

Hampshire Water Transfer and Water Recycling Project

Environmental Statement – Appendix 8.4 Bats

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The Southern Water logo consists of three stylized, wavy blue lines of varying lengths, positioned to the right of the word 'Water'.

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1 Introduction

1.1 Overview

- 1.1.1 This technical report has been prepared by Southern Water Services Limited (the Applicant) in relation to the Hampshire Water Transfer and Water Recycling Project (hereafter referred to as ‘the Proposed Development’). A detailed description of the Proposed Development can be found in Environmental Statement (ES) Chapter 3 Description of the Proposed Development, Volume I (Document reference 6.1, DCO Volume 6) and have informed the scope of this study. The Application Glossary (Document reference 1.7, DCO Volume 1) sets out the abbreviations and definitions used in the DCO application for the Proposed Development.
- 1.1.2 The Proposed Development comprises the construction, operation and maintenance of the following components:
1. Water Recycling Plant site (WRP site) and associated pumping stations.
 2. Pipelines between Budds Farm Wastewater Treatment Works (WTW) and the WRP site.
 3. Pipelines between the WRP site and Bedhampton Springs, connecting to pipelines being delivered by Portsmouth Water between Bedhampton Springs and Havant Thicket Reservoir.
 4. Pipeline between the WRP site and Otterbourne Water Supply Works (WSW).
 5. Above Ground Plant (AGP) comprising Intermediate Pumping Stations (IPS) and Break Pressure Tanks (BPT) located along the Pipeline between the WRP site and Otterbourne WSW.
- 1.1.3 The Proposed Development would also comprise the use of the following infrastructure:
1. Havant Thicket Reservoir (which has been consented separately by Portsmouth Water and is currently under construction) for the storage of recycled water.
 2. The existing Eastney Long Sea Outfall (LSO), Eastney Pumping Station, and associated Eastney Transfer Tunnel (TT) for the release of reject water from the WRP site.
 3. Pipelines and other related works (which have been consented separately by Portsmouth Water) for the transfer of recycled water and source water between Bedhampton Springs and Havant Thicket Reservoir.
- 1.1.4 The construction and operation of the Proposed Development would be supported by other temporary and permanent works and will require the demolition, disassembly and/or temporary relocation of a number of small structures.
- 1.1.5 This report details baseline data for bats collected between July 2022 and December 2024 and is one of nine technical reports produced to inform the ecological assessment presented within ES Chapter 8 Terrestrial and freshwater biodiversity, Volume I (Document reference 6.1, DCO Volume 6). The survey

scoping and methodology used for establishing the ecological baseline for bats are provided in section 1 and section 2, respectively of this report.

1.2 Objectives

- 1.2.1 Environmental Impact Assessment (EIA) Scoping Report Chapter 8 Terrestrial and freshwater biodiversity (refer to ES Appendix 5.1 EIA Scoping Report, Volume II (Document reference 6.2, DCO Volume 6)), identified potential effects on bats with further study being recommended.
- 1.2.2 To inform the assessment of likely effects on bats the following objectives were to:
1. Undertake a desk study to identify any records of bats within 7km of the Order Limits from the last ten years.
 2. Undertake surveys to confirm presence or likely absence of bats within suitable habitat in the field survey area through identification of potential roosting features, foraging areas and commuting routes. Survey types undertaken were:
 3. Daytime Bat Walkovers
 4. Ground-level tree assessments (GLTA)
 5. Aerial tree inspections
 6. Preliminary roost assessment (PRA) of structures
 7. Emergence surveys of trees and structures
 8. Nighttime bat walkovers (NBW)
 9. Highlight and map key connective locations (KCL) for bats within the Order Limits, by using habitat suitability modelling (HSM), informed by data records and static detector monitoring, to model the potential movement of bat species across the Order Limits between highly suitable habitats in the 7km Zol.

1.3 Bat ecology

- 1.3.1 Bats use large areas of the landscape and can travel up to 20km or more from their roosting locations; the landscape through which they travel includes a range of different habitat types. The Bat Conservation Trust (BCT) have identified Core Sustainance Zones (CSZ) for different bat species which identify the area surrounding a communal bat roost within which habitat availability and quality will have a significant influence on the resilience and conservation status of the colony using the roost. These CSZs defined by BCT are based on literature research and the confidence in the size of the CSZ is based on the available research for a particular species; the CSZs will inform the scope of baseline assessment. The CSZs range between 1km and 6km from roost locations, depending on species.
- 1.3.2 The presence of a particular species at any location within the landscape is dependent upon resource availability for roosting and foraging, and factors influencing the connectivity of these resources for commuting. Any factors which negatively impact their roosting, foraging or commuting resource may cause a species' population decline.
- 1.3.3 Habitats of value to bats are varied, with different species having different habitat requirements. Some key habitats include woodland, scrub and shrub habitats, watercourses and riparian habitats, grasslands and pasture habitats and

hedgerows. Linear features such as hedgerows, tree lines and watercourses also provide important commuting habitat for bats, with many species reliant on linear connectivity to link roost sites and foraging habitats.

- 1.3.4 Three species, out of the assemblage of species known to be present in the vicinity of the Proposed Development, are more heavily protected. These are Bechstein's bat *Myotis bechsteinii*, barbastelle *Barbastella barbastellus* and greater horseshoe bat *Rhinolophus ferrumequinum*, all of which are listed under Annex II of the Conservation of Habitats and Species Regulations 2017 (as amended) [1] (see section 1.4).
- 1.3.5 Barbastelle are widely distributed through southern and central England, albeit they are uncommon and occur in low numbers [2]. This species prefers to roost under loose bark in well-established broadleaved woodland with large numbers of veteran and dead trees and they forage throughout woodland and riparian habitats with a diverse structure. They can commute up to 20km to their foraging grounds with their CSZ, considered to be 6km radius [3]. However, for this report, the weighted average of 6.47km [4] has been rounded up to 7km for a more robust baseline assessment of barbastelle populations.
- 1.3.6 Bechstein's bat are uncommon and have been recorded sparsely throughout southern England [5]. The Bechstein's bat is a woodland specialist that is strongly associated with ancient, old-growth, broadleaved woodland, preferring to roost in areas with continuous, closed canopy and a high density of natural tree cavities [5]. Their optimal foraging habitat is also in ancient semi-natural broadleaved woodland and near watercourses [5]; they do not travel very far to their foraging grounds, with their CSZ estimated at 3km radius [3].
- 1.3.7 Greater horseshoe bats occur rarely within southern England with a small number of records of individual bats. Preferred foraging habitats include ancient semi-natural woodland and cattle grazed pastures. They tend to forage on the boundaries of grazed pastures and woodland, tree lines and thick hedgerows [2]. They do not travel very far to their foraging grounds with their CSZ estimated at 3km radius [2].

1.4 Legal context

- 1.4.1 Bats are classified under the Habitats Directive (Council Directive 92/43/EEC) as a species requiring strict protection in Europe. In the UK, this is enacted by the Conservation of Habitats and Species Regulations 2017 (as amended) [1] where all species of bat are afforded protection under Schedule 2. Regulation 43 of the Habitats and Species Regulations makes it an offence to:
1. deliberately capture, injure or kill a bat.
 2. 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).
 3. damage or destroy a breeding site or resting place of a bat.

4. 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.
- 1.4.2 Annex II of the Habitats Directive lists species designated as “European protected species” and lists species of Community Interest; the conservation of which may require the designation of Special Areas of Conservation (SAC). These Annex II bat species are:
1. Barbastelle
 2. Bechstein’s bat
 3. Greater horseshoe bat
 4. Lesser horseshoe bat *Rhinolophus hipposideros*
- 1.4.3 Bats are fully protected under Schedule 5 of the Wildlife and Countryside Act 1981 (as amended) [6]. For all bat species, this is in respect of section 9(4)(b) and (c) and (5) only, which makes it an offence to:
1. Intentionally or recklessly disturb these species while occupying a structure or place of shelter used for that purpose.
 2. Obstruct access to any structure or place which these species use for shelter or protection.
 3. Sell these species or offer or expose for sale or transport for sale.
 4. Publish or cause to be published any advertisement which conveys the buying or selling of these species.
- 1.4.4 The Natural Environment and Rural Communities (NERC) Act 2006 [7] places a duty to conserve and enhance biodiversity on public authorities in England. This requires a public authority (including the Secretary of State) that has functions exercisable in relation to England to consider what action it can properly take to further the general biodiversity objective, namely the conservation and enhancement of biodiversity through the exercise of its functions. The Act also places a duty on the Secretary of State to maintain lists of species (Section 41 species) which are regarded as being of principal importance for both the conservation and enhancement of biodiversity in England. This list includes seven bat species:
1. Barbastelle
 2. Bechstein’s bat
 3. Brown long-eared *Plecotus auritus*
 4. Greater horseshoe bat
 5. Lesser horseshoe bat
 6. Noctule *Nyctalus noctula*
 7. Soprano pipistrelle *Pipistrellus pygmaeus*.
- 1.4.5 Any operations that may impact upon bats or their places of rest or shelter may require a European Protected Species (EPS) mitigation licence obtained from Natural England (NE).
- 1.4.6 A survey licence is required for intrusive surveys where bats are at risk of disturbance or being directly impacted, such as inspecting by endoscope or

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entering known roosts. A licence is not required to conduct non-invasive surveys such as emergence surveys or NBWs.

2 Methodology

2.1 Background

- 2.1.1 This section describes the field survey methodology used to establish the ecological baseline for bats; it has been designed to identify the distribution of bats within the field survey area including roosting, foraging and commuting habitat.
- 2.1.2 The purpose of these bat surveys is to facilitate the application of the mitigation hierarchy in the design and assessment process to avoid, where possible, potential likely significant effects to bat species. This would ensure that any populations with the potential to be affected by the Proposed Development would be maintained at a favourable conservation status.

