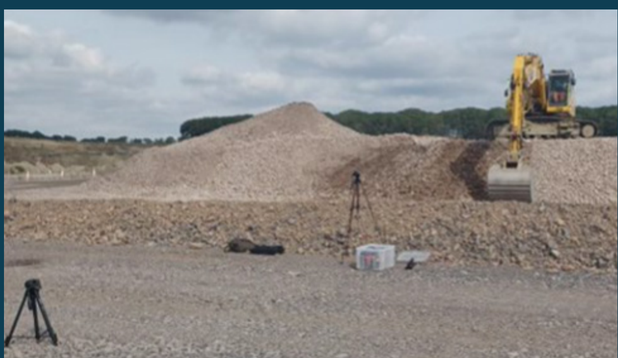
Dust suppression (bowser - towed by tractor - pumping out water): measurement range 5-20m

- Measured levels do not exceed ~60 dB LZ_{eq},T at any frequencies, at distances greater than 5m, and are less than 55 dB LZ_{eq},T at distances greater than 10m.
- Measured levels do not exceed ~50 dB LZ_{eq},T at any frequencies at distances greater than 15m.
- For frequencies above ~10kHz, measured levels fall below 50 dB LZ_{eq},T at a distances greater than 5m.



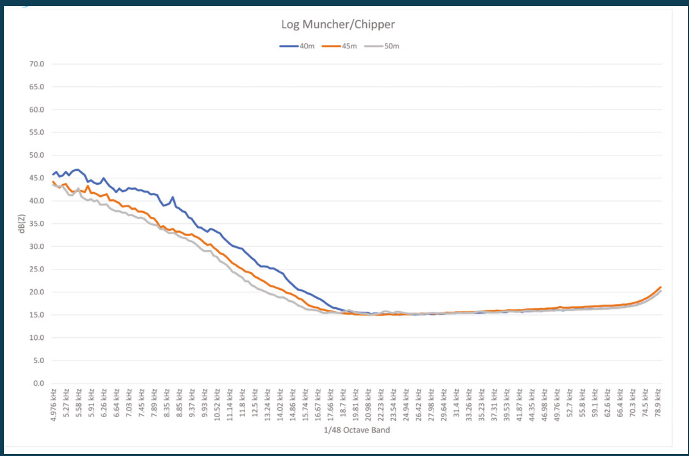
Stockpile management (excavator loading rubble into 30-tonne articulated dump-truck): measurement range 20-35m

- Measurements within 20m were not undertaken
- At distances of 20m or more, measured levels do not exceed ~55 dB LZ_{eq},T at any frequencies.
- At distances of 20m, measured levels are below 45 dB $LZ_{eq,}$T for frequencies above ~10kHz.



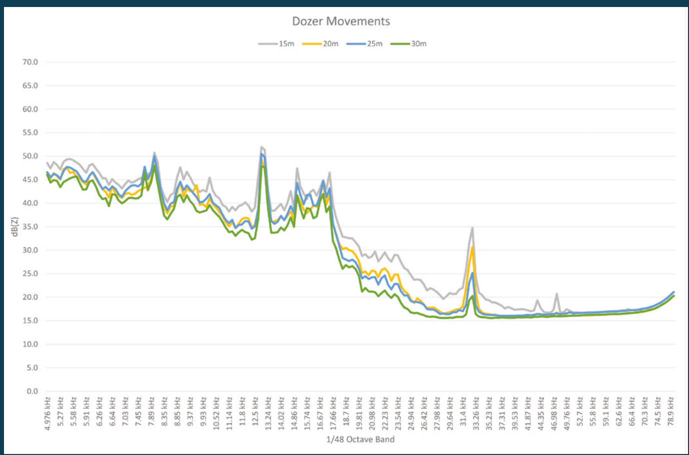
Noise measurement of stockpile management

Noise measurement of dust suppression bowser



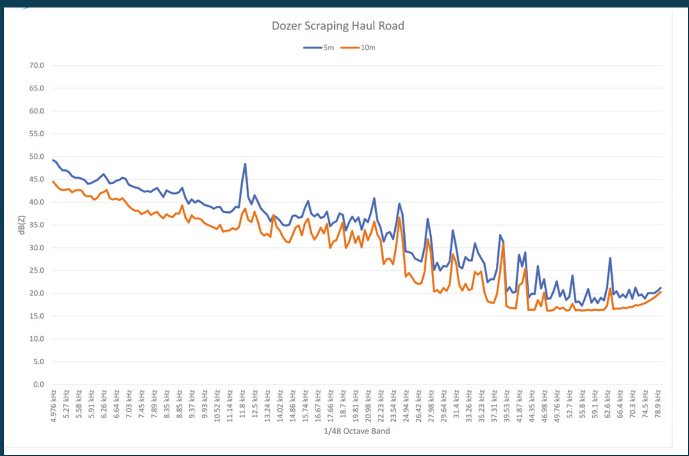
De-vegetation works (large log muncher/chipper): measurement range 40-50m

- Measurements within 40m were not undertaken for logistical reasons.
- Measured levels do not exceed~50 dB $_{LZeq}$, T at any frequencies, at distances greater than 40m.



Dozer movements (Caterpillar D6 22-tonne): measurement range 15-30m

- Measurements within 15m were not undertaken for health and safety reasons.
- Measured levels do not exceed ~50 dB $LZ_{eq,}$T at any frequencies at distances greater than 15m (beyond one small spike that marginally exceeds this over a narrow frequency band at 12-14 kHz, (a similar peak is at ~33 kHz), probably caused by a squeal from the caterpillar tracks).
- At frequencies >18 kHz, measured levels do not exceed 45 dB LZ_{eq},T. A spike in the 31.4 kHz frequency band present at each set back distance does not exceed 35 dB LZ_{eq},T.



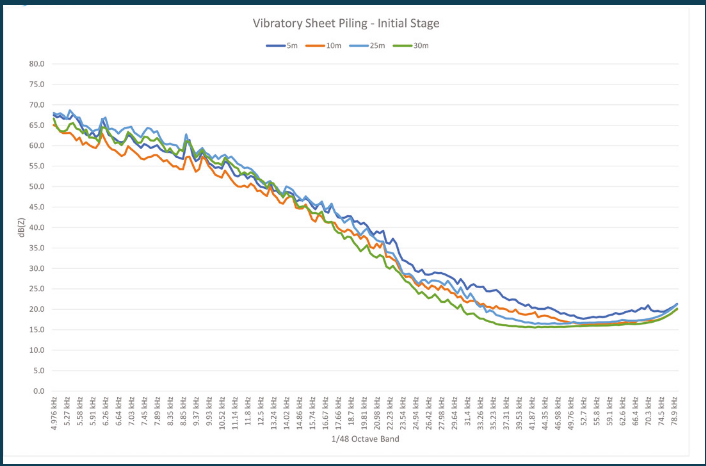
Dozer (scraping haul road): measurement

- Measured levels do not exceed~50 dB LZ_{eq},T at any frequencies at distances greater than 5m.


Noise measurement of chainsaw tree felling

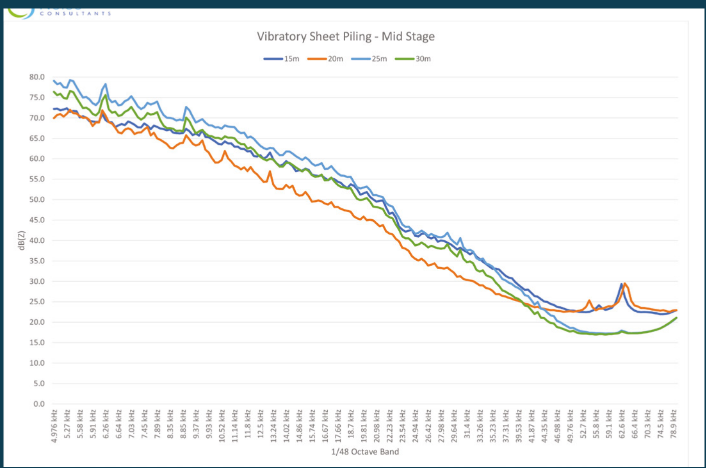

Noise measurement of dozer in action

Auger piling, using a RTG RG21T Telescopic Leader Rig, fitted with a RTG MR 150 AVM Hydraulic Vibrator: measurement range 5-30m.



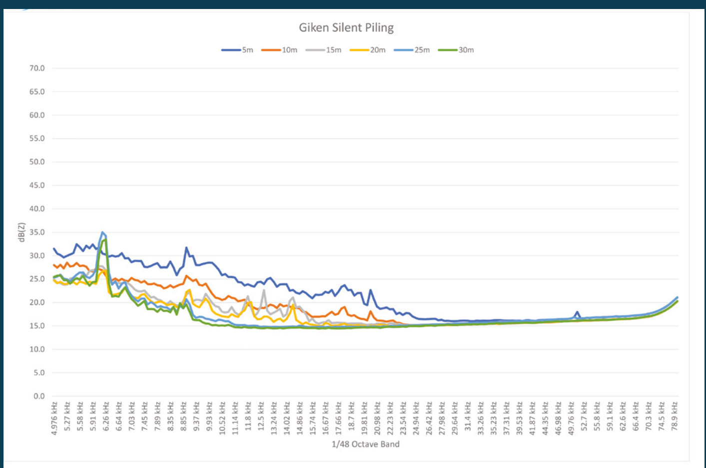
Initial stage: deep sheet piles being inserted; mid-stage: sheets half-way down. At 5-10m, the mid-stage activity could not be isolated from the initial piling measurement as the pile met little resistance upon insertion whilst these closer measurements were taken.

- Measured levels at different frequencies are similar at distances between 5m and 30m, and increasing the measurement set back distance does not appreciably result in a reduction in the measured level. The measurements were not made concurrently, but sequentially, so there is the potential for variations in source operation.
- Measured levels do not exceed ~70 dB LZ_{eq},T at any frequencies at distances greater than 5m.
- For frequencies above ~10kHz, measured levels are between 50-60 dB $LZ_{eq,}$T at distances of up to 30m.

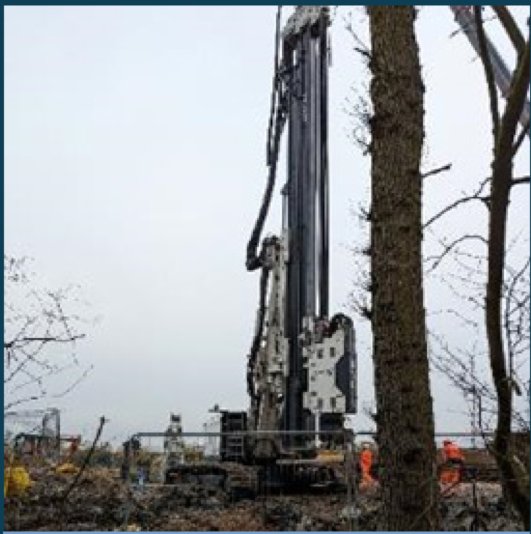


- The measured levels at different frequencies are similar at distances between 15m and 30m, and increasing the distance did not result in an appreciable reduction in the measured level. The measurements were not made concurrently, but sequentially, so there is the potential for variations in source operation.
- Measured levels do not exceed ~80 dB LZ_{eq},T at any frequencies at distances greater than 15m (note the mid-stage of piling here generated more noise than the initial stage).
- At frequencies above ~10kHz, noise remains at ~60-70 dB LZ_{eq},T, even at distances of ~30m.

Giken 'silent' piling rig installing sheet piles: measurement range 5-30m



- Measured levels do not exceed ~35 dB LZ_{eq},T at any frequencies, even at distances of 5m.
- This type of piling has lower noise emissions, but not suitable in all circumstances (much slower and more expensive).

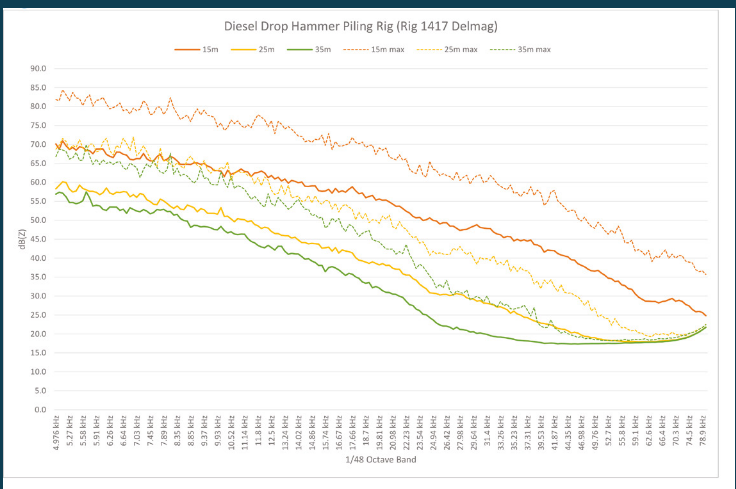


Noise measurement of Auger piling

Noise measurement of Giken piling

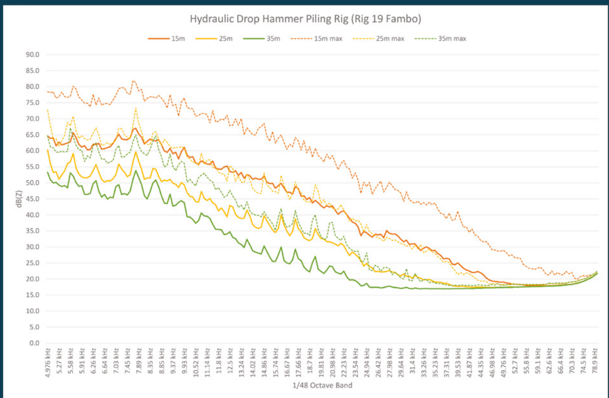
For the following two activities, noise from percussive piling (equivalent to a large hammer) was measured. These were measured at set-back distances of 15m, 25m and 35m.