2.2 Survey guidance

- 2.2.1 The following survey guidance has been considered in the methodology design:
1. Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Freshwater, Coastal and Marine version 1.1 [8]
 2. The Bat Conservation Trust: Bat Surveys for Professional Ecologists: Good Practice Guidelines, 4th edition [3]
 3. Bat Tree Habitat Key [9]
 4. A Study of Bat Roosts in Yew Trees [10]
 5. Bat Conservation Trust: Thermal Imaging: Bat Survey Guidelines [11]
 6. Chartered Institute of Ecology and Environmental Management (CIEEM): UK Bat Mitigation Guidelines: a guide to impact assessment, mitigation and compensation for developments affecting bats [12]

2.3 Zone of influence

- 2.3.1 The geographical scope of the assessment has been informed by:
1. The Order Limits which include temporary land take for the construction of the pipeline, temporary construction compounds, as shown on ES Figure 1.1 Location of the Proposed Development and Order Limits, Volume III (Document reference 6.3, DCO Volume 6), access routes and lay down sites, as well as areas of permanent above-ground infrastructure where there would be permanent land take.
 2. The likely effects of the Proposed Development on ecological features within the 'zone of influence' (Zol).
- 2.3.2 The Zol is the area over which ecological features may receive impacts from a development. It covers the Order Limits and the wider landscape where pathways (ecological or hydrological links) exist for the transfer of impacts away from the works area. The Zol for each ecological feature varies in size depending on the nature of the effects and the sensitivity of the ecological features to those effects.
- 2.3.3 The Zol has been determined by:

1. Consideration of the activities during construction and operation associated with the Proposed Development.
2. The scale, duration and timing of the works.
3. Ecological data, including aerial photography and Ordnance Survey (OS) mapping, biological records of protected and notable species and baseline data collected from field survey.

2.3.4 Based on the scale and duration of the Proposed Development it is considered that construction activities within the Order Limits would typically produce temporary and localised impacts.

2.3.5 The Zol, desk study area and field survey area for bats are detailed in Table 2-1.

Table 2-1 Zol, desk study area and field survey area for bats

Ecological Feature	Zol	Desk study area	Field survey area
Bats	Order Limits plus 7km	Bat local records – Order Limits plus 7km Statutory designated sites - Order Limits plus 10km	Order Limits plus up to 800m

2.3.6 The desk study area provides contextual information on the presence of bats within the surrounding landscape and informs the impact assessment for bats. The Zol and desk study area for bat local records was driven by the largest weighted average of the CSZ of bat species likely to be present within the region (barbastelle) [4]. While the BCT good practice guidance refers to a 6km CSZ for barbastelle, it also states that “*conservation should protect and enhance [barbastelle] foraging habitats within a 6.5km CSZ*”. As such, a 7km desk study area is considered appropriate. Additionally, the desk study area was extended to 10km for statutory designated sites which have been designated for bats.

2.3.7 The 7km Zol has been used for HSM which ensures that NEs Definition of Favourable Conservation Status for barbastelle [2] is adhered to for factors relating specifically to barbastelle. Favourable conservation status is the minimum threshold at which NE can be confident that a species is thriving in England and is expected to continue to thrive sustainably in the future. This includes three conservation status parameters: natural range; population; and, the extent and quality of habitat supporting the species population.

2.3.8 The field survey area covers those areas in which works associated with the Proposed Development may result in contravention of legislation protecting bats; therefore, a 10m buffer for the assessment of roosts is considered proportionate for the Proposed Development, given disturbance impacts beyond 10m are unlikely to be significant for temporary and permanent works following good practice precautionary working methods.

2.3.9 For earlier surveys in 2022, the static detector surveys were deployed based on a previous iteration of the Order Limits which broadly equates to an 800m buffer of the Order Limits in certain places.

2.3.10 The field survey area was split into the Bat Direct Impact Zone (BDIZ), which refers to the areas within the Order Limits that are not subject to trenchless techniques,

and the Bat Indirect Impact Zone (BIIZ), which refers to a 10m buffer from the BDIZ extent within which temporary or permanent disturbance impacts may occur. Therefore, areas of tunnelling and the Eastney LSO pipeline are not including in the BDIZ or the BIIZ.

- 2.3.11 The Proposed Development includes the use of Havant Thicket Reservoir for the storage of recycled water, the use of the Eastney LSO, Eastney PS, and associated Eastney TT for the release of reject water from the WRP site. The Proposed Development also uses pipelines that have been consented and are to be constructed separately by Portsmouth Water between Bedhampton Springs and Havant Thicket Reservoir. These components are considered as part of the future baseline and are, therefore, considered to be existing infrastructure. As such, the terrestrial and freshwater biodiversity assessment only considers the operational change of use.

2.4 Desk study

Data search

- 2.4.1 Records of bats, including roosts and individual records, were obtained from Hampshire Biological Record Information Centre (HBIC), East Hampshire District Council (EHDC), Havant Borough Council (HBC) and Sussex Biodiversity Records Centre (SBRC) covered the area within the 7km Zol of the Proposed Development. Records were obtained between July 2024 and December 2024 for records between 2014 and 2024.
- 2.4.2 The Multi-Agency Geographic Information for the Countryside (MAGIC) website was reviewed to identify the locations of any EPS mitigation licences with respect to bats within the desk study area.

Desk-based scoping

- 2.4.3 The field survey scoping process has been designed to focus survey effort on features that were most likely to be subject to potential impacts from the Proposed Development and to provide information for the HSM (detailed in section 2.6).
- 2.4.4 Aerial imagery, Light Detection and Ranging (LiDAR) surveys and habitat survey information, where available (e.g. habitat maps provided by HBIC and SBRC and the results of habitat surveys undertaken for the Proposed Development), were used to identify habitat features with potential to be used by roosting bats within the Proposed Development footprint and 10m buffer.
- 2.4.5 Any land where a building or built structure (hereafter all referred to as a 'structure') or tree is present was scoped in for ground-truthing surveys. In instances where this was unclear and presence could not be confirmed via aerial imagery, a precautionary approach was taken and the land scoped in.
- 2.4.6 Once a list of structures and trees was obtained, locations where precautionary working methods could be reliably implemented was agreed, and additional survey was not required at these locations.
- 2.4.7 Ground-based roost assessments were subsequently completed for structures and trees within the field survey area to identify the presence or likely absence of roosting bats and inform any licensing or mitigation requirements.

2.5 Field survey

Preliminary roost assessment

- 2.5.1 A PRA was completed of structures within the field survey area to assess their potential to support roosting bats between July 2024 and September 2024, and January 2026. The categorisation of suitability to support roosting bats was completed in line with good practice guidance [3].
- 2.5.2 All PRAs were conducted using a high-powered torch, a head torch, close focusing binoculars, a camera and endoscope (where required by the survey) to identify and grade features suitable to support roosting bats. This involved looking for potential roost features (PRF), such as wall cavities, raised or missing tiles or damaged soffit boxes, and any signs of bats, such as droppings, staining and feeding remains.
- 2.5.3 The bat roost suitability of structures was assessed in line with good practice guidance as described in Table 2-2, with hibernation sites assessed as low (no/very limited hibernation suitability), moderate (for a non-classic site) and high (for a classic site) suitability as per good practice guidance [3].

Table 2-2 Guidelines for assessing potential roosting suitability of structures and trees.

Potential Roosting Suitability	Description of roosting habitat
None	No habitat features on site likely to be used by any roosting bats at any time of the year (i.e. a complete absence of crevices or suitable shelter at all ground or underground levels).
Negligible	No obvious habitat features on site likely to be used by roosting bats; however, a small element of uncertainty remains as bats can use small and apparently unsuitable features on occasion.
Low	A structure with one or more potential roost sites that could be used by individual bats opportunistically at any time of the year. However, these potential roost sites do not provide enough space, shelter, protection, appropriate conditions, and/or suitable surrounding habitat to be used on a regular basis by larger numbers of bats (i.e. unlikely to be suitable for maternity and not a classic cool or stable hibernation site but could be used by individual hibernating bats).
Moderate	A structure with one or more potential roost sites that could be used by bats due to their size, shelter, protection, conditions, and surrounding habitat but are unlikely to support a roost of high conservation status (with respect to roost type only, such as maternity and hibernation – the categorisation described in this table is made irrespective of species conservation status, which is established after presence is confirmed).
High	A structure with one or more potential roost sites that are obviously suitable for use by larger numbers of bats on a more regular basis and potentially for longer periods of time due to their size, shelter, protection, conditions and surrounding habitat. These structures have the potential to support high conservation status roost, e.g. maternity or classic cool and stable hibernation sites.

Source: Collins [3]

Ground level tree assessments

2.5.4 Following a range of preliminary assessments in 2022, which were eventually superseded, a team of two surveyors conducted the GLTAs between April and September 2024. Surveyors used high powered torches and binoculars to assist with identifying and grading any features suitable to support roosting bats. Trees were graded according to Table 2-3.

Table 2-3 Tree bat roost suitability categories

Suitability	Description of roosting categories
NONE	Either no potential roosting features in the tree or highly unlikely to be any.
FAR	Further Assessment Required to establish if PRFs are present.
PRF	A tree with at least one potential roosting feature.

Source: Collins [3]

2.5.5 Where features could be fully inspected from ground-level, by torch or endoscope inspection, they were graded according to Table 2-4, stating whether they were also a confirmed bat roost where bats or evidence of bats was recorded.

Table 2-4 Guidelines for categorising the potential suitability of potential roost features.

Suitability	Description of roosting habitat
PRF-I	A potential roosting feature that is only suitable for individual or very small numbers of bats either due to size or lack of suitable surrounding habitats.
PRF-M	A potential roosting feature that is suitable for multiple bats and may therefore be used by a maternity colony.

Source: Collins [3]

Aerial tree-climbing inspections

2.5.6 All trees identified as FAR or PRF during the GLTA were subject to aerial tree-climbing surveys to inspect the entirety of features present, where possible, in accordance with good practice guidance [3].

2.5.7 The aerial tree-climbing inspections were used to update the GLTA results and record additional characteristics of each feature, including approximate internal cavity dimensions. The initial PRF classifications were then reviewed and reclassifications made, where necessary.

2.5.8 Any additional PRFs observed during the tree climbing inspections that were not already identified from the GLTA, were recorded and inspected and then included in additional survey work, as appropriate.

2.5.9 Trees where close inspection revealed they did not contain any features identified as PRF-M were removed from the scope for additional assessment and their classification updated accordingly.

2.5.10 Trees identified as having PRF-M suitability during an initial tree-climbing inspection were subject to two additional tree-climbing inspections in line with good practice guidance [3] for the assessment of the presence or likely absence of

roosting bats (a total of three inspections between May to September, with at least two surveys between May and August).

- 2.5.11 Where it was not possible to fully inspect all features on a tree during an aerial inspection, or if a tree was unsafe to climb, dusk emergence surveys were carried out.

Dusk emergence surveys

- 2.5.12 The scope for dusk emergence surveys was to obtain baseline survey data for trees that could not otherwise be fully assessed. This included trees that were unsafe to climb. Emergence surveys of trees were conducted between July and September 2024. No emergence surveys were conducted on structures.
- 2.5.13 Trees with features rated as PRF which could not be climbed, were subject to a single emergence survey. These surveys consisted of at least two surveyors positioned around the tree so that all PRFs could be clearly observed for any bats emerging from, or returning to, the feature. The Night Vision Aids consisted of Canon XA65 cameras with infra-red (IR) capabilities and additional IR torches and were used to record any emergences to assist with emergence observations in low light areas.
- 2.5.14 If roosting bats were recorded during the emergence survey, a second emergence survey was carried out a minimum of three weeks after the first survey. During the emergence surveys each surveyor was equipped with a full spectrum Elekon Batlogger M detector.

Hibernation surveys

- 2.5.15 No hibernation surveys were conducted on structures or trees; there were no structures with hibernation suitability identified within the field survey area, and the assessment assumes all trees with PRF-M suitability have hibernation suitability.

Bat activity surveys

Static detector surveys

- 2.5.16 Anabat Swift automated static bat detectors were placed in suitable habitat for a minimum of five consecutive nights at 26 locations in July and August 2022 to provide data on bat activity within and close to the Order Limits in accordance with survey guidelines [3]. The locations of the static detectors are shown in ES Figure 8.20 Static detector survey locations, Volume III (Document reference 6.3, DCO Volume 6) and details of the surveys provided in Table D-1 in Annex D.
- 2.5.17 One Anabat Swift automated static bat detector was deployed during each NBW between June and September 2024 and left to record for five consecutive nights as per good practice guidance [3]. The locations of the static detectors are shown in ES Figure 8.19 Nighttime bat walkover results, Volume III (Document reference 6.3, DCO Volume 6)] and details of the surveys provided in Table D-1 in Annex D.

Nighttime bat walkovers

- 2.5.18 Two NBWs were completed at three locations across the Proposed Development in 2024, focusing on areas with the potential for significant impacts from the

presence of permanent infrastructure, such as at the WRP site, or due to the potential to cause severance to known Annex II populations (based on the data search), such as at Otterbourne and Wickham Golf Course.

2.5.19 These surveys provided supplementary information for the HSM modelling and were conducted between May and September 2024; details are provided in Table C-1 in Annex C.

Sonogram analysis

2.5.20 For static detector data and emergence survey data, sound files (WAV format) from the Anabat Swift static detectors were processed using the British Trust for Ornithology (BTO) Acoustic Pipeline software [13]

2.5.21 The BTO Acoustic Pipeline auto-identification software assigned a species label to each recorded file. All files from all bat species in each location were manually checked and verified, except for common pipistrelle *Pipistrellus pipistrellus* and soprano pipistrelle, both of which are confidently identified in auto-identification software. Manual verification of species identification was completed using the techniques and resources set out in Acoustic Ecology of European Bats Species Identification, Study of their Habitat and Foraging Behaviour [14], which included checks to 10% of common pipistrelle and soprano pipistrelle outputs and checks to files auto-identified as ‘Noise’; at least 10% of ‘Noise’ and ‘Speckled bush-cricket’ outputs were manually checked.

Surveyor competencies/qualifications

2.5.22 Table 2-5 details the competencies and qualifications required by the surveyors for each survey type.

Table 2-5 Surveyor competencies/qualifications

Survey Type	Competencies/Qualifications
All surveys	All surveyors were led by a competent and appropriately experienced member of CIEEM [15]
PRA	Building inspections were led by an experienced ecologist who holds at least a Level 1 NE survey licence for bats, or by an experienced ecologist accredited to work under their mentor’s NE bat survey licence. Any surveyors using an endoscope to inspect PRAs held at least a Level 2 NE survey licence for bats.
GLTA	Ground-level tree assessments GLTA were completed of trees by a team of two surveyors led by a competent ecologist, experienced in the survey and grading of a PRF.
Aerial tree-climbing Inspections	Aerial tree-climbing surveys were undertaken by two experienced surveyors both holding a City & Guilds CS38 Tree Climbing and Aerial Rescue qualification and led by a Level 2 bat licensed surveyor (or accredited under a Level 2 bat licence).
Emergence surveys/NBW/static automated detector surveys	Surveys were completed by teams of at least two surveyors, led by a competent and appropriately experienced ecologist.

2.6 Habitat suitability modelling

- 2.6.1 Habitat suitability modelling enables species' distributions to be predicted over large areas, and thus, where bat species are likely to cross the Proposed Development; gathering a baseline on how bats move through the landscape will inform the final mitigation measures required for the Proposed Development, by identifying KCLs within the footprint of the Proposed Development. HSM is a statistical technique that predicts the distribution of a species from environmental data and species' presence data. Key Connective Locations (KCLs) represent linear features such as hedgerows, lines of trees and watercourses which contribute to the predicted movement of bat species between areas of suitable habitat in the landscape.
- 2.6.2 The modelling was conducted using Circuitscape, which is predictive software that uses electrical circuit theory to represent the landscape as a resistance surface through which a given species can move according to resistivity values posed by landscape features. Resistivity values are based on a bat species' preference to commute through, forage or roost within a particular habitat; a greater preference for a particular habitat is indicated by a lower resistivity value, for example.
- 2.6.3 This technique was used to identify pathways of connectivity within and around the Proposed Development at a landscape scale and also areas where bats are less likely to be present, for example, in more unsuitable habitat. The model outputs allow the identification of important locations within the Proposed Development. These could be areas where movement is funnelled, where connectivity is reduced to a single feature in the landscape, like a treeline or river corridor passing through an area of generally unsuitable habitat such as urban development, and thus keeping it intact may be particularly important for foraging and commuting bats.
- 2.6.4 For all UK bat species, presence data from static detector sampling and biological records provided in the data search formed the basis of the model outputs.

Static detector surveys for habitat suitability modelling

Sampling locations

- 2.6.5 Static detector locations were chosen using statistical tests to measure the similarity of a set of sampled points to the wider landscape. A Python script was created to generate 40 static detector locations.
- 2.6.6 Land cover data obtained from UK Centre for Ecology & Hydrology (UKCEH) in 2024 was used to ensure a variety of habitats were included in the static detector surveys. The static detector locations are shown in ES Figure 8.21, Static detector locations for habitat suitability modelling, Volume III (Document reference 6.3, DCO Volume 6).

Static detector deployment

- 2.6.7 Full spectrum Anabat Swift static detectors were used to record bat activity at the static detector locations. These surveys were designed to identify the presence of bat species rather than abundance. Static detectors were placed between September and October 2023 and between May and August 2024 (see Table D-2 for details of static detector deployments).

- 2.6.8 Static detectors were left in-situ for at least ten nights but may have been left for longer than this depending on when access was available for collection. Microphones were placed at least one metre above the ground where possible using a cane or nearby vegetation.
- 2.6.9 Research shows that ten consecutive nights of static monitoring surveys in suitable weather conditions is sufficient to give confidence that the survey would confirm the presence all UK bat species resident in the survey area [16].
- 2.6.10 Although the time required to identify the presence of serotine *Eptesicus serotinus* and Leisler's *Nyctalus leisleri* bat is unknown, it is assumed that they would be relatively close to the three nights required for noctule. This assumption is based on their known core sustenance zones [4], rarity, call amplitude and flight behaviour [17].
- 2.6.11 Upon collection the data was analysed as described in paragraphs 2.5.20 to 2.5.21 to confirm the presence of bat species or species groups recorded.
- 2.6.12 Weather information was collected from the Met Office Weather Observation website [18]. Data included temperature, wind speed and rainfall rate. Weather considered suitable is based on criteria from Mathews *et al.* [16]:
1. Temperature is 10°C or above at sunset.
 2. Average wind speed 8m per second or below.
 3. Average rainfall rate below 2.5mm per hour.
- 2.6.13 All static detector locations met the minimum weather criteria for at least ten nights.

Bat species guilds

- 2.6.14 Many bat species have similar hunting behaviour and flight characteristics because they occupy similar ecological niches. These similarities mean that the risks and mitigation required for species with similar ecological niches are broadly the same. To facilitate effective consideration of trends in landscape use by different bat species, bat species were split into three traditionally recognised guilds: open habitat species, edge habitat species and cluttered habitat species [17].
- 2.6.15 Guilds were assigned based on their flight speed and height, willingness to cross gaps and tolerance of lighting. The species guilds effectively follow those given in the Conference of European Directors of Roads bat mitigation measures on roads guidelines [17]. The list of species considered likely to be present within the 7km ZoI are grouped by their flight characteristics in Table 2-6.
- 2.6.16 The HSM outputs are discussed in terms of a bat species' guild due to their likely similar interaction with the Proposed Development.