The results are presented as the average $LZ_{eq,}T$ and LZ_{max} spectra in 1/48th octave bands across the measurement period.



Diesel drop hammer piling (Rig 1417 Delmag)

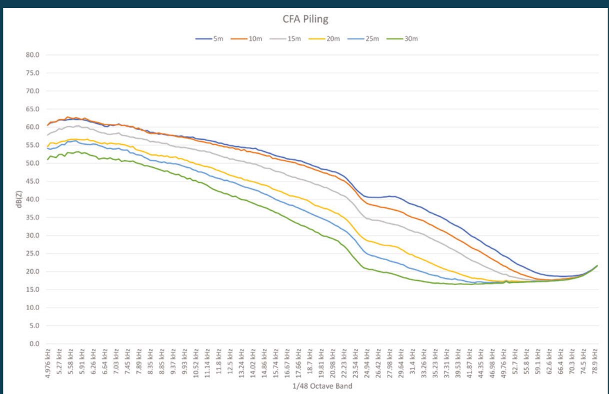
- Measured levels only just exceed ~70 dB $LZ_{eq,}T$ at any frequencies at distances from 15m.
- Lmax levels are a little higher, but follow the same pattern at distances from 25m.
- At distances from 35m, measured levels only exceed~50 dB $LZ_{eq,}T$ at frequencies below c.8.5kHz. These frequencies may be below the audible range of *Myotis* species (though not *Eptesicus* or *Plecotus*) (West, 2016).



Hydraulic drop hammer piling (Rig 19 Fambo)

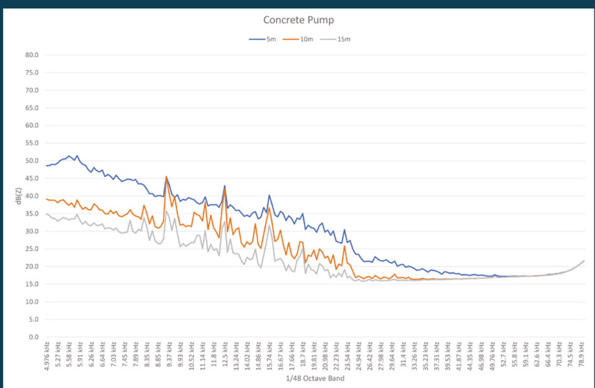
- Measured levels do not exceed ~70 dB $LZ_{eq,}T$ at any frequencies at distances from 15m.
- Lmax levels are a little higher, but follow the same pattern at distances from c.25m.
- At distances greater than 35m, measured levels only exceed~50 dB $LZ_{eq,}T$ at frequencies below c.8.5kHz. These frequencies may be below the audible range of *Myotis* species (though not *Eptesicus* or *Plecotus*) (West, 2016).

Secant pile walls consist of overlapping reinforced and non-reinforced piles, which can be installed by different methods Here, continuous flight auger (CFA) piles are drilled and concreted in one continuous operation; reinforcement is placed into the wet concrete after casting. The following three graphs relate to the CFA piling operation.



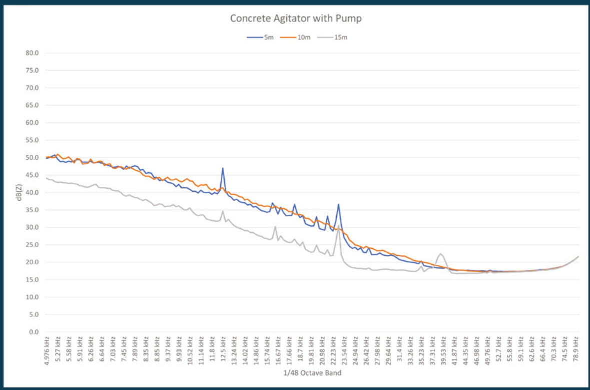
CFA piling: measurement range 5-30m

- Measured levels do not exceed ~65 dB $LZ_{eq,}T$ at any frequencies.
- At 30m, measured levels do not exceed ~55 dB $LZ_{eq,}T$ at any frequencies.
- At all distances >5m, measured levels only exceed~50 dB $LZ_{eq,}$ T at frequencies below c.8kHz. These frequencies may be below the audible range of *Myotis* species (though not *Eptesicus* or *Plecotus*) (West, 2016)12.



Concrete pump used during CFA piling: measurement range 5-15m

- Measured levels do not exceed ~50 dB $LZ_{eq'}T$ at any frequencies at distances greater than 5m.



Graphs supplied by Noise Consultants

Concrete agitator with pump: measurement range 5-15m

- Measured levels do not exceed ~50 dB LZ_{eq},T at any frequencies at distances greater than 5m.

Interpretation

Field measurements from natural daytime sounds in rural locations (Reason & Bentley, 2020) suggest levels of 40 dB or more in the frequency range 8 to 20 kHz are not uncommon, with readings from gently rustling reeds at a distance of around 10 m resulting in approximately 50 dB in this frequency range. Storm events (high winds, heavy rain) would generate higher levels of sound.

It is possible audible non-natural, unfamiliar or unpredictable noise exceeding 50 dB LZ_{max} could begin to have deleterious effects (e.g. increased stress) on roosting bats. However, this does not mean that disturbance should be considered significant as soon as construction noise exceeds that level:

- In most locations, there will be some level of anthropogenic noise to which bats are accustomed (for example, traffic or agricultural activities).
- For roosts, the surrounding structure (building or tree) is likely to provide some protection against high-frequency noise, particularly where bats are deep within a cavity.
- A higher-level stimulus would be required to be detectable at frequencies close to the upper and lower frequency limits of a bat's auditory capabilities (noting that 'detectable' does not equate to 'disturbing' or even 'noticeable'). For more detail, see Reason and Bentley (2020); Harvey & Associates (2019).
- For bats in flight, given high sound levels produced by other bats' echolocation, the more relevant frequency range (i.e. one which disturbs bats to the extent that they change their behaviour) is likely to be that which overlaps with echolocation, and likely at higher sound levels than 50 dB. On that basis, none of the activities above would cause sufficient noise to result in disturbance to bats in flight.

The character of the sound as well as the bat species needs to be considered. Worked examples are shown in **APPENDIX 5**.

Definitions:

L_{eq}	Equivalent continuous sound level (LAeq denotes A-weighting used; LZeq denotes no weighting).
L_{max}	The maximum noise or vibration level during a measurement period or a noise event. Lmax sound levels should include other descriptors e.g. A or Z frequency-weightings and F, S or I time constants.
Octave Band	Octave Bands divide the audio spectrum (frequencies) into ten equal parts. The centre frequencies of these bands are defined as 31.5 Hz, 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1 kHz, 2 kHz, 4 kHz, 8 kHz and 16 kHz. Sound levels that have passed through an octave band pass filter are termed octave band sound levels. Each octave band includes a range of frequencies whose upper frequency limit is twice that of its lower frequency limit. For example, the 1000 Hertz octave band contains noise energy at all frequencies from 707 to 1414 Hertz (rounded to 710 and 1410 Hz). Dividing the octave bands gives more detail (third-octave bands are commonly used; 1/48th octave bands, as used here, provides very fine detail).
T	The time period over which sound was measured.
Time constants	Dating from a pre-digital period (but set in standards, so still used), these constants can be 'fast', 'slow' or 'impulsive'. A detailed explanation is beyond the scope of this document; the important point is that the parameter used should be stated (so measurements can be replicated). For the type of application described above, fast time weighting is usually used.
Z-weighted	The Z is for 'zero' frequency-weighting, implying no weighting across the audio spectrum.
A-weighted	Designed to reflect the human hearing range which is most sensitive between 500 Hz and 6,000 Hz (overall hearing range 20 Hz to 20 kHz).

Thanks to all parties involved in generating this data. This work was carried out on behalf of HS2 Ltd, and involved Noise Consultants Ltd., Pell Frischmann, RSK Biocensus and EKFB (Eiffage Kier Ferrovial Bam joint venture).

Case study 39

Barbastelle tree roost, Somerset

Reason for inclusion: to demonstrate lessons learnt from surveys and mitigation implemented for a barbastelle maternity tree-roost, identified adjacent to a large, multi-phased residential development.

Studies from 2007 for a large, multi-phased, 27ha residential and school development identified that a mature oak tree supported a barbastelle maternity roost. The tree was isolated from other woodland vegetation within an improved, sheep-grazed grassland field (historically woodland pasture); the closest habitat was a woodland copse (100m north) with hedgerows 70m west and 130m north. The tree itself remained outside the development red line boundary, with potential disturbance impacts identified.

Baseline data (2007-8)

The roost was identified in 2007 (bat transect surveys) and confirmed with targeted emergence/dawn surveys; surveyed by emergence in 2008 and 2011 to support outline planning; then in 2012 to inform reserved matters.

The tree supports extensive vertical splits, and tear outs provided numerous access/egress points leading to internal cavities. From 2007 to 2013, the main roost entrance was a feature on its southern aspect, though other access points were also used.

A number of surveys (emergence and dawn) were undertaken in 2008, with at least 32 individuals present on 24 July and 38 on 7 August, potentially a continuous period of occupation of at least two weeks. The colony had left by 4 September.

Main roost access July 2008

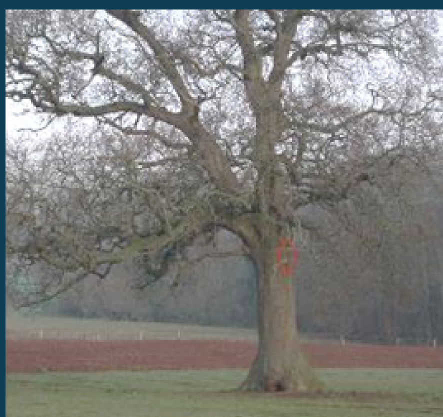
Pre-construction monitoring (2011)

Emergence surveys were undertaken monthly: 40 barbastelles were present in mid-May, 50 in mid-June and 54 in mid-July. This similarly suggested limited roost-switching over an even longer period. The colony appeared to have left by 25 August.

Mitigation

A 125m no-works buffer zone was incorporated around the roost, where no development would take place. Construction activities within 200m of the roost were restricted to October to March inclusive so as not to coincide with maternity roost occupation.

Landscape planting included 1m high, 10m wide vegetated bunds (scrub and woodland planting) around the perimeter of the field surrounding the roost, connecting to the woodland copse to the north. Planting (undertaken winter 2013/14) is now largely well-established.



Winter 2012/13 (southern aspect). Bunds in formation around the field.

Mid-construction monitoring 2012

Construction began in 2012 with the development spine road and landscaping works. In mid-June, surveys confirmed that at least 54 bats emerged.

Roost counts that were completed between 2008 and 2012 used a torch with a red filter below the egress point (this technique was not used for subsequent counts).

Mid-construction monitoring 2015

In mid-June, emergence surveys confirmed that at least 28 bats emerged. Very few bats (3) were seen at the subsequent count in mid-July (no NVA were used for these surveys). Emergence appeared to be delayed compared to earlier surveys. A similar number (3) also emerged in mid-August, indicating continued occupation of the roost, but in lower numbers, and potentially no longer for the same purpose.

By this time, i.e. c.2015, the original access point had all but naturally sealed up, with bats emerging from a lightning split on the northern aspect.

Mid-construction monitoring 2017

No bats were recorded emerging from the tree in mid-May, despite two barbastelles being recorded in-situ from a tree-climbing inspection during the daytime inspection on the same day; nor in mid-June/mid-July.

Mid-construction monitoring 2018-19

Monitoring was not a planning condition, but the developer did commission further surveys of the tree in 2018 and 2019. No bats were recorded emerging from trees in May, June or July in either year, though no NVAs were used, so occupation at these times can't be ruled out. Barbastelle passes were recorded during the mid-august dawn survey in 2019, with the timing highly indicative of roosting behaviour

End of construction monitoring - 2022

Construction was completed in December 2022. A single pro-bono monitoring survey was undertaken in mid-July 2022, using an infra-red camera. Analysis of video footage identified 15 barbastelles emerging from 21:54 until 22:09 from the lightning split in the trunk on the northern side of tree.