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Table 2-6 Bat groups and key similar characteristics

Ecological niche	Genus	Species	Flight speed	Willingness to cross gaps and open habitat	Flight height	Light tolerance
Cluttered habitat	<i>Myotis</i>	Natterer's bat	Slow	Least willing to cross gaps and open ground.	Generally fly close to linear features, when crossing open habitat will usually fly close to the ground.	Least tolerant of light. Artificial lighting may present a barrier to these species.
		Daubenton's bat				
		Whiskered bat				
		Brandt's bat				
		Bechstein's bat				
	<i>Plecotus</i>	Brown long-eared bat				
		Grey long-eared bat				
<i>Rhinolophus</i>	Greater horseshoe					
Edge habitat	<i>Pipistrellus</i>	Common pipistrelle	Medium	Less affected by small and medium sized gaps.	Tend to fly within 10m of the ground or linear features.	Mixed – some species such as pipistrelles will hunt insects drawn to lights, other edge habitat species such as barbastelle are likely to avoid lighting.
		Soprano pipistrelle				
		Nathusius' pipistrelle				
	<i>Barbastella</i>	Barbastelle				
	<i>Eptesicus</i>	Serotine				
Open habitat	<i>Nyctalus</i>	Noctule	Fast	Least affected by open habitat and gaps in connectivity.	Usually fly high 10m + above open habitat.	Light tolerant, will often predate insects drawn to lights.
		Leisler's bat				

Source: Elmeros et al. [17]

Modelling

- 2.6.17 This section summarises the key components of the Circuitscape data preparation and analysis process. The detailed methodology is provided in Annex E.
- 2.6.18 HSM was conducted using Circuitscape, software which applies connectivity models from circuit theory to mathematical graphs [19]. Circuitscape requires two key inputs: species presence data (biological records and static monitoring data) and environmental variables (land cover, hedgerows, water courses and light pollution).
- 2.6.19 Prior to processing, a resistance layer is created using the resistivity values assigned to each bat species for each environmental variable, dependent on the species' association with a particular environmental variable. For example, for light pollution, a low resistivity value is assigned to a species that is less sensitive to lighting.
- 2.6.20 The analysis was conducted on 11 species or groups of species found to be present within the Zol.
- 2.6.21 Brown long-eared bats and grey long-eared bats were grouped as long-eared bats due to the difficulty of separating the species purely from sonograms. While grey long-eared are known to be present along the south coast, there are no records within the 7km Zol; the closest record is approximately 10km east of the Proposed Development.
- 2.6.22 Alcatheo *Myotis alcathoe*, Brandt's *Myotis brandtii*, Daubenton's *Myotis daubentonii*, Natterer's *Myotis nattereri* and whiskered bats *Myotis mystacinus* were grouped together due to the difficulty of separating the species purely from sonograms. With similarities in habitat preferences, the grouping is not a limitation to assessing and identifying KCLs across the Proposed Development.
- 2.6.23 As an Annex II species, Bechstein's bat was assessed separately in order to identify any difference in movements from other *Myotis* spp., around the landscape based on their known presence. The sample size was large enough for HSM to be used.
- 2.6.24 Barbastelle, common pipistrelle, Leisler's bat, Nathusius' pipistrelle *Pipistrellus nathusii*, noctule, serotine and soprano pipistrelle were all modelled separately.

Environmental variables

- 2.6.25 Based on current literature, expert opinion and previous studies on the movement and dispersal ability of bat species [3], 24 environmental variables were selected and ranked based on their association with bats. The environmental variables were grouped into four datasets: land cover, hedgerows, inland water and light pollution, and combined to provide the final output. The data sources for each environmental variable are provided in Table E-1 in Annex E. A 50m resolution was used for each environmental variable.
- 2.6.26 For a given species, resistivity values were assigned for each land cover type. These values were assigned between 1-100, based on the habitats known to be commonly used by each bat species for foraging, commuting and roosting preferences. A resistivity value of 1 reflected a highly suitable habitat and a

resistivity value of 100 reflected a highly unsuitable habitat. Resistivity values were assigned based on academic literature provided in the BCT guidelines [3], the Favourable Conservation Status guidance from NE [2, 5] and guidelines for bat mitigation on roads [17].

- 2.6.27 For inland water and hedgerows, each 50m grid square within the Zol was assigned a value between 0 and 1 if it intersects with an inland water or hedgerow feature; the value was based on a species' preference for using these features [3]. Otherwise, it was assigned a value of 1. Weightings close to 0 indicate preferred habitat and vice versa.
- 2.6.28 Light pollution values were first normalised (assigned a value between 0.01 and 1 with the former corresponding to the lowest light pollution value and the latter the highest) and then multiplied by a species-specific weighting, reflecting the sensitivity of each species to this variable [17].
- 2.6.29 The four variable values for each 50m resolution grid square within the Zol were then multiplied together resulting in a final dataset of resistance for each species or species' group. These composite datasets were then normalised between 1 and 100, for ease of interpretation.

Species' presence locations

- 2.6.30 A single species' presence dataset was created by combining data from static detector surveys and from local records data, in order to be processed in the Circuitscape software. Presence locations will hereafter refer to locations where a species has been recorded as present.

Model parameters

- 2.6.31 Models were produced using Circuitscape version 5. The pairwise modelling mode was used and the habitat suitability inputs were framed in terms of resistance, rather than conductance; the default mode of Circuitscape.

Outputs and interpretation of habitat suitability modelling

- 2.6.32 The final model for each species was a single cumulative current map; an electrical resistance map which uses a green-yellow-red colour scheme for the purpose of visualising high resistance areas (displayed as green) down to low resistance areas (displayed as red).
- 2.6.33 The outputs show areas of high and low connectivity by displaying the potential movement of bats throughout the landscape, highlighting where bats are more likely to use higher suitability habitat, i.e. areas of least resistance.
- 2.6.34 The extents and locations where high connectivity was observed were then used to identify KCLs crossed by the Proposed Development.

2.7 Deviations, Limitations and Assumptions

Desk study

- 2.7.1 An absence of desk study records for a species does not necessarily indicate a lack of species' presence; the area may simply be under-recorded. While important

roosts which are used regularly and have been used for a long time have a reasonable likelihood of being recorded (typically buildings or dwellings) this is less likely for those which are used infrequently and for short durations (typically includes tree roosts).

- 2.7.2 Desk study records were often provided with a low precision, often to 1km grid square. Where this is the case, the roost was mapped at the grid reference provided but the roost location could be anywhere within that 1km grid square. In the case of records with a six-figure grid reference (e.g. SU604260), the roost location could be anywhere within that 100m grid square.

Preliminary roost assessments

- 2.7.3 There were five structures which were not surveyed due to a lack of access. This is not a significant limitation as the assessment and any mitigation required will be based on a worst case scenario. Pre-construction surveys will update the baseline and mitigation appropriate to those updates implemented.

Ground level tree assessments and aerial tree-climbing inspections

- 2.7.4 Preliminary surveys were conducted in 2022 and 2023; these have been included in the results of this report where 2024 bat surveys could not be conducted because of access limitations. Furthermore, due to later design changes, new trees were added to the BDIZ and BIIZ that were unable to be surveyed due to time limitations.

- 2.7.5 Some potential roost features (PRFs) in trees, such as flaking bark, are often delicate and even the most robust are a sign of damage or decay. These PRFs therefore, by their nature, are ephemeral. Perhaps because of this, it is known that most tree roosts are not occupied by bats all of the time [9]. In addition, signs of bats such as droppings degrade much quicker in a natural, humid environment like a tree cavity than they would in a building roost. It is possible that despite conducting surveys in line with good practice guidance tree roosts may be missed because they are not occupied at the time of survey and signs of bats are absent. This is not a significant limitation as the assessment and any mitigation required will be based on a worst case scenario. Pre-construction surveys will update the baseline and mitigation appropriate to those updates implemented.

- 2.7.6 Due to limited time constraints based on access limitations, priority was given to trees within the BDIZ, as these are more likely to be impacted by the Proposed Development, and more specifically, trees identified as PRF-M during GLTAs were also prioritised for aerial tree-climbing inspections.

- 2.7.7 A number of areas could not be accessed due to landowner refusal; therefore, bat surveys could not be conducted. This is not a significant limitation as the assessment and any mitigation required will be based on a worst case scenario. Pre-construction surveys will update the baseline and mitigation appropriate to those updates implemented.

- 2.7.8 Further assessments of 118 trees with FAR, PRF, PRF-I, or PRF-M bat roosting suitability (as defined in Table 2-3 and Table 2-4) were unable to be completed due to access issues. These comprised 54 trees with FAR suitability, 44 with PRF suitability, 17 with PRF-I suitability and five with PRF-M suitability. In addition, after

the design change, 158 trees were brought into the BDIZ and BIIZ that were not surveyed. This comprises of 15% of the total trees present. Any gaps in survey data have been accounted for by adopting a precautionary approach to the bat assemblage, therefore, the baseline is considered to be reliable and representative of a worst case scenario.

Dusk emergence surveys

- 2.7.9 The emergence survey scope was reduced below that of the recommended good practice guidelines, with trees identified as PRF subject to one emergence survey; due to access constraints, survey coverage was prioritised over repeat surveys. This is not a significant limitation as the assessment and any mitigation required will be based on a worst case scenario. Pre-construction surveys will update the baseline and mitigation appropriate to those updates implemented.
- 2.7.10 Emergence surveys were not conducted on structures identified as suitable for roosting bats; This is not a significant limitation as pre-construction surveys will update the baseline and mitigation appropriate to those updates implemented.