Disturbance Levels

Prior to development, the fields (no public access) were subject to sheep grazing with disturbance limited to occasional grass cutting and baling only. The farmer occasionally accessed the fields in a vehicle.

During construction, disturbance levels were minimised through implementation of 'no works' buffers.

Post development, although the field technically remains in private ownership and has been fenced off, it is frequently used by dog walkers from the new adjacent residential development who walk laps of the field. However, no evidence of vandalism or damage has been noted to date of the tree and no vehicular access is obtained (other than occasional grass cutting).

Habitat/connectivity

Pre-construction, the sheep-grazed field surrounding the roost was maintained as short, cropped improved grassland. Post-construction the field is largely unmanaged, with sporadic cutting only, and no sheep have been observed within the field for several years (since 2015/16). No specific management regime was prescribed as the field remained in private ownership.

The landscaped bunds remain within the developer's control, covered by the site management plan.

Overview

Barbastelle numbers appeared to significantly decrease from 2015, with emergence noted from the northern aspect (lightning strike) only at about the same time. However, comparison between surveyor observations and infrared camera footage in 2022 indicated that previous observer counts may have significantly underestimated the number of roosting bats during the construction phase. Importantly, 15 barbastelles were recorded emerging in 2022, and therefore the tree remains part of the colony's roost resource and still supports a maternity colony.

Constraints

- There were inconsistencies in survey frequency, timing, effort and equipment between baseline, mid-construction and post-construction monitoring.
- The lack of NVAs (less common at the time) prevented an accurate assessment of barbastelle numbers.
- Barbastelles appeared to use this tree for longer periods than in other studies where frequent roost-switching has been observed. The use of other trees between and outside the surveys conducted was not explored.
- Lack of internal roost measurements meant it was not possible to assess structure and micro-roosting conditions and changes over time.
- The impact assessment focused on disturbance rather than a landscape-scale assessment of the availability and use of foraging habitats.
- No monitoring was formally required.

Lessons learned

- Roost numbers may have changed for a combination of reasons, including natural changes in the roost features supported by the tree.
- NVAs during emergence would have allowed more accurate counts. However, this tree is undoubtedly part of a wider roost resource. While its function has changed over time, it appears now to be being used for breeding.
- The 125m 'no works' and 200m 'restricted works' were agreed in the absence of previous research, but this strategy appears to have secured some level of long-term security for the roosting bats. In the absence of other data, these are contextual, not 'minimum' distances.
- A more comprehensive understanding of the wider roost network would allow a more accurate assessment of impacts and mitigation effectiveness, and an appropriate monitoring strategy to be developed.

Thanks to Polly Luscombe at Clarkson & Woods Ltd for text and photos.

Case study 40

Management of disturbance

Reason for inclusion: to demonstrate tolerance to noise and management of disturbance

Essential works (carriageway repairs) were required to a viaduct which carries the M5 motorway. There are two separate viaduct structures carrying the northbound and southbound carriageways. The viaducts are comprised of interconnected hollow box voids and connect to abutment chambers at each end. The structures are used all year round, including by breeding and hibernating lesser horseshoe bats, as well as other species, including brown long-eared bats.

Overview of mitigation

The intention was to capture and move bats from the abutment chambers, under licence, to allow essential resurfacing and replacement of joint bearings on the carriageway above to go ahead. Work was planned to disturb only one abutment chamber at any one time. This was originally planned to occur between breeding and hibernation, but was unavoidably delayed into the winter.

In the first week of February, three lesser horseshoe bats were moved on Day 1, one brown long-eared bat on Day 2, and nine lesser horseshoe bats on Day 3.

After the first week, it became clear that lesser horseshoe bats were choosing to return to roost in the chamber they had been moved from, despite being moved, excluded from the adjacent viaduct chambers (but not from entry to the viaduct itself) and the chamber being illuminated. It was concluded that the lesser horseshoe bats were relatively tolerant of the disturbance.

Exclusion and lighting were halted, and the bats were allowed to choose where they wanted to roost. It was evident that the bats (up to 12 lesser horseshoe bats counted) were tolerant of the disturbance caused by the works, as they chose to stay in the abutment chamber being worked on.

The structure at night; many individuals are involved and road closures are not undertaken lightly.

The viaduct has a large void through it and at each end in abutment chambers.

Lessons learned: a licence was obtained to allow the capture and exclusion of bats. However, human entry and bat capture probably caused more disturbance than the carriageway repairs. In hindsight, the continued presence of bats during the works suggests that neither temporary exclusion or translocation was necessary. However, the works may have caused the bats to become active during hibernation unnecessarily, and the behavioural response of bats during the maternity season was not tested.

Similar repairs in future should therefore seek to avoid the maternity and hibernation seasons on a precautionary basis. Doing so (and assuming no capture or exclusion) would render it unlikely that the works would reach a disturbance threshold which would require a licence under current legislation.

Should works be necessary during the hibernation season, it is similarly unlikely that a licence would be required, but the bats' behaviour should be monitored non-intrusively (e.g. by trail camera) to check for signs of arousal to inform future works.

The abutment chambers and connecting tunnels are used by lesser horseshoe bats and other species

Thanks to Richard Green Ecology, Kier Highways and National Highways for text and photos

Case study 41

Use of a s.106 agreement to secure long-term funding for management

Reason for inclusion: to demonstrate the use of a Section 106 agreement to secure long-term management and monitoring in Wall Park, Brixham

Overview of mitigation

Greater horseshoe bats (GHS) use the maternity roost at the Berry Head component of the South Hams Special Area of Conservation (SAC), which lies 120 m from the site. Funding for habitat creation, management and ongoing ecological monitoring was secured by a Section 106 Agreement. Arcadis ecologists collaborated with stakeholders to design 7 ha of Ecological Management Land (EML) which included mitigation intended to buffer the Berry Head roost, enable GHS to continue to use the habitats on site and commute to their foraging habitat to the south-west (Inset 1, and enhance foraging opportunities on site (within the 'Roost Sustenance Zone'). The mitigation was designed with the following features:

- retention and sensitive management of linear features;
- maintenance and enhancement of existing hedgerows;
- establishment of new species-rich hedgerows connected to the existing hedgerow network, doubling the hedgerow resource and creating of smaller field units;
- grazing of 4.35 ha of grassland by organic cattle;
- designation of dark corridors (where lighting levels should not exceed 0.5 lux) within commuting and foraging habitat.

Design principles

GHS commute through the EML from the maternity roost at Berry Head to foraging habitat to the west of Brixham. These commuting routes fall within the GHS 'Roost Sustenance Zone' (the area where feeding activity is concentrated) and are an important part of the 'Strategic Flyway' for the Berry Head component of the South Hams SAC.

Mitigation requirements for the GHS were outlined in the Habitats Regulations Assessment (HRA) for Qualifying Features associated with the SAC, and in the Environmental Statement (ES). The required mitigation has been and continues to be implemented through the Landscape and Ecological Management Plan (LEMP) for the EML. The ongoing monitoring has been directed by an Ecological Monitoring and Early Warning Strategy (EMEWS), which identifies how the effectiveness of the mitigation measures will be determined by setting out objectives and identifying when remedial measures would be required.

Inset 1. Wall Park site and South Hams SAC GHS Sustenance Zone

The delivery of the mitigation was enabled via a Section 106 Agreement. This secured funding for creating, managing and monitoring the EML from the original developers. The freehold of the EML was transferred to Torbay Coast & Countryside Trust (TCCT), securing management beyond the 25-year term of the LEMP.

The Berry Head GHS bats were already geographically vulnerable from the expansion of Brixham toward their roost. Development of the wider Wall Park site (and other similar developments along the coast) risked restricting bat movements, reducing access to foraging habitat and jeopardising the colony's survival. The EML has protected the GHS strategic flyway along this part of the coast and has improved habitat connectivity, including the provision of a new double hedgerow through the centre of the EML (Insets 2 and 3). Areas of permanent pasture provide enhanced foraging opportunities for GHS, particularly for young bats and lactating females, through organic cattle-grazing (Inset 4), which supports their key prey species.

Inset 2. Wall Park Landscape and EML Plan

Inset 3. New double hedgerow (one earth-mounded, one ground level) through the centre of the EML

Photo: Polly Taylor

Monitoring carried out from 2016 was initially focused on ensuring the mitigation had been implemented correctly, and is now assessing the extent to which it has been successful. Monitoring will continue until 2024 and, once the two neighbouring third-party developments have been completed, monitoring actions will be synchronised across the wider area to enable a comparison of post-construction bat activity. Monitoring will include automated and manual activity surveys, SAC roost counts, and dung beetle presence/abundance surveys.

Overview of monitoring results

Baseline surveys undertaken between 2009 and 2012 established that the habitats within undeveloped fields (formerly used as a golf course) along the southern edge of the Wall Park site were important as part of a foraging/commuting corridor for GHS from the nearby Berry Head roost.

Two key components of the GHS strategic flyways were identified across the site – one along the northern boundary of the current EML and the other along the southern boundary, adjacent to Gillard Road. In addition, some opportunistic foraging was identified over the grassland habitat.

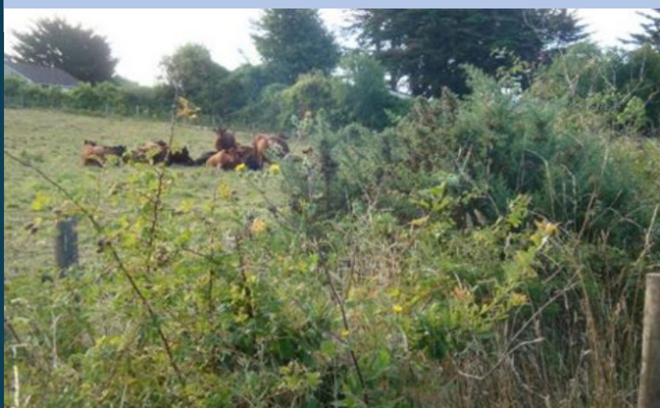
Monitoring between 2016 and 2021 found that GHS are continuing to use the habitats within the EML. The Berry Head GHS population has had some fluctuations but has largely remained stable, with roost counts in 2021 similar to those in 2009 (63 and 65 GHS bats respectively).

Manned surveys in 2021 have found similar counts of GHS using the two features that form part of the strategic flyway compared to 2009 (one and two GHS bats respectively). Two surveyors were stationed along the southern feature, and whilst the counts remained stable at one position, they had fallen at the other in 2021 compared to 2009 (nine compared to 18 GHS bats respectively).

The decline in GHS numbers along part of the southern

Inset 4. New certified organic Red Devon cattle within cattle-grazed pasture in the EML

Photo: Emma Davis



feature warrants further investigation. However, they could be explained by GHS using different routes to commute along; for example, the new hedgerow features and/or greater numbers using the habitats on the neighbouring third-party land. Indeed, over the automated survey recording season, GHS passes along the new double hedgerow through the centre of the EML accounted for the highest proportion of activity at 27.3%, illustrating the importance of this feature as a new commuting route. GHS passes along the southern feature over the survey season accounted for 22% of the total activity; another new hedgerow feature located close to the northern flyway was the third most actively used, with 17.7% of the total activity. These automated findings suggest that the new hedgerow features offer not only additional commuting routes but also are used in preference to the existing strategic features in some months.

Challenges

1. Disconnect and data gaps between static results and manual survey: the original manual survey methodology had surveyors placed along GHS flightlines to enable comparisons between baseline and post-construction monitoring. However, to date, there have been no manned surveys along the new hedgerows and, as such, the extent to which they are being used by GHS is unknown. Given changes to static survey methodology, the evolution of detectors, and the creation of new hedgerows, standardised data on GHS use of both the strategic flyways and the new hedgerows are now being collected.

2. Delays to development/planned monitoring and delays in the implementation of neighbouring schemes have meant that the planned synchronised survey approach has not yet been possible. Without this, it has not been possible to determine a baseline for GHS activity across all three developments along the local coastline, and therefore harder to determine whether relative bat activity along the strategic flyway has declined.

3. Uncontrolled removal of habitat features: trees provided screening and were originally protected on the residential development site adjacent to the EML. However, elements of this screening have been removed by new residents, which had the potential to elevate light lux levels along the boundary of the EML and thus deter GHS bats from using the adjacent feature. However, a lighting assessment was carried out in 2022 to confirm that all light levels were below 0.5 lux and that no remedial measures were required.

Lessons learned

1. Static surveys were costed into the monitoring programme; however, manned surveys (see Challenge 1) would have enabled newly created features such as hedgerows to be monitored to supplement and provide context to the static data recorded at such features.