Static detector surveys

- 2.7.11 During the 2022 static detector survey, three static detectors failed to record for the full five nights due to technical failures. Two statics (locations 22 and 24) recorded for four nights and one static (location 26) recorded for one night. This is not considered to be a significant limitation as the data was primarily collected for HSM. The 2022 static detector data is considered invalid, and data used for HSM was updated in 2024; therefore, while the 2022 static detector data gives additional information on bat activity along the Order Limits, there is not a significant limitation with the technical failures. However, it should be considered when reviewing the results of bat activity levels.
- 2.7.12 Due to change in the Order Limits, the majority of the 2022 detector locations are outside of the BDIZ or BIIZ. This is not considered to be a significant limitation as the data collected from these locations provide additional data for HSM which identified potential key pathways of all bat species which cross the Order Limits.

Bat sonogram analysis

- 2.7.13 Species identification by sonogram is limited (to a certain extent) by similarities in call structure. In addition, all bats can modulate their calls according to the habitats they are navigating, their behaviour and the information they require at the time. This imposes limitations on reliable analysis of all calls particularly between species of the same genus in the genera *Plecotus*, *Myotis* and *Nyctalus*.
- 2.7.14 Where a call was not sufficiently characteristic to verify a bat to species level, then species were grouped as *Myotis* spp. and *Plecotus* spp. in the results. While this is not a significant limitation for *Plecotus* spp., being unable to distinguish Bechstein's bat calls from other *Myotis* spp. has implications on the mitigation requirements for this species. This limitation has been addressed by using desk study data records of Bechstein's bats identified through advanced licensed bat survey techniques (ALBST) for the purpose of HSM.

Habitat suitability modelling

- 2.7.15 Only 36 of the 40 static detector locations generated by HSM were deployed due to access limitations at four locations. This is not a significant limitation as the data was combined with local species records to provide additional species' presence records in the HSM outputs.
- 2.7.16 For Bechstein's bat presence, results of static detector surveys could not be used due to the difficulty in separating *Myotis* spp. to species level using their bat sonograms. To allow for a Bechstein's bat HSM output, desk study data records of this species identified through ALBST and confirmed roosts were collated from a variety of sources (HBIC, SBRC, EHDC and HBC as well as planning applications) and used in the modelling.
- 2.7.17 The datasets used for land cover could not specify the land use for improved grassland, which means the HSM output is limited such that serotine preferences for cattle-grazed pasture could not be modelled. This is not a significant limitation as improved grassland was included in the dataset, which would include cattle-grazed grassland.
- 2.7.18 Greater horseshoe bat was included in the HSM. However, due to the low numbers provided by the desk study (five records at four locations) the processing capacity for HSM is limited. The HSM outputs for all other bat species are likely to provide enough information about how bats move through the landscape; it is considered reasonable to assume greater horseshoe bats would use similar KCLs shown in the HSM outputs for all other bat species, as part of the cluttered habitat species guild. This is also representative of greater horseshoe bat's expected range, i.e. primarily in the south-west.

3 Results

3.1 Desk study

Data search

Designated sites

- 3.1.1 There are no SAC designated for bats within the 10km desk study area. However, Singleton and Cocking Tunnels SAC is located 15.2km north-east of the Order Limits and supports barbastelle and Bechstein's bat. The Draft Sussex Bat SAC Planning and Landscape Enhancement Protocol [20] cites a 12km buffer referred to as a wider conservation area for Singleton and Cocking Tunnels SAC. Although the Proposed Development is outside of the wider conservation area, there is overlap with the ZoI. Despite limited data to support this, it is deemed highly likely to be functionally linked with the Sussex Bat SACs, including Singleton and Cocking Tunnels SAC [21].
- 3.1.2 The Proposed Development (Section D: The Water Recycling Plant site to Portsdown Hill) is also partially located within the Havant Bat Protocol area, specifically for Bechstein's bat.

Species records

- 3.1.3 The desk study returned 11,798 records for at least 16 species of bat within 7km of the Order Limits, containing records for:
1. Alcahloe bat
 2. Barbastelle
 3. Bechstein's bat
 4. Brandt's bat
 5. Brown long-eared bat
 6. Common pipistrelle
 7. Daubenton's bat
 8. Greater horseshoe bat
 9. Leisler's bat
 10. Nathusius' pipistrelle
 11. Natterer's bat
 12. Noctule
 13. Parti-coloured bat *Vespertilio murinus*
 14. Serotine
 15. Soprano pipistrelle
 16. Whiskered bat
- 3.1.4 Records were also returned for unidentified *Myotis*, *Nyctalus*, *Pipistrellus* and *Plecotus* species.

- 3.1.5 A summary of the local records returned from the desk study are given in Table 3-1 and locations displayed in ES Figure 8.15, Bat local record data within the desk study area, Volume III (Document reference 6.3, DCO Volume 6).
- 3.1.6 The majority of these species were recorded within the BDIZ, including recent records of both barbastelle and Bechstein’s bats in Staunton Country Park. The desk study highlighted only two roosts of barbastelle recorded approximately 650m south-west of the Proposed Development – the Pipeline between the WRP site and Otterbourne WSW, Section K: River Hamble to Lower Upham (Section K) – as part of licensed building work. Barbastelle have been recorded sporadically across the length of the Proposed Development.
- 3.1.7 The desk study revealed there were a total of 114 Bechstein’s records located in their CSZ identified in the desk study, with all but one record associated with Staunton Country Park and the Havant Bat Protocol area. There was a single record from mist-netting survey conducted in Fiddler’s Green Wood in 2014, approximately 600m south-west of the Proposed Development – the Pipeline between the WRP site and Otterbourne WSW, Section G: Crockerhill to Wickham (Section G).
- 3.1.8 Five records of greater horseshoe bat were identified, the closest of which was located approximately 570m east of the BDIZ, near the Pipeline between the WRP site and Otterbourne WSW - the WRP site and the temporary construction compound F-1. These records are close to the easternmost extent of greater horseshoe bats known distribution in the UK.
- 3.1.9 A single record for parti-coloured bat was returned from Purbrook in 2014, approximately 2km north-east of the BDIZ at temporary construction compound E-1, within the Pipeline between the WRP site and Otterbourne WSW, Section D: the WRP site to Portsdown Hill (Section D).
- 3.1.10 The data records obtained from the desk study are summarised in Table 3-1. The table has summarised the records in terms of the BDIZ, which refers to the areas within the Order Limits that are not subject to trenchless techniques.

Table 3-1 Data search results

Species	CSZ [3]	No. of Records	Date of Most Recent Record	Closest Record to the BDIZ
Alcathoe	Unknown	9	2023	1.5km north
Barbastelle	7km*	153	2023	130m north-west
Bechstein’s bat	1km	173	2023	600m south
Brandt’s bat	1km	51	2020	800m north
Brown long-eared bat	3km	431	2023	100m west
Common pipistrelle	2km	4377	2023	Within
Daubenton’s bat	2km	144	2023	250m south
Greater horseshoe bat	3km	5	2022	570m east
Leisler’s bat	3km	91	2023	82m south

Species	CSZ [3]	No. of Records	Date of Most Recent Record	Closest Record to the BDIZ
Nathusius' pipistrelle	3km	246	2023	240m south
Natterer's bat	4km	186	2023	140m west
Noctule	4km	848	2023	Within
Parti-coloured bat	Unknown	1	2014	2km north-east
Serotine	4km	940	2023	40m north
Soprano pipistrelle	3km	2975	2023	Within
Whiskered bat	1km	85	2023	140m north
Whiskered/Brandt's bat	1km	21	2023	1.5km south
Unknown species	Up to 6km	94	2023	300m east
<i>Nyctalus</i> species	Up to 4km	41	2022	82m south
<i>Nyctalus/Eptesicus</i> agg.	Up to 4km	12	2021	646m west
<i>Myotis</i> species	Up to 4km	1014	2023	40m north
Long-eared species	Up to 3km	424	2023	40m north
Pipistrelle species	Up to 3km	217	2023	Within
Vespertilionidae species	Up to 6km	2	2019	5.3km east

*weighted average of 6.5km rounded up [4]

Desk-based scoping

3.1.11 A total of 28 buildings and 429 trees were identified within the field survey area from LiDAR imagery. All trees were ground-truthed due to the inaccuracies of assessing from LiDAR imagery alone. Areas of woodland were also identified within the BDIZ and BIIZ from aerial imagery.

3.2 Field surveys

Preliminary roost assessments

3.2.1 There were 44 structures within the BDIZ subject to a PRA, and of those surveyed, 42 structures were assessed as having no suitability for roosting bats. The locations of the buildings are shown in ES Figure 8.16, Preliminary Roost Assessment (buildings), Volume III (Document reference 6.3, DCO Volume)] and survey details of the structures are provided in Table A-1 (in Annex B).

- 3.2.2 One structure (B647519), a metal prefabricated building, was assessed as having low suitability for roosting bats due to the presence of a gap between the roof and the walls. It was assessed as having no hibernation suitability.
- 3.2.3 A small stables structure (B647538), with wooden cladded sides and metal corrugated roof lined with wooden boarding, was assessed as having high suitability for roosting bats due to the presence of a bat box to the eastern aspect of the structure. It was assessed as having no hibernation suitability.

Ground level tree assessments

- 3.2.4 The results of surveys for which only GLTAs were carried out are shown in Table 3-2. The location of all trees surveyed are provided in ES Figure 8.17, Ground Level Tree Assessment and Aerial Tree-climbing Results, Volume III (Document reference 6.3, DCO Volume 6).
- 3.2.5 These GLTA surveys identified a total of 438 trees with no suitability for roosting bats, 116 trees with FAR suitability for roosting bats, 62 trees with PRF suitability for roosting bats, 205 trees with PRF-I suitability for roosting bats, and 48 trees with PRF-M suitability for roosting bats.