2. During the financial calculations to establish the s.106 habitat management and monitoring fund value, consideration should have been given to a ring-fenced supplementary fund, which could be activated if necessary. This would have enabled, for example, monitoring to be extended beyond the original monitoring period in order to collate and compare data between sites that have been subject to development delays.

3. Legally binding restrictive covenants should be applied to residential properties next to flyways/commuting routes, to prevent the removal of boundary vegetation and/or regulate illumination.

Inset 5. Lesser horseshoe bats (LHS) were also using the former holiday park buildings; a bat barn created for them in 2015 has already been used frequently over several years by small numbers of this species.

Photo: Katherine Turner

Text and figures supplied by Nancy Davies, Arcadis; photos as individually credited

Case study 42

A487 Porthmadog, Minffordd and Tremadog Bypass

Reason for inclusion: to provide an example of a road crossing structure

A lesser horseshoe bat (LHS) maternity roost (Bron-y-Garth) containing between 200 and 300 bats was present close to the footprint of the proposed A487 Porthmadog, Minffordd and Tremadog Bypass Scheme. The road alignment was changed to reduce impacts, but the constructed alignment still crossed several flightlines along hedges and other linear landscape features. This risked severing the roost from foraging habitats and killing bats in road traffic collisions; LHSs can be reluctant to cross open spaces but also can remain faithful to traditional routes for some time after construction, flying low (often less than 1.5 m) over the carriageway.

Overview of mitigation

A 7 m wide vegetated bridge with 1.8 m high solid parapets was constructed over the road in cutting on the line of the most-used flightline. Several 2.5 m box culverts were constructed under the road through embankments on other flightlines to allow LHSs to safely cross the road. The Welsh Government would not accept a green bridge with soil over the deck, so large planting boxes, planted with native shrubs, were used to provide bats with a surrogate hedge flightline. These are movable by forklift to enable bridge inspections. Upturned tree stumps (from trees removed as part of the project), with root mass, soil and brash were also used to provide habitat for small mammals and invertebrates and allow them to cross over the road.

Design principles

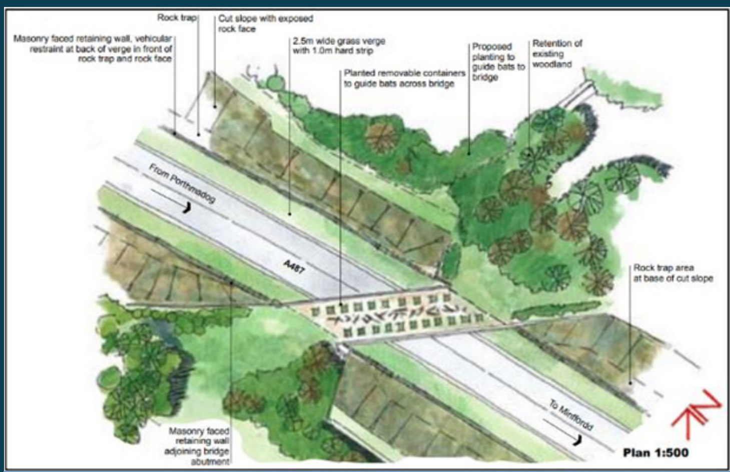
Safe road crossings: provided on all LHS flightlines.

Replacement foraging habitat: principally provided on the roost side of the road to reduce the need for bats to cross the road and provide a strong flightline towards high quality woodland habitat away from the road.

Temporary measures during construction: hurdle fencing used to guide bats to crossing structures before planted trees and shrubs had matured; avoidance of lighting; culverts maintained free of obstruction during construction.

Criteria for success

- Numbers of LHSs crossing the road at known crossing locations to be comparable to base-line data (also considering other factors that might affect numbers).
- A significant proportion (≥95%) of the bats crossing the scheme utilise the purpose-built crossing structures rather than crossing over the open road.
- Numbers of LHSs recorded at the roost show no significant decline over a five-year period (taking into account any regional or national trend (Welsh) in LHS roost numbers over this period). This assumes that the roost does not experience disturbance from another source, other than the road.
- Numbers of LHS corpses found on the road are not significant as a proportion of bats recorded at the roost.
- LHSs are recorded foraging in replacement foraging habitat.



Bridge crossing design for LHSs

Bridge crossing during construction

Culvert with hurdle fencing guide

Baseline surveys were conducted in 2004 & 2009.

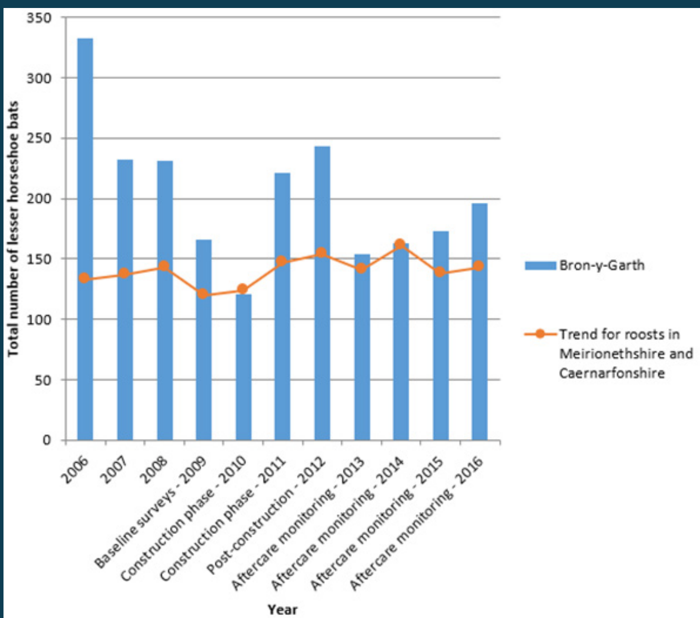
Construction monitoring was undertaken 2010 & 2011.

Annual post-construction monitoring was undertaken in 2012-2014, and extended to 2016 for an additional crossing point found during construction.

Crossing points were monitored each month from April to October using observers with bat detectors for two hours post-sunset and static bat detectors for the whole night.

Overview of monitoring results

Peak LHS roost counts shows the peak LHS roost counts for the Bron-y-Garth roost, as well as the trend for roosts within Merionethshire and Caernarvonshire for which data were available. The Bron-y-Garth trend differs from the trend for other roosts in 2007 (pre-construction), 2010 and 2015. In 2007, there was a decline of >100 bats at Bron-y-Garth compared to 2006, but a slight increase in numbers of bats in roosts within Merionethshire and Caernarvonshire. In 2010, there was a decline in numbers of bats at Bron-y-Garth, but a slight increase in numbers of bats in roosts in the local area. 2010 was during the construction phase of the scheme, and bats may have chosen to roost elsewhere as a result of increased disturbance. In 2015, there was an increase at Bron-y-Garth whilst there was a decrease at other roosts.



Peak LHS roost counts

Surveys showed that more emerging LHSs chose to fly away from the new road than pre-construction.

Surveys confirmed that bats successfully used the safe crossing points, with the ≥95% criteria met for monitored safe crossing points. In 2014, a peak of 72 LHS bats crossed over the bridge in September. A total of six LHSs were recorded as passing on the outside of the bridge (two in April and four in May) with the remainder all crossing on the inside of the bridge.

LHSs were recorded foraging in replacement foraging habitat along the scheme corridor.


Planters and tree stumps on bridge deck

Challenges

Unfortunately, a previously unidentified crossing point was discovered post-construction. This was through an active quarry and over a mainline railway, so survey access had not been possible and there was no obvious linear feature present. Small numbers of juvenile LHS corpses were found and additional mitigation measures provided. These included pruning trees to discourage bats from crossing at that location, and improving conditions through a nearby watercourse culvert by installing rear baffles to lights to reduce light spill and installing hurdle fencing around the top of the headwall. Monitoring at this location was continued in 2015 and 2016.

The greatest number of LHSs recorded crossing the carriageway during a single survey visit in 2016 was five. One corpse was found in 2016 (the same in 2015) and this was deemed not significant to affect the Bron-y-Garth population.

Lessons learned

LHSs successfully used safe crossing structures provided on the line of existing flightlines.

LHS flightlines can exist where there are no obvious features. In this case, the bats were crossing through the quarry over fairly open ground with just a few small trees.

It can be difficult to discourage bats from using a traditional flightline.

LHSs will utilise new foraging habitat within a few years of planting.

Case study published with the consent of the Welsh Government; text and photographs supplied by Richard Green (Richard Green Ecology). The work was undertaken by Richard Green/Arcadis.

Case study 43

Maes-yr-Helmau to Cross Foxes Improvement Scheme

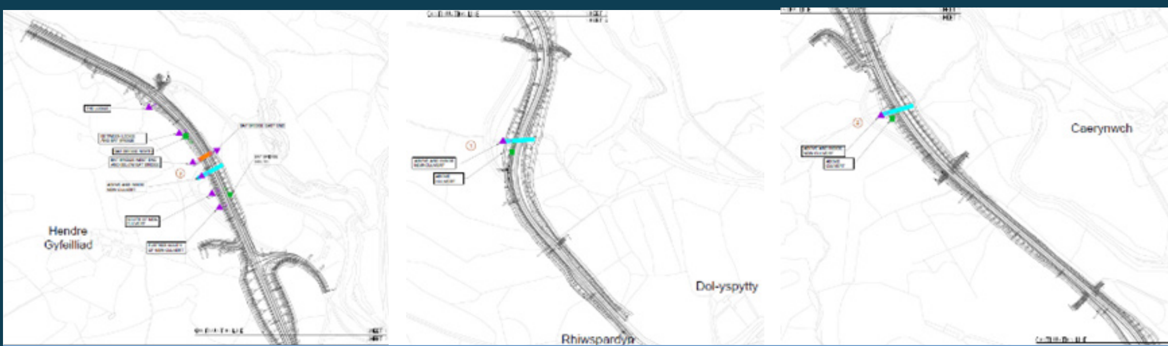
Reason for inclusion: to demonstrate the use of bollard lighting in reducing bat casualties

Bat mitigation was required for a section of the A470 Maes-yr-Helmau to Cross Foxes Improvement scheme. The location was notable for its environmental sensitivity, being within the Snowdonia National Park, but also a Site of Special Scientific Interest and SAC. Where the Scheme unavoidably cut through woodland, there was the potential for mortality of lesser horseshoe bats (LHS), a qualifying feature of the Meirionnydd Oakwoods and Bat Sites SAC, as well as fragmentation impacts.

Overview of mitigation

The existing road was narrow (around 5.5 m minimum) with no verges, tight bends and limited visibility. The new road is 7.3 m wide with 1 m hard strip southbound and 0.6 m northbound, and minimum 2 m grass verge. For environmental reasons, there were departures and relaxations in horizontal alignment and visibility requirements.

Mitigation included oversized culverts and a high-level 'bat bridge' linking the woodland canopy on either side. Bollard lighting was also used to make sections of road between the culverts less attractive, and to encourage bats that did continue to cross to do so above traffic height. The mitigation also included habitat enhancements which are not discussed here.



Diagrams show the distribution of the oversized culverts (2.7 m diameter) along the scheme (blue bars).

Low-level bollard lighting illuminates the highway, minimising light spill into the woodland and ensuring bats are not deterred from using the culverts.

The lighting is automatically switched on close to sunset for two hours, which includes periods of peak traffic when these overlap with the bat active season.

All elements of the mitigation were monitored for five years, with the aim of assessing the effectiveness of the 'safe' crossing structures in preventing severance of commuting/foraging habitat and bat mortality.

Monthly visits were made May to September to monitor the four bat crossings, comprising both manual surveys and automated detector surveys (one night per month).

As with the pre-construction surveys, in order to set the results of the Scheme monitoring in the context of the wider LHS bat population, the nearest known maternity roost was also monitored.

Use of the bat bridge was never demonstrated; its gantry-type design is now recognised as ineffective (the gap between the tree canopies was also short, reducing the likelihood that any type of bridge structure here would be used). However, the culverts and bollard lighting combined were successful.

Overview of monitoring results: culverts

94% of LHS used **Culvert Crossing Point 1** in 2018, consistently making use of the new culvert since its construction in 2012, and predominantly using the culvert rather than flying over the road. In most years, activity at this location post-construction was markedly higher than that recorded at the old culvert, throughout the active season.

LHS activity at **Culvert Crossing Point 2** has increased substantially since the construction of the new road and culvert. Since 2012, they have been recorded using the new culvert throughout their active season with a much higher proportion of the activity recorded within the culvert rather than over the road, indicating the effectiveness of this mitigation. This is in contrast to the old road, where a greater proportion of the bats were recorded crossing over the road. During additional monitoring by YGC, 96% crossed safely via the culvert in 2018; 95% in 2019.