Table 3-2 Summary of GLTA results

Bat roost suitability	Within BDIZ	Within BIIZ
NONE	292	146
FAR	96	20
PRF	45	17
PRF-I	84	121
PRF-M	19	29

Aerial tree-climbing inspections

- 3.2.6 Following the GLTA survey, aerial inspections were carried out on a total of 101 trees that had been identified as potentially suitable for roosting bats. All trees subjected to aerial inspections were located within the Proposed Development of the Pipeline between the WRP site and Otterbourne WSW, and the WRP site. Table 3-3 details the results of the aerial inspection surveys and their locations are provided in ES Figure 8.17, Ground Level Tree Assessment and Aerial Tree-climbing Results, Volume III (Document reference 6.3, DCO Volume 6). The majority of trees subjected to aerial inspection surveys were within the BDIZ; however, nine were within the BIIZ.

Table 3-3 Summary of aerial tree-climbing inspections

Bat roost suitability	Within BDIZ	Within BIIZ
NONE	36	4
FAR	20	5
PRF-I	21	0

Bat roost suitability	Within BDIZ	Within BIIZ
PRF-M	10	5

Dusk emergence surveys

- 3.2.7 A total of ten trees required emergence surveys as they were considered unsafe to climb.
- 3.2.8 There were no bat roosts recorded within the ten trees subject to emergence surveys.

Bat activity surveys

Static detector surveys

- 3.2.9 Throughout the static detector surveys, common pipistrelle, soprano pipistrelle, and *Myotis* spp. were regularly recorded at all 28 locations (locations 1 to 25, WRP site, Wickham Park Golf Course and Otterbourne).
- 3.2.10 Noctule, Leisler’s bat, serotine and long-eared bats were recorded at over 70% of all locations. Noctule was recorded at 26 locations but were not recorded during the autumn period at the Wickham Park Golf Course location. Leisler’s bat was recorded at 20 locations but were not recorded during the autumn period in the Otterbourne location. Serotine was recorded at 24 locations, and long-eared species were recorded at 26 locations.
- 3.2.11 Barbastelle were recorded in lower numbers (less than 50 passes) at eight locations (locations 4, 7, 8, 10, 12, 16, 22 and 24) at the Pipeline between the WRP site and Otterbourne WSW, Section E: Portsdown Hill to Boarhunt (Section E), Section F: Boarhunt to Crockerhill (Section F), Section K: River Hamble to Lower Upham (Section K) and Section L: Lower Upham to Brambridge (Section L). Barbastelle were recorded in higher numbers at location 1 and 2; the Pipeline between the WRP site and Otterbourne WSW, Section M: Brambridge to Otterbourne WSW (Section M). The highest number of total bat passes recorded was at location 2, located within the BDIZ along a hedgerow adjacent to Otterbourne Park Wood. This location also had the highest concentration of barbastelle bats, recording 54% of all barbastelle activity at all locations. All other locations did not record barbastelle.
- 3.2.12 At the WRP site, common pipistrelle were the most recorded species of bat, representing 87.9% of all bat activity recorded at the WRP site. Other species recorded included soprano pipistrelle (maximum 135 passes in summer) noctule (maximum 25 passes in summer) Leisler’s (maximum 23 passes in summer) and *Myotis* species (maximum three passes in spring).
- 3.2.13 At Wickham Park Golf Course, soprano pipistrelle were the most recorded species of bat, representing 44.6% of all bat activity recorded at Wickham Park Golf Club, with common pipistrelle representing 36.4% of all bat activity recorded, and there were substantially more common pipistrelle passes recorded (1029 passes) and a higher number of *Myotis* spp. bat passes (401 passes) in autumn, compared with the summer period (486 passes and 304 passes, respectively). Also, Wickham Golf Course had the highest number of bat passes for soprano pipistrelle in both

periods (914 passes in summer and 943 in autumn) than at the WRP site and Otterbourne.

- 3.2.14 At Otterbourne, common pipistrelle were the most recorded species of bat, representing 65.5% of all bat activity recorded, with barbastelle representing 8.3% of all bat activity recorded, and there were over 50% more barbastelle and *Myotis* spp. bat passes in autumn period (202 passes and 101 passes, respectively), compared with the summer period (94 passes and 53 passes, respectively).
- 3.2.15 The static detector surveys recorded species that were not recorded on the NBWs. Table D-3 (Annex A.4) shows the total number of bat passes for each bat species at each static detector location, with locations and results provided in ES Figure 8.20, Static detector survey locations, Volume III (Document reference 6.3, DCO Volume 6).

Nighttime bat walkovers

- 3.2.16 Two NBWs were carried out at three locations within the Order Limits; the WRP site, Wickham Park Golf Club and Otterbourne.
- 3.2.17 The highest levels of bat activity during the NBWs were recorded at the Otterbourne transect, adjacent to Otterbourne Park Wood. The locations and results for all NBWs are provided in locations shown in ES Figure 8.19, Nighttime bat walkover results, Volume III (Document reference 6.3, DCO Volume 6).
- 3.2.18 The majority of bats recorded within the WRP site were common and soprano pipistrelle, which were recorded foraging and commuting throughout the transect, including along tree lines and over grassland and scrub. Three noctules were also recorded commuting over the WRP site. All results from the NBWs carried out at the WRP site are shown in Table C-2 (Annex C) and in ES Figure 8.19, Nighttime bat walkover results, Volume III (Document reference 6.3, DCO Volume 6).
- 3.2.19 The majority of bats recorded at Wickham Park Golf Course were common and soprano pipistrelle, which were recorded foraging and commuting throughout the survey, although they were not observed. Two commuting noctules and one commuting *Myotis* spp. were also recorded but were not observed. All results from the NBWs carried out at Wickham Park Golf Course are shown in Table C-3 (Annex C) and in ES Figure 8.19, Nighttime bat walkover results, Volume III (Document reference 6.3, DCO Volume 6).
- 3.2.20 Common and soprano pipistrelle were recorded foraging and commuting throughout the surveys at Otterbourne, along woodland edges, tree lines and hedges, over grassland and within a woodland canopy. Noctule and Leisler's bats were recorded commuting high overhead, and small numbers of *Plecotus* spp., *Myotis* spp. and barbastelle bats were recorded commuting, although not observed. All results from the NBWs carried out at Otterbourne are shown Table C-4 (Annex C) and in ES Figure 8.19, Nighttime bat walkover results, Volume III (Document reference 6.3, DCO Volume 6).

3.3 Habitat suitability modelling

- 3.3.1 The outputs of the model showing the areas of high and low connectivity (as determined by the modelling) are shown in the following figures:
1. ES Figure 8.22, Habitat suitability modelling output for *Myotis* species, Volume III (Document reference 6.3, DCO Volume 6)
 2. ES Figure 8.23, Habitat suitability modelling output for long-eared bats, Volume III (Document reference 6.3, DCO Volume 6)
 3. ES Figure 8.24, Habitat suitability modelling output for Bechstein's bat, Volume III (Document reference 6.3, DCO Volume 6)
 4. ES Figure 8.25, Habitat suitability modelling output for greater horseshoe bat, Volume III (Document reference 6.3, DCO Volume 6)
 5. ES Figure 8.26, Habitat suitability modelling output for common pipistrelle, Volume III (Document reference 6.3, DCO Volume 6)
 6. ES Figure 8.27, Habitat suitability modelling output for Nathusius' pipistrelle, Volume III (Document reference 6.3, DCO Volume 6)
 7. ES Figure 8.28, Habitat suitability modelling output for soprano pipistrelle, Volume III (Document reference 6.3, DCO Volume 6)
 8. ES Figure 8.29, Habitat suitability modelling output for barbastelle, Volume III (Document reference 6.3, DCO Volume 6)
 9. ES Figure 8.30, Habitat suitability modelling output for serotine, Volume III (Document reference 6.3, DCO Volume 6)
 10. ES Figure 8.31, Habitat suitability modelling output for Leisler's bat, Volume III (Document reference 6.3, DCO Volume 6)
 11. ES Figure 8.32, Habitat suitability modelling output for noctule, Volume III (Document reference 6.3, DCO Volume 6)

Bat species guilds

Cluttered habitat species

- 3.3.2 The general trend identified from the HSM for each cluttered habitat species (*Myotis* spp. and long-eared bat) showed large extents of low and moderate suitability across the 7km Zol, with low habitat suitability particularly immediately south of the Order Limits, corresponding to the urban areas. High habitat suitability is seen in areas of woodland and along watercourses which are known to be commonly used by these species for foraging, commuting and roosting [3].
- 3.3.3 Connectivity for Bechstein's bat was modelled separately to all other *Myotis* spp., with high connectivity identified around Staunton Country Park and eastwards towards Southleigh Forest in the direction of Singleton and Cocking Tunnels SAC (approximately 15km east). The output shows very low connectivity to most areas of the 7km Zol west of Staunton Country Park. This is supported by recorded absence, from desk study results from ALBST surveys conducted by Havant Borough Council for the Havant Bechstein's Bat Protocol, of this species at locations between Wickham and Purbrook. There are pockets of isolated suitable habitat along the Proposed Development, but with limited connectivity to the known Bechstein's bat population at Staunton Country Park.

- 3.3.4 The sample size for the greater horseshoe bat model was too small; however, due to the greater horseshoe bats similar habitat preferences within the cluttered habitat species guild, and their high sensitivity to light, it is likely that the outputs for other species, such as long-eared bats and *Myotis* spp., also reflect the potential movements of greater horseshoe throughout the 7km Zol.