Numbers of LHS passes recorded at **Culvert Crossing Point 3** have steadily increased since 2012 with a minimum of 97% of recorded activity within the culvert rather than over the road during the post-construction monitoring period; again, the mitigation has been clearly shown to be effective. When surveyors were positioned at the entrance to Culvert Crossing Point 3, prior to 2016, bats were observed 'using' the landscape features at the culvert entrance, such as the 'dormouse ropes', the brook and translocated hazel, to fly into the culvert. On occasion, bats were seen to fly in and out of the culvert entrance, suggesting that they were possibly also foraging within it.

The culvert with stream flowing through

Close-up of one of the lamp units

Overview of monitoring results: bollards

It is not possible to conclude that every LHS crosses the Scheme safely on all occasions. However, the low-level bollard lighting appears to have contributed to the decreased instances of bats crossing unsafely at times of peak bat commuting activity (the risk of mortality by collision, as confirmed by traffic counts, is substantially reduced outside of these hours).

No bat casualties have been detected at the crossing points since their construction.

Challenges

In 2018, the peak number of LHS at the maternity roost at St. Mark's Church, Brithdir, had decreased 63% since 2017 (75% since numbers were recorded pre-construction in 2011). The presence of a tawny owl (2017) and barn owl (2018), in conjunction with unusually warm conditions experienced in May, June and July 2018, were considered to have had a significant impact.

This observed decline in numbers is in accord with natural fluctuations recorded at this roost over a prolonged survey period (NBMP data since 2002), and is unlikely to have occurred as a result of the Scheme given the factors above, the absence of dead bats on the Scheme and the continued, and often increased, levels of LHS bat activity around the culverts and foraging areas.

Lessons learned

A number of failures of the bollard lighting occurred in earlier years, though this improved over time.

The mechanism for controlling the lighting needed to be carefully selected to be robust, and continued operation regularly monitored to detect any malfunctions and ensure rapid repair.

The timing the lighting turned on is variable, influenced by natural light levels (in turn influenced by cloud cover). The time at which lighting switches off was determined by traffic levels and the consequent risk of mortality.

For other schemes, lighting design is rapidly evolving, and therefore the make and model, and numbers of lights needed, would be situation-specific. The distribution of lighting units used would similarly be type/model and situation-specific, and would therefore need to be modelled.

Case study published with the consent of the Welsh Government; photographs supplied by Nancy Wilkinson, YGC. The work was undertaken by Arcadis ecologists supported by YGC.

Case study 44

Example large-scale monitoring protocol for tree clearance

Reason for inclusion: to outline a large-scale monitoring protocol subsequent to tree clearance over a wide area. It has been agreed for an infrastructure scheme (following extensive radio-tracking), but could equally be applicable for e.g. large-scale management of ash dieback. This example was agreed in England and therefore the text refers back to Natural England licence terminology.

Aims

Mitigation and compensation measures had been implemented to address impacts on tree-roosting bat species, arising from tree clearance ahead of the scheme construction. The proposed licence monitoring aims to establish whether these measures are effective in maintaining the relevant bat species at favourable conservation status (FCS).

In summary, FCS relates to the long-term distribution and abundance of the populations of species in their natural range. At a local level, this is best viewed as the contribution to wider FCS for the species concerned.

Currently the FCS of a species is measured and assessed with consideration given to the species' range, population size, and the condition and extent of relevant habitats, all of which inform likely future status of the populations concerned (see JNCC Joint Statement, 2018).

Baseline Data

The baseline data collected using Advanced Licence Bat Survey Techniques (ALBST) relating to the assemblage of bats consist of the following:

- Capture information of free-flying bats, including species, location, sex and breeding identifying the **assemblage of bat species**;
- Radio-tracking target species (target species were tagged) providing **confirmed roost locations and type/feature**, even those well outside of the licensed area;
- Emergence surveys (with IR cameras) of the confirmed roosts providing **number of bats** (population estimate), **status of the roost**(s) (i.e. day/maternity/mating);
- **Habitat information** such as number of PRFs, woodland type, extent (ha) and anticipated losses (ha) as a result of the scheme.

With the level of baseline data gained using ALBST, the distribution and abundance of the populations of species in their natural range may be robustly measured. Using the same techniques for monitoring over the long term, the FCS can be confidently assessed.

Monitoring Objectives

An effective monitoring approach is determined by a range of factors to ensure it is proportionate to the predicted impacts on the conservation status of the species/assemblage concerned. Here, the monitoring approach needed to provide the best method(s) of assessing (in a qualitative way) the effectiveness of the mitigation measures employed at the relevant sites and whether the clearance works have been detrimental in the short, medium and longer term.

To assess whether the mitigation measures have been successful in maintaining FCS of the species concerned, the following questions will need to be answered:

1. To assess the impact on the *local occurrence/distribution* of the species concerned: has the **number/assemblage of bat species** occurring within the site* changed or been reduced, despite mitigation?
2. To assess the impact on the *local occurrence/distribution* of the species concerned: has the **breeding status** of the relevant bat species occurring on the site* changed or been reduced?
3. For qualitative assessment of the impact on the *population and distribution* of the species concerned, has the **population type** (i.e. presence of maternity roosts) of key target species** changed or been reduced, despite mitigation?

4. Has the area of **compensatory habitat** developed sufficiently to provide for the species concerned in the long term?
5. To what extent have the **roost mitigation features** been used by the species concerned?

The monitoring methods to be used must provide the data necessary to answer these questions.

**The site is the woodland parcel/habitat directly and indirectly impacted by tree clearance.*

*** Target bat species for this site were brown long-eared and Bechstein's bat. The licence area also supports barbastelle, which is of particular conservation interest.*

Indicative trapping locations were largely aligned with the trapping locations used to establish the baseline for this licence application, although some may have to move to accommodate habitat loss from tree clearance for the Scheme. Trapping/monitoring locations were designed to monitor generally for impacts to FSC; should any impacts be identified, the monitoring would need to be varied in future monitoring rounds to inform an investigation into the potential reasons for the impacts.

Rationale for proposed monitoring methods

The site primarily supported a resident maternity population of brown long-eared bats; day roosts for Bechstein's bat and barbastelle were also present.

Monitoring was required to confirm the continued presence of these species and roost types in numbers comparable to those determined from baseline survey data obtained in 2018 and 2019.

It was therefore important for the monitoring approach to include methods for assessing:

- the effectiveness of the replacement roost features (such as bat box inspections); and
- the continued presence of roosts of the bat population within retained woodland areas where they may still be using other trees.

The monitoring methods proposed to achieve these objectives are a mix of traditional roost checks and ALBST surveys comprising trapping, tagging and radio-tracking. These are set out in the monitoring matrix below. This work will be undertaken by ecologists approved by the named ecologist to ensure consistency in monitoring survey methods employed pre- and post-mitigation. Thermal imaging cameras will be used to support roost characterisation where necessary.

Had monitoring been confined to roost replacement features only, there is a risk that low uptake of these mitigation features by bats would suggest a poor assessment of FCS, when in fact the tree-roosting bat populations may still be adequately provided for within the retained woodland areas or, as the evidence suggests, in the surrounding residential areas and mature woodland. Therefore, the proposed combined approach not only provides data on the compensatory roost use, but should also place the mitigation roosts in context with the retained natural roosting habitat of the site as a whole.

ALBST monitoring surveys will be undertaken as part of the licence monitoring, taking into consideration the following factors:

- the requirement to gain data comparable to those obtained during pre-construction surveys;
- the ability to more accurately assess FCS by gathering data relating to the use of roosts across the full extent of the habitat concerned, rather than just the mitigation features created or installed;
- the ability to deliver each of the above at comparable or lower cost than a 'traditional' monitoring approach, whilst simultaneously requiring fewer skilled ecologists (a recognised potential constraint to future monitoring activities); and
- Potential to avoid unnecessary further intervention due to greater confidence in monitoring.

Monitoring methods

The monitoring matrix below was therefore developed to address the monitoring objectives, taking into account the challenges associated with tree-roosting bat species. It is acknowledged that there are limitations with all methods, especially in determining the population aspects of FCS. All monitoring will be undertaken or overseen by the ecologist/ accredited agents named on the mitigation licence.

The monitoring matrix outlines the FCS value the monitoring will inform, the objective, and the broad methodology. In addition, broad success indicators are given from which mitigation effectiveness can be assessed. Where assessed as ineffective, remedial action will be proposed.

Detailed survey methodologies for the monitoring approaches will be developed to achieve the aims of the monitoring strategy. The monitoring strategy will be reviewed following the tree-climbing and prior to felling, and then at the beginning of Year 5, following the first two rounds of monitoring. This is to incorporate any relevant changes, such as a better understanding of the number of roosts (including those found during tree-climbing inspections prior to felling), use of the area by bats established from the monitoring, changes to the Main Works programme, and advances in bat science and survey techniques. The techniques used and timing of subsequent rounds of monitoring may be varied as part of this review, and any relevant amendments to monitoring will be agreed with the client and Natural England.

Bat box/roost mitigation feature inspection methodology will follow that of the Bat Worker's Manual and Collins (2016) or its successor.

Monitoring matrix

FCS value	Objective (with monitoring objective number)	Method	Timing	Location	Broad success indicators
Distribution	**Monitoring of mitigation feature uptake by bats (5)** and comparison of **species assemblage (1)** and **breeding status (2,3)** pre- and post- tree clearance works.	2 x roost mitigation inspections confirming the presence of bat species and breeding status in June and September. Dropping collection for eDNA analysis to confirm species where possible.	Years 2 and 4, post-tree clearance. Review following Year 4.	Retained and new/ planted mitigation woodland areas.	Continued presence of the relevant bat species and associated breeding status post works. Confirmation of use of mitigation roost features.
	Comparison of species **assemblage (1)** and **breeding status (2)** pre-and post-clearance works.	Trapping surveys in June, August and September.	Years 2, 4 and 10, post-tree clearance Review following Year 4.	Retained and new/ planted mitigation woodland areas.	Continued presence of the relevant bat species and associated breeding status post-works (comparing pre-clearance works trapping data e.g. assemblage, numbers present, species and breeding status).
Distribution	Where species baseline data are sufficient, compare **roosting presence (3,5)** within same woodland parcel.	Radio-tracking of target bat species to locate roosts in June, August and September. Activity surveys if no tagged bats found.	Years 2, 4 and 10, post-tree clearance. Review following Year 4.	Retained and new/ planted mitigation woodland areas.	Continued presence of roost types and associated species. (comparing pre-clearance works tracking data e.g. roost types, locations and numbers present).

Population	Comparison of the **population type (3)** of bat species where baseline data of target species*** are sufficient for comparison.	Radio-tracking of target bat species to locate roosts, followed by emergence surveys using infra-red thermal imaging devices in June, August and September.	Years 2, 4 and 10, post-tree clearance. Review following Year 4.	Retained and new/ planted mitigation woodland areas	No decline or an increase in established baseline population presence and type of target bat species.
Habitat	Comparison of new **habitat** creation in relation to habitat areas lost **(4)**.	Assessment of woodland areas.		Mitigation areas only (new woodland creation/planting areas)	Woodland creation in place and meeting creation targets.
Roost Mitigation Feature	Monitoring of bat boxes confirming the **presence of bat species (1,5) and breeding status (2,3)**	2 x roost mitigation inspections in June and September. Dropping collection for eDNA analysis to confirm species where possible.	Years 2 and 4, post-tree clearance. Review following Year 4.	Retained and new/ planted mitigation woodland areas.	The baseline assemblage of bat species recorded using bat boxes and other mitigation features.
	(if relevant) Monitoring of other roost replacement features, e.g. monoliths salvaged from woodlands and 'veteranised' retained trees. Confirms the **presence of bat species (1,5) and breeding status (2,3)**	Ground-based, inspections (and tree climbing inspections where needed/safe); recommendations for replacement as necessary; supervision of replacement. Emergence/re-entry surveys to confirm use or otherwise inform requirement for re-siting/additional features.	Years 2 and 4, post-tree clearance. Review following Year 4.		

***Target bat species are those which roosted consistently at the site from which a satisfactory baseline population assessment could be undertaken in pre-licence surveys.

APPENDIX 5:
Assessing the risk of disturbance from noise

Worked examples to help identify the likelihood of noise affecting bats (following Reason and Bentley, 2020)

This section expands on **Section 7.3** (Mitigating the impacts of noise). It provides worked examples, and suggests a template for noise assessments. It is included to encourage consistency of approach to noise assessment, which is in its infancy.

There are two reasons for ascertaining whether a particular scenario would result in disturbance from noise[136]: the first is to determine the measures that might need to be applied to *remove/avoid that disturbance;* the second is to assess if any remaining disturbance would be *licensable*. Much of the information on which such decisions are currently based rely on inferences from human responses, or those of other mammals or birds, all of which have very different hearing to bats. It is therefore inappropriate to rely on precautionary measures derived to suit other species, e.g. buffer distances established to avoid disturbance to breeding birds. Further research is needed; until this is available, professional judgement is required, although there are now some data available to inform that judgement (see Case study 38).

As noted in **7.3.23,** in any assessment of the risk of disturbance to bats, baseline levels of *noise/disturbance* need to be taken into account, and the extent/nature of any predicted change needs to be considered. The assessment of change should consider both the character of new noise (continuous, regular and/or familiar; or discontinuous/intermittent, irregular, novel), and its source (traffic, agricultural machinery, light plant, heavy plant), which will dictate its frequency spectrum (see below).

In an ideal world, the amount and character of noise generated in any situation would be modelled based on known parameters. However, in many circumstances, specific unweighted noise data (Reason & Bentley, 2020) are *not available*. There is a limited amount of information available on high-frequency sounds generated by various activities, as most measurements are collected to be of relevance to humans, and therefore do not accurately reflect what a bat can hear (or could be disturbed by). Relevant data often cannot be collected in most circumstances to support an assessment, not least because its cost would be disproportionate to many common scenarios. Secondly, the impact assessment (and any licensing) precede the works, so any assessment has to rely on data collected in similar circumstances and propagation calculated. Again, the data on which to base such calculations are not widely available at the current time. Indeed, there are no agreed standards for predicting high-frequency sound propagation so, at best, predictions would be no more than estimates (though the data presented in Case study 38 certainly do help).

Not all disturbance is licensable[137]; many factors need to be considered. It is not enough for a bat to be 'aware' of a noise for an offence to be triggered, but it isn't yet possible to identify a threshold sound pressure level above which any species becomes disturbed. In any case, there is unlikely to be a single threshold, as outlined in Reason and Bentley (2020). The threshold of an adverse effect is also not the same as a significant adverse effect (the same is true of humans, where a noise may cause annoyance or even sleep-deprivation, but not sufficiently to be considered significant). It's worth reiterating that 'echolocating bats… have evolved in noisy environments, where they are naturally exposed to continuous intense sound levels from their own and neighbouring sonar emissions' (Simmons *et al.,* 2016).

Putting to one side the wording of the various offences for bats across the devolved administrations, and considering only the ecological aspects, the decision in a particular circumstance should first be: could the impact of noise (after any control measures have been applied) have adverse consequences, and could these be significant? This will help to determine if any elements are licensable.

136. Acousticians generally refer to noise as 'unwanted sound' but since both noise and sound are widely used terms, references to one can be taken as references to another.
137. 'Licensable' as used here is a short-hand that includes notifications required under the W&CA in England where the 'incidental result' defence is relied upon.

In order to determine if there may be impacts of disturbance through noise, and whether those impacts may be licensable[134], it is helpful to first consider the mechanisms by which sound is propagated from a source. The following is very much an outline of what might be relevant to a consideration of noise impacts on bats; space precludes a more detailed exploration of how sound travels here, but information is available on the internet to explain this subject in more detail.

- Sound is an energy created by vibrations that travel through air. It is comprised of different frequencies, and those which bats hear overlap with those that humans hear; however, the overlap is limited (and differs between species).
- Much of what bats hear is 'ultrasound' which humans cannot hear. Higher frequencies are attenuated (lose energy) more quickly than lower frequencies, which is helpful when considering impacts on bats from particular activities.
- Noise propagation is also modified by ground effects (which vary according to the type of ground); to a degree, by the presence of foliage (particularly at higher frequencies); and by temperature and humidity. Sound passes through hot air faster than it passes through cold air, and dry air absorbs far more acoustical energy than does moist air (this is why detectors record bat calls differently in different conditions).

Sound propagation is also affected by meeting a structure.

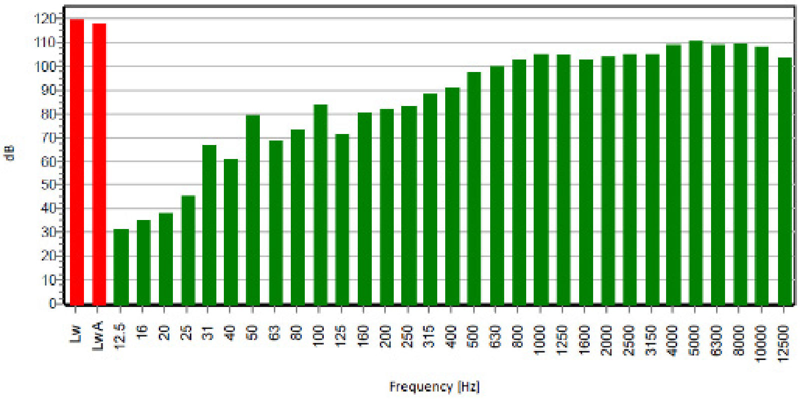
- **Airborne sound** can pass through a structure, as the minute vibrations of air incident on a structure are carried though it and re-radiated into the space on the other side. I*magine someone talking in the room above – the sound of their voice (fluctuations in air pressure) hit the floor and are carried through and re-radiated from the ceiling into the room below.*
- Sound can also pass through due to **structure-borne transmission**, where vibrational energy passes into the structure and is then re-radiated. *In the above example, imagine someone in the room above stamping their foot – the energy of the foot striking the floor is not sound, but arrives at the ears of someone in the room below as sound.*
- Finally, sound can travel either by **a flanking path** (perhaps a ventilation duct between upstairs and downstairs, to continue the analogy) or around the structure (it goes out of the window upstairs bounces off the wall opposite and back in through the downstairs window).

Airborne noise is important when assessing impacts on foraging/commuting bats. The latter three mechanisms are also important for understanding the behaviour of noise in and around a structure, given that a key licensable[134] impact to consider is the effect of noise on bats within a 'place of shelter'. As in air, high frequency sound is transmitted less well through structures than low frequency sound. A further consideration is that of vibration, which is even less well-understood.

Anecdotal information of how bats have responded in other situations can be helpful, as long as the way in which bats hear is taken into account and the underlying reasons for those responses are understood. In an example given in **4.3.7**, a maternity colony of Daubenton's bats occupied a bridge supporting a busy A-road; the bats were under the road deck, and separated from the traffic by just 30cm of concrete and tarmac. This would seem to be a circumstance where disturbance would occur (and a licence was obtained for that reason). The bats returned to roost in completed bridge sections whilst pressure blasting was undertaken within 5 m (separated via screening). However, ecologists monitoring the work at the location where the bats re-occupied the roost had to wear ear defenders. This seems counter-intuitive, and needs more explanation.

High-pressure water-blasting has a sound frequency spectrum which contains very little low-frequency sound and an unusually high amount of high frequency sound (4k and above; C. Bentley (pers. comm.)). It can be very noisy (hence the need for human ear defenders), but the dominant higher frequency airborne sound (think of a 'hiss') would be readily attenuated by a heavy concrete structure (in this case, the bridge). The pressure washer would therefore generate relatively little structure-borne sound. With such high-frequency sounds, flanking paths (defined above) are also less likely to be a problem, as high frequencies are more readily absorbed by surfaces (so reflect less) and diffract (bend) less around obstacles than lower frequencies.

Figure A5.1: **Typical frequency spectrum for high-pressure water jetting, showing more energy (dB) at higher frequencies than lower frequencies** (source: C. Bentley).



In contrast to the high-pressure water-jetting example above, in the first (hypothetical but common) scenario below, a jackhammer is to be used. This will produce a very different type of sound, more or less evenly spread across the spectrum, with considerably more lower-frequency sound than the high-pressure water-jetting described above. 100dB from a jackhammer might result in 80dB below the bridge; 100dB from high pressure jetting might generate 40dB below the bridge (C. Bentley, pers. comm.). It's possible both would be tolerable to bats. However, using a jackhammer is also far more likely to generate structure-borne noise as it is imparting **vibrational energy** into the structure in order to achieve its primary function.

When is disturbance licensable?

In practical terms, **disturbance which results in no observable change in behaviour, or which results in changes which have no adverse implications for bats, is unlikely to be licensable**. However, there is no settled legal rule or threshold on this and this view is presented as a starting-point to assist consultants with decision-making. Deciding, in advance of the works taking place, whether there would be 'no adverse impacts' remains difficult on current evidence, and will always depend on the specific circumstances of each site and project.

As an illustration, causing bats to emerge from an existing secondary access point in preference to their primary access point as a result of disturbance is a behaviour that may have no adverse effects, if this is for a short period. However, on the assumption that bats have a reason for not preferring a secondary access point, then an extended period of works causing that change may be considered licensable.

It is possible that some aspects of noise- or vibration-induced stress may have effects on fitness that are not readily apparent. For example, for a longer-running project, roost abandonment may or may not be identified, but secondary effects (such as loss of fitness) may still cause an impact. In such circumstances, a precautionary approach to assessing whether disturbance is licensable is recommended.

If there is any doubt as to how the law would apply in these circumstances, then specialist legal advice should be sought.

Where professional judgement is required, those making such assessments are encouraged to include a detailed rationale for their advice on whether or not works are licensable, especially in cases where their advice may be questioned. The following examples indicate the thought process behind a number of common scenarios that may help to determine if disturbance may occur, and whether such disturbance would be licensable. Whether or not the same structure is used in assessments, any rationale should, at least, include the factors set out in the template below (as relevant). A similar template has been accepted for licences currently in place.

Table A5.1: Example 1:	Noise impacts from repairs to the deck of a road bridge over a motorway	
Scenario		The repairs require the road surface to be broken up using a jackhammer. The repairs will take a week, but the bridge is large and only a small section will be affected at any one time. Expansion joints are not directly affected, but adjacent areas of road surface will be. The need for a road closure tied to other elements of a programme means there is very little flexibility in timing without incurring significant expense, though proposed timings for these works are not yet confirmed. No noise or vibration measurements are available.
Bat survey results		The bridge contains many expansion joints assessed as having ‘low’ suitability for roosting bats. Surveys recorded small numbers of non-breeding common pipistrelle, but bats have not been present during every survey undertaken to date. There are no other PRFs within or in the vicinity of the bridge. The area is sub-urban, with limited connections to more valuable habitat, but the desk study has identified maternity roosts of common pipistrelles within 500 m.
Noise/vibration parameters	**Seasonal timing**	Unknown.
	Time of day	Daylight hours only (i.e. when bats may be in identified roosts).
	Duration of works	1 week (overall); individual sections up to one day.
	Continuous/ intermittent	Intermittent (i.e. jackhammer not working constantly during this period).
	Frequency range	Likely to include noise at low frequencies and potentially some noise at higher frequencies and within the hearing range of bats.
	Intensity	Likely to be high during operation of the jackhammer in the vicinity of expansion-joint roost sites.
	Noise and vibration propagation	Structure-borne noise likely; affecting any expansion joints close to the working site. However, the structure will absorb much of this noise over fairly short distances. Vibration is likely, and will be greater/different to the vibration experience from traffic. Vibration effects are unpredictable, depending on the source, the materials through which the vibration passes, and how these are held together.
	Baseline noise levels	High but relatively constant and predictable, due to existing traffic on the bridge above roosts and motorway below.
Bat parameters	**Species’ susceptibility**	This species appears relatively tolerant of noise and other forms of anthropogenic disturbance.
	Roost type	Non-breeding roost, hibernation considered unlikely but possible for individual/very small numbers of bats.
	Habitat	Only roosts affected, no disruption to commuting/foraging habitat.
	Pre-development experience of population	Likely to be habituated to some level of noise/vibration given pre-development situation. However, use of a jackhammer would represent a change.
Assessment of likely impacts		The works are of short duration and unlikely to affect breeding or hibernation roosts (low potential for individual bats only at any time of the year). In summer, if expansion joints that are close to the works on any particular day are occupied by bats at the time of the works, it is possible that the noise or, perhaps more likely, vibration, could encourage them to move to another expansion joint within the bridge, and these short movements may take place during daylight hours. However, it is unlikely that they would be deterred from using all of the expansion joints, given the size of the bridge. As there have been no observations of birds of prey or corvids nesting/roosting on or under the structure, the predation risk should daytime movements occur is likely to be very low. Thus, while movement between expansion joints would be an observable change in behaviour, it is unlikely to have adverse consequences from a short-lived exposure to predation. In winter, the risk of hibernating bats being present is considered similarly low (in terms of likelihood and numbers) but joints cannot be directly inspected, so this cannot be quantified. There is evidence to suggest that torpid bats are not as affected by anthropogenic noise (Luo et al., 2013) and appear to tolerate some vibration (4.3.90). Taking all factors into account, the likelihood of displacing hibernating bats, if present, is likely to be low.
Noise mitigation measures required **[NOTE: this does not consider mitigation for other receptors that may be present, most likely nesting birds, or standard actions such as tool-box talks.]**		No restrictions on timings necessary, given roost status. No other mitigation measures required (screening is unlikely to reduce structure-borne noise/vibration).
Licensing		Whilst disturbance is unlikely to meet the threshold of disturbance as set out in the Habitats Directive, it may meet the threshold of disturbance for offences which derive from domestic legislation (see 2.5.7) and still require licensing. In England, if reliance on the ‘incidental result’ defence is intended, a formal notification will be required. A licence is potentially avoidable, given the bridge is large and assuming multiple expansion joints are available. A precautionary approach may be preferred by some SNCBs, particularly given the unknown effects of vibration. In the absence of a licence, a PWMS is recommended. [Note: the use of daytime and night-time cameras (and/or static detectors) could be used to inform future projects.