Edge habitat species

- 3.3.5 The HSM outputs for edge habitat species identified large extents of low and moderate suitability across the 7km Zol, with low habitat suitability particularly immediately south of the Order Limits, similar to outputs for the cluttered habitat species guild.
- 3.3.6 The modelled habitat suitability for this guild shows more variation between each species; the outputs highlight the habitat preferences of barbastelle for broadleaved woodland and greater sensitivity to light, in comparison to the more generalist habitat preferences of the common pipistrelle, for example.
- 3.3.7 For barbastelle, high habitat suitability has been identified in areas of woodland, such as Otterbourne woods, Park Hills Wood and Staunton Country Park, and along watercourses which are known to be commonly used by these species for foraging, commuting and roosting [3].
- 3.3.8 For common and soprano pipistrelle, the output identified large extents of high suitability habitat across the 7km Zol, particularly throughout the northern part of the 7km Zol where there is a mosaic of arable field and woodland well connected by tree lines and hedgerows; these species are known to use arable hedgerows as well as having a strong preference for woodland habitat [3].
- 3.3.9 For Nathusius' pipistrelle, the output identifies high connectivity along water courses and through woodland habitats, two habitats with which this species is known to be strongly associated. The output also highlights high connectivity along the coast and across the saltwater inlets; as a migratory species, Nathusius' pipistrelle is less averse to crossing saltwater habitats. The outputs show that these coastal habitats are important in the species' movement throughout the landscape, particularly using these habitats to avoid urban environments.
- 3.3.10 For serotine, the output identifies low to moderate connectivity throughout the field survey area, with higher suitability in areas where woodland, pasture and arable fields are connected by hedgerows. Serotine exhibit preference for tree-lined hedgerows and woodland edges [3]. The datasets used for land cover could not specify the land use for certain habitat types, which means the output is limited such that serotine preferences for cattle-grazed pasture could not be modelled.

Open habitat species

- 3.3.11 The output identified higher suitability across all habitats for both noctule and Leisler's, due to their higher-flying behaviour; both species are known to be equally active throughout all habitats [3]. The output also shows these species' affinity for water and woodland, with high suitability along watercourses and across woodland and waterbodies.

- 3.3.12 Where known suitable linear features and habitat features are sparse between areas of high habitat suitability, the output has identified low to moderate connectivity in residential areas, such as the Purbrook area.

Key connective locations

- 3.3.13 The output has identified KCLs (see in ES Figure 8.33, Key connective locations for bats, Volume III (Document reference 6.3, DCO Volume 6) for all bat species through specific hedgerows, lines of trees and watercourses which contribute to the predicted movement of each bat species between high areas of suitable habitat in the landscape.

- 3.3.14 In total, there are 21 areas where key habitats likely to be used by significant numbers of bats (such as woodland, hedgerows and watercourses) were present within the Order Limits and within or well connected to substantial areas of habitat with high suitability and/or known roosts and records. KCLs (KCL-A to KCL-U) are listed below, detailed in Table E-2 and shown in ES Figure 8.33, Key connective locations for bats, Volume III (Document reference 6.3, DCO Volume 6):

1. A – Hermitage Stream
2. B – Brockhampton Mill Lake
3. C – Portsdown Hill (east)
4. D – Portsdown Hill Road (west)
5. E – Wallington River
6. F – Crockerhill
7. G – Crockerhill (between Wickham Road and Forest Lane)
8. H – River Meon
9. I – Wickham Golf Club (Tanfield Lane)
10. J – Prickett’s Hill (south)
11. K – Prickett’s Hill (north)
12. L – Waltham Chase (Little Bull Lane)
13. M – River Hamble
14. N – Winter’s Hill
15. – Lower Upham (Scivier’s Lane)
16. P – Park Hills Wood
17. Q – Fishers Pond (east of Winchester Road)
18. R – Fishers Pond (Winchester Road)
19. S – Fishers Pond (Bow Lake)
20. T – River Itchen
21. U – Otterbourne (Kiln Lane)

- 3.3.15 This section considers the connectivity of bat roosts to the Proposed Development where the CSZ crosses into the Order Limits. KCLs referred to in this section as KCL-A to KCL-U can be found described in Table E-2 (Annex E) and mapped in ES Figure 8.33, Key connective locations for bats, Volume III (Document reference 6.3, DCO Volume 6).

3.3.16 The HSM outputs for all bat species show connectivity for bat populations along linear features expected to be used by bats, i.e. the outputs have highlighted the potential movement of bats (predominantly along watercourses, hedgerows and treelines) between high suitability habitat such as woodland and waterbodies. However, there are hedgerows and tree lines that cross the Proposed Development which have lower connectivity; this is due to the isolation of hedgerows and lack of connections with other suitable habitat.

Bechstein's bat

3.3.17 The desk study revealed there were a total of 114 Bechstein's records located in their CSZ identified in the desk study, with all but one record associated with Staunton Country Park and the Havant Bat Protocol area. There was a single record from mist-netting survey conducted in Fiddler's Green Wood in 2014, approximately 600m south of the Proposed Development – the Pipeline between the WRP site and Otterbourne WSW, Section G: Crockerhill to Wickham (Section G).

3.3.18 There are no areas of high habitat suitability across the Proposed Development for Bechstein's bat. Due to the CSZ of Bechstein's bat and the known absence of Bechstein's bats the output shows very low connectivity to known suitable habitat west of Staunton Country Park.

Myotis species

3.3.19 The desk study revealed a total of nine Natterer's bat roosts, two Daubenton's bat roosts and three whiskered bat roosts within their respective CSZs. There were no records of Brandt's or unidentified whiskered/Brandt's bat roosts within the *Myotis* spp. CSZ.

3.3.20 The HSM output identified moderate connectivity northwards from the nearest identified Natterer's bat roost to the Proposed Development, located in Park Hills Wood approximately 460m south of the BDIZ – at the Pipeline between the WRP site and Otterbourne WSW, Section L– to areas of high habitat suitability such as Fisher's Pond and Deep Bushes Copse, with KCLs at KCL-P and KCL-Q.

3.3.21 There were 27 records of Natterer's bat within the BDIZ between 2018 and 2023, associated with Staunton Country Park, but there are no areas of high habitat suitability across the Proposed Development for Natterer's bat.

3.3.22 The nearest identified Daubenton's bat roost to the Proposed Development was a roost of 20 individuals recorded in 2017 approximately 860m south of the Order Limits at Stoke Common Wood – at the Pipeline between the WRP site and Otterbourne WSW, Section L. The high suitability of the River Itchen corridor provides the only KCL (KCL-T) between suitable habitat on both sides of the Proposed Development. Also, another key connective route for this particular roost is along Bow Lake, leading from the roost location over the Proposed Development at KCL (KCL-S).

3.3.23 The nearest identified whiskered bat roost was recorded in 2017 approximately 120m north of the BDIZ at Fisher's Pond - at the Pipeline between the WRP site and Otterbourne WSW, Section L. The HSM shows high suitability northwards, away from the Proposed Development with open pasture and hedgerow habitats, and high connectivity across the Proposed Development towards highly suitable

habitats in the woodland to the south. The KCLs for the potential movement of bats within this roost across the Proposed Development are KCL-Q, KCL-R, and KCL-S. Another whiskered bat roost was recorded in 2017 approximately 700m south of the Proposed Development in Allbrook at the Pipeline between the WRP site and Otterbourne WSW Section M. The high suitability of the River Itchen corridor provided suitable connectivity across the Proposed Development at KCL-T.

Long-eared bats

- 3.3.24 The desk study identified a total of 432 records of long-eared bats within 3km of the Proposed Development, with 36 records occurring within the BDIZ; however, none of these records were confirmed roosts of long-eared bats. The desk study identified a total of 78 roosts within 3km of the Proposed Development, with 54 records confirmed as brown long-eared bat roosts.
- 3.3.25 The nearest record of a long-eared bat roost to the Proposed Development was identified in 2017 in Wickham, approximately 40m north of the BDIZ – at the Pipeline between the WRP site and Otterbourne WSW, Section H: Wickham to Shedfield (Section H). This roost is located in an area of moderate habitat suitability, with high suitability habitat connected northwards along Winchester Road and onto woodland to the west. There is high connectivity to large areas of woodland to the east via KCL-J and KCL-K.
- 3.3.26 The nearest recorded brown long-eared maternity roost is in Curdridge, approximately 662m south of the Proposed Development at the Pipeline between the WRP site and Otterbourne WSW, Section J: Shedfield to the River Hamble (Section J). The HSM output shows high connectivity from this roost location northwards to the River Hamble and southwards to the woodland around Shawford's Lake. KCLs identified for this roost are KCL-L and KCL-M.
- 3.3.27 A brown long-eared hibernation roost is located in Southwick approximately 770m north of the Proposed Development, located along a river and mature tree line. There is low habitat connectivity southwards as there is relatively unsuitable habitat to the south of the Proposed Development, at the Pipeline between the WRP site and Otterbourne WSW, Section E, in combination with the light pollution from urban areas; therefore, no KCLs have been identified here.

Greater horseshoe bat

- 3.3.28 The nearest record to the Proposed Development of greater horseshoe bat presence was identified in 2022 at South Moor, Langstone, approximately 600m east of the BDIZ, at the Pipeline between Budds Farm and the WRP site. This record is located in an area of moderate habitat suitability, with low to moderate connectivity along Brockhampton Mill Lake and up Hermitage Stream, at KCLs KCL-A and KCL-B. One record is located approximately 800m east of the BDIZ (and approximately 310m north of the Order Limits at the Pipeline between the WRP site and Otterbourne WSW, Section D) at high suitability habitat at Portsmouth Golf Course. From there, there is high connectivity westwards to the south of Portsdown Hill Road and then northwards to a mosaic of woodland via KCL-C and KCL-D.

Barbastelle

- 3.3.29 The HSM output shows high suitability around the barbastelle bat population at Staunton Country Park with high connectivity predominantly eastwards to large areas of woodland near Westbourne and towards Singleton and Cocking Tunnels SAC. There is also high connectivity southwards towards Portsmouth Golf Course.
- 3.3.30 The HSM output highlights coastal movement of barbastelle via the saltwater inlets and connected water courses like Brockhampton Mill Lake and Hermitage Stream (KCL-A and KCL-B).
- 3.3.31 There are no known roosts within northern parts of the field survey area. However, this area is identified as high suitability habitat due to the mosaic of broadleaved woodland and hedgerows in the landscape, with multiple KLCs across the Proposed Development between Wallington River and Otterbourne (KCL-E to KCL-U).
- 3.3.32 The output highlights the woodland at Otterbourne as high habitat suitability, but the connectivity is predominantly westwards. There is moderate connectivity across the Proposed Development at Otterbourne with a KCL at Kiln Lane (KCL-U) and a KCL at the River Itchen (KCL-T).