<table>
<tr><th colspan="4">Table A5.2: Example 2: Noise impacts from vegetation clearance and digging a trench</th></tr>
<tr><td colspan="2">Scenario</td><td colspan="2">A pipeline is being laid through an agricultural field that is regularly ploughed. A track lies alongside a tree-line which contains several mature trees supporting PRFs. For these minor works, the pipeline will go through a low hedgerow that links to the tree-line, but the tree-line itself will not be affected. The short hedgerow breach (5-10 m) and trench works will be approximately 10 m from the tree-line at the closest point, and take place only in daylight hours.

No noise measurements have been taken.</td></tr>
<tr><td colspan="2">Bat survey results</td><td colspan="2">A confirmed roost of 17 noctules was recorded using one of the trees during the previous maternity period.</td></tr>
<tr><td rowspan="8">Noise/vibration parameters</td><td>Seasonal timing</td><td colspan="2">Unknown.</td></tr>
<tr><td>Time of day</td><td colspan="2">Daylight hours only .</td></tr>
<tr><td>Duration of works</td><td colspan="2">The contractors will be located in this area for one month digging the trench and moving soil on either side of the hedgerow; the hedgerow breaching works will take place over 1-3 days.</td></tr>
<tr><td>Continuous/ intermittent</td><td colspan="2">Intermittent.</td></tr>
<tr><td>Frequency range</td><td colspan="2">Unknown; however, the data presented in case Study 38 indicates noise would be emitted at frequencies above 5kHz.</td></tr>
<tr><td>Intensity</td><td colspan="2">Unknown, though likely to be similar to agricultural vehicles using the field; however, the data presented in Case Study 38 indicates limited exceedance of typical noise levels compared to agricultural activities (chainsaw within 15m).</td></tr>
<tr><td>Noise propagation</td><td colspan="2">Airborne, but the tree itself may provide some protection against high-frequency noise, if the bats are deep within a cavity.</td></tr>
<tr><td>Baseline noise levels</td><td colspan="2">Low; occasional agricultural vehicles nearby.</td></tr>
<tr><td rowspan="4">Bat parameters</td><td>Species' susceptibility</td><td colspan="2">Unknown, but considered likely to be more susceptible during breeding season. However, noctules move roosts regularly, including within the maternity season, even in the absence of disturbance.</td></tr>
<tr><td>Roost type</td><td colspan="2">Maternity, possibly also other times of the year.</td></tr>
<tr><td>Habitat</td><td colspan="2">Only roosts (and potential roosts) within the tree-line affected. Limited disruption to commuting/foraging habitat (minor breach within one adjacent hedgerow).</td></tr>
<tr><td>Pre-development experience of population</td><td colspan="2">Only likely to be habituated to agricultural levels of anthropogenic noise.</td></tr>
<tr><td colspan="2">Assessment of likely impacts</td><td colspan="2">No noise characteristics were supplied, but the character and intensity of noise during the works will be broadly similar to that of previous agricultural use of the field, so collection of additional noise data is not justified.

The works are of relatively short duration, but would result in more continuous anthropogenic noise, as vehicles would be present daily rather than occasionally.

Given this more continuous noise, even though the character of the noise is likely to be similar to baseline levels, licensable disturbance could occur during the breeding season, i.e. result in a roost movement. However, any such response is likely to be no more adverse than normal roost movements, even during the maternity season.

At other times of the year, it is unlikely that disturbance from the proposed works could result in an adverse impact, and therefore is not considered licensable.</td></tr>
<tr><td colspan="2">Noise mitigation measures required

[NOTE: this does not consider mitigation for other receptors that may be present, most likely nesting birds, or standard actions such as tool-box talks.]</td><td colspan="2">Restriction on timings of works to avoid working close to the roost during the maternity period.

Review activities and equipment to be used against available data (e.g. see Case study 38: Noise measurements of construction activities). Review location of works in proximity to the tree, and determine if they could be moved to a point at which a disturbance offence is unlikely.

If working close to the roost during the maternity period is unavoidable, daily monitoring may be required to identify whether bats are present (and therefore likely to be disturbed) or absent (therefore cannot be disturbed), and construction activities scheduled accordingly.</td></tr>
<tr><td colspan="2">Licensing potentially required during the maternity period.

Two scenarios are considered for the maternity period, given that noctules change roost frequently, even when young are present.

The odds are that bats will not be present during the works or, if present, would move on within a short number of days.

Option 2 relies on the judgement of the consultant and the fact that a licence should be a measure of last resort.

This illustration is specific to the species and context as described.</td><td>Option 1: assume bats may be present, undertake surveys within correct season (to ensure licence application valid), apply for licence. Provide sufficient justification in licence application detailing why the disturbance impact is unavoidable or cannot be reduced to insignificant levels*.

• Pro: certainty that works can go ahead as planned even if bats present.
• Cons: risk of delay if licence is late; constraints to survey window. Burden on licensing team. Cost of licence. Bats disturbed if present (because licence allows this and no monitoring is required).

* In England, a notification under the W&CA may suffice.</td><td>Option 2 : assume bats may be present, but are likely to be absent. Monitor daily using direct observations or cost-effective IR cameras .

• Pro: works can only take place when bats are absent, but this is a relatively low risk and there are no constraints associated.
• Con: small risk of delay (likely days not weeks) in the unlikely event that bats are present at the time of the works. As these are minor works, flexibility can be built in (as would be the case if a nesting bird appeared).</td></tr>
</table>

138. See, for example: https://www.bsg-ecology.com/bat-cam-wins-cieem-best-innovation-award-2022/; also Lang (2022).

Table A5.3: Example 3 : Longer-term construction of significant infrastructure		
Scenario		Construction of a large-footprint development (power-generation) will take at least five years. The construction activities (and associated noise) in different locations will vary over this period, depending on the requirements of each phase of construction. High-frequency noise levels have been predicted, based on the construction phase considered most likely to produce significant high-frequency noise. The location is currently rural and quiet.
Bat survey results		The area supports a valuable woodland assemblage, including species that hunt by passive listening, and other Annex II species. The woodland assemblage includes species likely to be more sensitive to noise. Areas of woodland supporting breeding roosts are located immediately adjacent to construction; roosts are known to be at heights reaching 20 m.
Noise/vibration parameters	**Seasonal timing**	All year.
	Time of day	24-hour working.
	Duration of works	5 years.
	Continuous/ intermittent	Intermittent.
	Frequency range	High-frequency noise modelling indicates noise levels within the audible range to bats (8kHz+) would be above baseline levels within a 100 m radius from the works, during the noisiest phase of works.
	Intensity	Potentially high for bats closer to sources of noise.
	Noise propagation	Variable; may be experienced as noise (airborne) and/or vibration (via the ground, or through a structure).
	Baseline noise levels	Low.
Bat parameters	**Species' susceptibility**	Variable for assemblage, but roosts and commuting/foraging areas for species considered to be relatively susceptible are present.
	Roost type	Breeding roosts, likely also hibernation.
	Habitat	Roosts, commuting and foraging habitat may be affected, due to night-time working.
	Pre-development experience of population	Not habituated to anthropogenic noise beyond intermittent agricultural operations.
Assessment of likely impacts		The character and intensity of noise will be above baseline levels, and *potentially significant* during one or more phases of construction. Disruption to roosts, flight-lines and foraging areas is possible, extending over a period of months (and therefore in several seasons). It is not possible to phase works to avoid the active season for bats; consequently there is potential for disturbance to be significant (abandonment of roosts, and avoidance of flight-lines and/or foraging areas) during the noisier phases of construction (those generating the most high-frequency noise and potentially vibration). Roost switching during the day would be an adverse (and observable) change in behaviour; use of a different foraging patch in order to avoid noise at night would only be detectable if the behaviour persisted. While observable effects appear possible, this long-running large-footprint development may lead to more subtle effects, including loss of fitness (not so readily determined) and/or competition for a reduced roost or foraging resource.
Noise mitigation measures required [NOTE: this does not consider mitigation for other receptors that may be present, most likely nesting birds, or standard actions such as tool-box talks.]		Further noise modelling for each phase of construction is recommended, as this may identify specific phases or activities that are most likely to result in impacts on bats. This could potentially inform programming of certain operations to avoid or minimise impacts. In the absence of project-specific data/modelling, review activities and equipment to be used against available data (e.g. see Case study 38: Noise measurements of construction activities) in order to assess likely impacts on receptors. Mitigation may include screening noise sources (rather than receptors, many of which are at height), or applying restrictions on the timing/ proximity of certain operations to avoid periods when maternity roosts are occupied. The first option may be difficult to achieve and/or not cost-effective. Tailoring restrictions in particular locations (rather than applying blanket buffer zones or preventing certain works during the maternity season) may require additional survey work to confirm roost status at the relevant time Where a roost resource would be affected, providing alternative roost sites outside of the areas where noise levels are highest would be required. Compensatory flightlines/foraging habitat may also be required.
Licensing		Likely to be required where there is a risk of roost abandonment (depending on species/roost type) or measurable avoidance of areas for foraging/commuting (using observable change as a threshold). This would also cover the more subtle effects outlined above, and secure appropriate mitigation/compensation. If disturbance is considered unlikely to meet the threshold of disturbance as set out in the Habitats Directive, it may meet the threshold of disturbance for offences which derive from domestic legislation (see 2.5.7). In England, if reliance on the 'incidental result' defence is intended, a formal notification will be required.

This section has been developed with the assistance of David Wells, CEC Ltd; Clive Bentley, Sharps Acoustics; and Phil Bowater, Natural England.

APPENDIX 6: Method statement guidance

The following sets out the requirements for a Precautionary Working Method Statement (PWMS) that describes the mitigation measures required to avoid impacts to biodiversity during any works.

PWMSs must be completed by a suitably qualified ecologist who has, through relevant education, training and experience, gained recognised qualifications and expertise in the field of ecology and environmental management (see BS42020:2013 Clause 3.24), and has the required relevant experience of the biodiversity features potentially affected by the proposed works.

This guidance does not cover licensable mitigation which typically follows templates provided by SNCBs.

The following is comprehensive, and not all sections will be relevant to every project. It is very important to consider the audience for the PWMS, which should be proportionate to the impacts.

Whether or not a full PWMS is considered appropriate for the scale of development using the template below, it will also be necessary to provide a toolbox talk supported by a brief illustrated practical guide no more than 3-4 pages long **(template included below).** This should outline the important methods and restrictions that are relevant to those undertaking the work and most likely to directly encounter bats.

Table A6.1: Information required for a comprehensive PWMS

Headings	Content
Cover page	• Date of issue and a version number • Confirmation that the client, contractor and ecologist have all read and agreed with the PWMS in advance of the works (sign-off could be combined with the names and contact details below). • This may be required for submission to LPA to discharge a condition of planning if secured as part of an ecological report.
Contents page	• Table of Contents.
Background information Existing documents may be referenced but the PWMS should include sufficient information to ensure that legislative infringements are avoided.	• Site name • Site address • Ordnance Survey Grid Reference • Site location map (with a suitably scaled Ordnance Survey base) • Name and contact details of developer • Name and contact details of contractors involved with the works (as far as they are known) • Name, contact details and evidence of the competence of the ecologist that has produced the method statement • Description of the proposed works • Description of the purpose and objectives of the proposed works • Planning status (including reference numbers) if appropriate – does the project have consent? Is it permitted development? Is it essential maintenance? Is this method statement accompanying a planning application or discharging planning conditions? • Legislation relating to the species concerned and justification for a licence not being required • Consideration of other environmental constraints • Reference to guidance documents used to inform the preparation of the method statement

Site information and survey Existing documents may be referenced but the PWMS should include sufficient information to ensure that legislative infringements are avoided.	• Description of site location and habitats (including surrounding habitats) • Description of desk study undertaken, including sources used and dates of searches • Description of field surveys undertaken, including details of the methods used, competence of personnel involved, level of effort, dates, times, weather conditions, etc. • Survey results summary, to include: status of the population (assessed in a national, regional and local context if appropriate), assessment of habitat quality, estimate of population size to be affected, etc. • Detailed results to be provided in an appendix if appropriate • Clear identification of whether the survey accords or does not accord with current good practice guidance (and justification and explanation of the implications if it does not accord) • Summary of any survey limitations and an explanation of the implications of these • Where a precautionary approach is being taken due to inadequate survey information resulting from survey restrictions during the Covid-19 outbreak, gaps in survey data and additional precautionary measures undertaken should be detailed with any potential implications stated • Appropriately scaled map(s) showing survey area and results • Photographs of site and specific habitat features, as necessary
Impact assessment as relevant to subject of PWMS Existing documents may be referenced but the PWMS should include sufficient information to ensure that legislative infringements are avoided.	• Quantity (in ha/m2 or linear metres, as appropriate) and type of habitat permanently lost in relation to the species concerned • Quantity (in ha/m2 or linear metres, as appropriate) and type of habitat temporarily lost in relation to the species concerned, and specify the timeframe of the loss • Quantity (in ha/m2 or linear metres, as appropriate) and type of habitat permanently damaged in relation to the species concerned • Quantity (in ha/m2 or linear metres, as appropriate) and type of habitat temporarily damaged in relation to the species concerned, and specify the timeframe of the damage • Identification and assessment of other impacts on the species concerned, such as the risk of killing, injury, disturbance, fragmentation, pollution, increased predation • Assessment of the overall impact of the works proposed on the population of the species concerned, with reference to appropriate contextual information • Scaled map to show impacts
Mitigation, compensation and enhancement strategy Existing documents may be referenced but the PWMS should include sufficient information to ensure that legislative infringements are avoided.	Describe the measures to be employed to avoid/minimise impacts, including, for each measure: • Justification for the measure to be used – is it a recommended measure in relevant good practice guidance, or not? If not, why is it proposed? • Likely effectiveness of measure with justification, based on good practice guidelines and/or relevant research • Quantity (in ha/m2 or linear metres, as appropriate) of any new habitat being created, or existing habitat being improved • Full details of any capture methods, including timings • Design drawings of specific features, such as bat roost access features or bat boxes, and details of materials to be used • Details of persons and their roles and responsibilities for implementing the mitigation/compensation works • Details of any operations needing to be overseen by an ecologist • Details of any tool-box talks or signage required to raise awareness and ensure appropriate behaviours • Name, contact details and requirements for the competence level of ecologists overseeing any specific operations • Details of specific machinery or equipment to be used • Disposal of any wastes arising from mitigation/compensation works • Scaled map(s) to show extent & location of mitigation/compensation measures.
Emergency provisions	• What should happen and who needs to be contacted/informed when the provisions of the PWMS are not followed and/or species are found in unexpected circumstances
Monitoring [Longer-term monitoring may be in a separate document, but responsibilities and remediation mechanisms must be clear.]	• Proposals for monitoring, including methods, timing, survey effort, personnel competence level, frequency, start and end dates • Details of how monitoring will be reported and to whom • Details of baseline to be used and criteria for determining success/failure • Mechanisms for remediation
Management [as set out for monitoring	• Details of responsibility for any ongoing management or maintenance of habitat/features from initial aftercare to any long-term management
Timetable	• Start and finish dates for all activities proposed, identifying activities that are seasonally constrained (i.e. must take place at a specific time of year) and any assumptions made with dates that may change, such as start of construction or phases of development.
Declaration	• A form to be provided at the end of the PWMS for site operatives to sign and date to confirm they have read and understood the PWMS and will implement it.
References	• As appropriate
Supporting figures	• As needed
Supporting appendices	• As needed

Reproduced from CIEEM (2021), with minor amendments. Guidance on Ecological Survey and Assessment in the UK During the Covid-19 Outbreak. Version 4. Published February 2021. Chartered Institute of Ecology and Environmental Management, Winchester, UK.

Table A6.2: **Tool-box talk template (bats)**

TOOL-BOX TALK BATS

COMPANY LOGO

FINDING EVIDENCE OF BATS

A bat is a small, nocturnal, flying mammal

- Bats can get into gaps as small as 1 cm and may be tucked up in cracks and crevices
- Other bats hang free or squeeze up together where the roof timbers meet
- Signs of bats include droppings, urine-staining, grease marks or cobweb-free entrances
- Bat droppings can be obvious in a roof void, or hidden in crevices or under tiles
- Bat droppings look similar to mouse droppings, but crumble to dust in the hand when rubbed. Sometimes they are curved or segmented

HOW BATS USE BUILDINGS

Bats use buildings for different uses, breeding, hibernation (winter), or day roosts

- Maternity roosts are larger colonies of bats in summer, typically from about 10 to 500 individuals, depending on species
- Hibernation roosts in buildings are often only a single or a few bats in winter, potentially more in colder areas such as basements and cellars
- Day roosts are generally only a single or a few bats

Add thumb-nail pictures

1) Bat in crevice
2) Bat hanging free (horseshoe)
3) Bat cluster on roof timbers
4) Droppings on a roof void floor
5) Droppings and/or bat under tile
6) Bat in a gloved hand showing small size

LEGAL PROTECTION

All species of bat, their breeding sites and resting places are protected under:

- The Wildlife and Countryside Act 1981 (as amended) & The Conservation of Habitats and Species Regulations 2017 (as amended)*
- It is illegal to kill, injure, capture or disturb, possess or offer for sale any bat*
- It is illegal to damage or destroy a bat roost (even if bats aren't occupying that roost at the time), or obstruct access to that roost*

** Amend in line with legislation in force – varies between the devolved administrations.*

WORKING METHODS: ROOF STRIP

- You must wear gloves at all times
- Strip the tiles from the roof by lifting them away by the leading edge of the tile to prevent crushing of any bats that may be beneath the tile (do not slide).
- Turn each tile to view the underside as bats may cling beneath; look under each one carefully as you go: lift – look – remove if nothing there.
- Examine the space exposed for signs of bats, particularly droppings. These can be in large piles or just a few droppings. This confirms a roost, even if no bats are present.

WHERE YOU MAY FIND BATS

- Bats like ridge tiles and bonnet tiles and frequently roost in spaces around mortar used to secure these tiles, but they will roost under any tile, including pan tiles.
- They may also creep into spaces under lead flashing and hanging tiles, or use spaces behind soffits, fascias and bargeboards, or gaps alongside windows and doors.
- Droppings can vary in colour from black to grey and also brown. They are often very small and can be easily missed.

IF YOU FIND A BAT OR EVIDENCE OF BATS

- If any bat(s) or evidence of bats is found, work must stop immediately and an ecologist must be contacted.
- Any tile that is removed must be replaced carefully to preserve the roost, and any evidence of bats, without crushing any bat present.
- No attempt should made to catch or handle any bats by any person, unless under the direction of an ecologist.

IF YOU FIND A BAT, CONTACT:

- ECOLOGIST NAME, ECOLOGIST NUMBER/E-MAIL

SAFE INSPECTIONS

- Most ecologists have not been trained to work from roof ladders. Anyone undertaking an inspection should not stray beyond their competence or confidence with heights.
- For this reason, from some locations (for example, under a ridge tile), it may be necessary for a roofer to pick up a bat under direction from the ecologist.
- If anyone does need to handle a grounded or injured bat, they must always do so under the direction of an ecologist and wear thick gloves to avoid getting bitten.

IN THE UNLIKELY EVENT OF A BAT BITE

Bats are not normally aggressive and will avoid contact with humans. **This means that there is no risk if you do not handle bats**. Some bats in the UK carry rabies viruses called European Bat Lyssaviruses (EBLV). The risk of encountering a bat carrying EBLV is low.

- The rabies virus is transmitted via a bite or scratch from an infected animal, or from its saliva coming into contact with your mucous membranes (in your eyes, mouth or nose).
- In the unlikely event that any person encountering a bat gets bitten, then that person MUST wash the bite site immediately with hot water and soap continuously for at least 5 minutes.
- That person MUST attend A & E whether they can see puncture marks or not. Bats can puncture the skin with no visible sign being present. Their saliva can also penetrate the skin through existing cuts and lesions.

APPENDIX 7: Research ideas

The following may be useful subjects for student or longer projects. Some are more complex than others, and inclusion does not indicate that these are the most important evidence gaps (or that they can easily be resolved). The more complex suggestions would need to be broken down into testable hypotheses.

These are ad hoc suggestions that have arisen during the development of the Bat Mitigation Guidelines; they have not arisen from a strategic review nor does this represent an exhaustive list. There are many other gaps to fill.

- All-male roosts are not often reported in the UK (see references in Bat Tree Habitat Key, 2018, p21). This may be because any gathering of bats between May and August is assumed to be a maternity roost, no matter the size or species. This assumption could be tested if bats from such colonies were trapped and examined more often.
- It is generally accepted that species that tend to fly within the roof void before emerging require a space uncluttered by roof timbers. Modern roof designs often incorporate trusses. Is there any evidence that these are a disincentive to species that tend to fly within the roof void before emerging?
- Many types of bat access tiles, bricks, etc are available. Which (if any) are the more successful?
- It's often said that noctules need a long drop from their roost (natural or bat box). Is this true for this or any other species? Is there a minimum or preferred height for natural roosts or bat boxes in some species?
- The use of lures has been suggested to help bats, notably tree-roosting bats, find new roosts. Could this work, and are there any impacts/disbenefits of doing so?
- How precise is a bat's mental map? It appears that retaining access points in the same place is helpful; how far can an access point move before it is harder for a bat to find?
- Could there be any effects from high-voltage transmission lines on bats (e.g. avoidance)?
- How do solar panels affect the micro-environment within the roof supporting them?
- What impacts might the spread of new predators have (e.g. edible dormice or green parakeets)? See: https://www.mammal.org.uk/2021/05/edible-dormouse-glis-glis-by-roger-trout-invasive-species-week/
- The impacts of high-frequency noise on bats, for example:

    What high-frequency noise do different activities on a construction site generate, as perceived by a bat (noting that 'perception' will differ between species)?

    What level of high-frequency noise (and at what frequencies) would result in disturbance sufficient to cause a bat to abandon a roost; avoid a foraging area; detour to use a different commuting route?

    How do the characteristics of noise (steady but high; lowish but with unpredictable high peaks; other) affect a bat's behaviour?

    Is there any evidence of habituation by roosting, foraging or commuting bats?

- The impacts of vibration on bats
- Little is known about the energetic cost of disturbance on bats, particularly where that disturbance is below the threshold which would cause bats to switch roosts during hibernation. A study could monitor either arousal frequency (e.g. using 'bat cams' in roosts) or other markers of stress prior to and during exposure to noise (e.g. controlled noise or maintenance work to see if there is a difference related to different types of disturbance). As roost switching is not uncommon, even during hibernation, noise, light, temperature and humidity data would also be required.
- Hibernation sites for crevice-dwelling species (e.g. in residential properties) can often be overlooked (e.g.

pipistrelles, brown long-eared and some *Myotis spp. hibernating below ridge tiles). Some will use various features within the same site throughout* the year; however, use outside of the 'bat-active period' can be missed from 'traditional' surveys and therefore unmitigated. It would be helpful to know how common this use is; a desk-based study of findings from completed re-roofing projects may help to answer this question.

- In parallel, an understanding of the frequency of winter activity and how this correlates to environmental conditions, particularly for bats in 'non-classic' hibernation sites, would be very helpful.
- The effectiveness of veteranisation in creating PRFs that are adopted by bats could be tested using cameras. Other questions around veteranisation include:
    - what is the success rate of augmentation (bat boxes) v. mimic replication (veteranisation) for each tree-roosting bat species
    - how long augmentation can be predicted to last v. mimic replication
    - what the cost implications of augmentation v. mimic replication are in terms of creation (think availability and skills)
    - what the cost implications are in respect of conditioned monitoring – a bat box can typically be accessed with a ladder and the bats viewed by taking off the front, whereas veteranisation might require climbing and view with an endoscope
    - what are the relative safety implications of augmentation v. mimic replication
- It has been suggested that veteranisation runs the risk of creating roost features for non-target species that might compete or otherwise displace the target species (of course, this is also true of bat boxes). Could either/both hypotheses be tested?
- Temporary flight-line structures are frequently used in construction, but the parameters that increase effectiveness have not been tested. Questions that could be answered include:
    - What size of gap in a linear feature acts as a deterrence to bats? This is not a simple question, as there will be species differences, but also differences relating to light levels (time of day) and proximity to roosts. Answering this question would help identify the circumstances in which temporary structures should be employed.
    - Which types of temporary structure are the most effective in practice in addressing gaps of different sizes? Ease of use (the extent of regular human intervention required) may need to be traded against physical effectiveness.
    - Is there an optimum/minimum height for temporary structures? This would also guide the minimum height of new planting, and therefore has cost implications.
    - If alternative (apparently sub-optimal) routes that are not well-used are improved (e.g. bolstered by filling gaps or modifying management), does use by bats increase? A hard question to test, but important when looking at diverting flight-paths.
    - More broadly, what factors determine success when 'encouraging' bats to divert onto alternative flightpaths? This would need to be distilled into a series of testable hypotheses.
- Exclusion may be more effective if certain stimuli are used. Lighting is not recommended (see **6.9.13**), but other stimuli have not been tested (for example, music, human voices, odours). This could be tested in a flight cage with captive bats.

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