Serotine

- 3.3.33 The desk study highlighted 16 serotine roosts between 2015 and 2023 within 4km of the Proposed Development, with the nearest recorded serotine roost identified approximately 320m from the Proposed Development in 2020 – at the Pipeline between the WRP site and Otterbourne WSW, Section H. The output identifies high suitability habitat eastwards across the Proposed Development at KCL-J and KCL-K.

Common pipistrelle and soprano pipistrelle

- 3.3.34 The desk study did not identify any common pipistrelle or soprano pipistrelle roosts within the BDIZ of the Proposed Development, but common pipistrelle and soprano pipistrelle have been recorded within Staunton Country Park.
- 3.3.35 The output shows a moderate to high suitability across the entire field survey area, as would be expected from such generalist species, but highlights higher connectivity in the northern part of the field survey area where there is a mosaic of arable fields, riparian habitat and woodland connected by hedgerows and tree lines. The modelling also shows the predicted movement of common pipistrelle and soprano pipistrelle throughout urban areas, likely due to their lower sensitivity to light.
- 3.3.36 There is a strip of low habitat suitability, approximately 1km wide, running the length of the Proposed Development between Willington River and Portsmouth urban sprawl; connectivity between the urban areas in the south and high suitability habitat in the north is predominantly at the KCLs at Wallington River (KCL-E) and at Portsdown Hill Road (KCL-C and KCL-D).
- 3.3.37 All KCLs identified for other bat species are also highlighted in the output for common pipistrelle and soprano pipistrelle (KCL-A to KCL-U).

Nathusius' pipistrelle

- 3.3.38 All *Nathusius' pipistrelle* records from the desk study were from bat activity surveys and no roosts have been identified within 3km of the Proposed Development.
- 3.3.39 For *Nathusius' pipistrelle*, there is moderate to high suitability across the field survey area with lower habitat suitability in urban areas. The output highlighted that watercourses predominantly provide the highest connectivity for *Nathusius' pipistrelle*, showing the KCLs for *Nathusius' pipistrelle* as the watercourses at KCL-E, KCL-H, and KCL-M.
- 3.3.40 Bat presence records identified along the coast highlights the predicted movement of *Nathusius' pipistrelle* over the saltwater inlets of the coastline and movement northwards where watercourses are present. The output highlights KCLs at KCL-A and KCL-B.

Noctule

- 3.3.41 The desk study highlighted one single roost in 2017 in Park Hills Wood approximately 430m south of the Proposed Development. The HSM output identified Park Hills Wood as high suitability for noctule with high connectivity for noctule in all directions, including northwards across the Proposed Development at the Pipeline between the WRP site and Otterbourne WSW, Section L. The output highlights KCLs at KCL-P and KCL-Q.

Leisler's bat

- 3.3.42 The desk study did not identify any *Leisler's bat* roosts within the BDIZ of the Proposed Development or within its CSZ of 3km; only 50 records from bat activity surveys were identified within 3km of the Proposed Development.
- 3.3.43 The output shows a general moderate to high suitability across the entire field survey area but highlights greater connectivity in the northern part where there is a mosaic of arable fields, riparian habitat and woodland connected by hedgerows and tree lines.
- 3.3.44 The output identified the potential movement of *Leisler's bat* over the saltwater inlets of the coastline and movement northwards where watercourses are present. The output highlights KCLs at KCL-A and KCL-B.

4 Summary

4.1 Desk study

Data search

Designated sites

- 4.1.1 There are no SACs designated for bats located within the 10km desk study area. However, there is overlap of the 12km wider conservation area of Singleton and Cocking Tunnel SAC and the 7km Zol of the Proposed Development. Therefore, despite limited data to support this, it is deemed highly likely to be functionally linked with Singleton and Cocking Tunnels SAC [21].

Species records

- 4.1.2 At least 16 bat species were recorded in the 7km Zol of the Proposed Development, during the desk study and field surveys; these included three species listed on Annex II of the Habitats Directive:

1. Barbastelle
2. Bechstein's bat
3. Greater horseshoe bat

- 4.1.3 The other 13 species identified were:

1. Alcaholic bat
2. Brandt's bat
3. Brown long-eared bat
4. Common pipistrelle
5. Daubenton's bat
6. Leisler's bat
7. Nathusius' pipistrelle
8. Natterer's bat
9. Noctule
10. Serotine
11. Soprano pipistrelle
12. Whiskered bat
13. Parti-coloured bat *Vespertilio murinus* (single record returned within Purbrook in 2014, approximately 1.2km north of the Order Limits)

- 4.1.4 Records were also returned for unidentified *Myotis*, *Nyctalus*, *Pipistrellus* and *Plecotus* species.

4.2 Preliminary roost assessments

- 4.2.1 Of the 44 structures within the BDIZ subjected to PRAs, 42 were assessed as having no suitability for roosting bats due to a lack of PRFs.
- 4.2.2 One structure (B647519) was assessed as having low suitability for roosting bats, and one structure (B647538) was assessed as having high suitability for roosting bats. Both structures had no hibernation suitability.

4.3 Ground level tree assessments and aerial tree-climbing inspections

- 4.3.1 A total of 829 trees within the BDIZ and BIIZ were subject to GLTA surveys and aerial tree-climbing inspections. The surveys identified a total of 417 trees with no suitability for roosting bats, 112 trees with FAR suitability for roosting bats, five trees with PRF suitability for roosting bats, 205 trees with PRF-I suitability for roosting bats, and 41 trees with PRF-M suitability for roosting bats. No confirmed roosts were identified during GLTA and aerial tree-climbing inspections. Table 4-1 provides a summary of bat suitability for trees within the BDIZ and within the BIIZ.

Table 4-1 Summary of trees with bat suitability

Bat roost suitability	Within BDIZ	Within BIIZ
NONE	287	130
FAR	94	18
PRF	40	14
PRF-I	84	121
PRF-M	18	23

4.4 Dusk emergence surveys

- 4.4.1 A total of ten trees required emergence surveys as they were considered unsafe to climb.
- 4.4.2 There were no bat roosts recorded within the ten trees subject to emergence surveys.

4.5 Bat activity surveys

Static detector surveys

- 4.5.1 Bat species or species' group recorded throughout the static detector surveys were:
1. Barbastelle
 2. Common pipistrelle
 3. Leisler's bat
 4. Long-eared spp.

5. *Myotis* spp.
6. Noctule
7. Serotine
8. Soprano pipistrelle

- 4.5.2 Common pipistrelle, soprano pipistrelle, and *Myotis* spp. were regularly recorded at all 29 locations.
- 4.5.3 Noctule, Leisler's bat, serotine and long-eared bats were recorded at over 70% of all locations.
- 4.5.4 Barbastelle were recorded in lower numbers (less than 50 passes) at eight locations. Barbastelle were recorded in higher numbers at location 1 and 2. The highest number of total bat passes recorded was at location 2, located within the BDIZ along a hedgerow adjacent to Otterbourne Park Wood; this location also had the highest concentration of barbastelle bats, recording 54% of all barbastelle activity across all locations. Similarly, at the Otterbourne static detector location in 2024, barbastelle represented 8.3% of all bat activity recorded. All other locations did not record barbastelle.
- 4.5.5 Common pipistrelle was the most recorded species of bat at all locations, except for location 3, 9, 10 and Wickham Park Golf Course, where soprano pipistrelle was the most recorded species.
- 4.5.6 *Myotis* spp. were recorded at all locations with the highest number of passes at Wickham Park Golf Course, with 401 passes in autumn and 304 passes in summer.
- 4.5.7 The static detector surveys recorded species that were not recorded on the NBWs. Table D-3 shows the total number of bat passes for each bat species at each static detector location, with locations and results provided in ES Figure 8.20, Static detector survey locations, Volume III (Document reference 6.3, DCO Volume 6).

Nighttime bat walkovers

- 4.5.8 The highest levels of bat activity during the NBWs were recorded at the Otterbourne location, adjacent to Otterbourne Park Wood. The locations and results for all NBWs are provided in locations shown in ES Figure 8.19, Nighttime bat walkover results, Volume III (Document reference 6.3, DCO Volume 6).
- 4.5.9 The majority of bats recorded within the WRP site were common and soprano pipistrelle. Three noctules were also recorded. All results from the NBWs carried out at the WRP site are shown in Table C-2 (Annex C) and in ES Figure 8.19, Nighttime bat walkover results, Volume III (Document reference 6.3, DCO Volume 6).
- 4.5.10 The majority of bats recorded at Wickham Park Golf Course were common and soprano pipistrelle. Two noctule bats and one *Myotis* spp. were also recorded. All results from the NBWs carried out at Wickham Park Golf Course are shown in Table C-3 (Annex C) and in ES Figure 8.19, Nighttime bat walkover results, Volume III (Document reference 6.3, DCO Volume 6).
- 4.5.11 Common and soprano pipistrelle were recorded foraging and commuting throughout the surveys at Otterbourne. Noctule and Leisler's bats were recorded, as well as small numbers of long-eared spp., *Myotis* spp. and barbastelle were

recorded. All results from the NBWs carried out at Otterbourne are shown Table C-4 (Annex C) and in ES Figure 8.19, Nighttime bat walkover results, Volume III (Document reference 6.3, DCO Volume 6).

4.6 Habitat suitability modelling

- 4.6.1 The HSM outputs show the potential movement of all bats species (particularly the cluttered and edge habitat guilds) throughout the landscape, predominantly using linear features like hedgerows and watercourses. The variations in the level of connectivity modelled between bat species is largely due to the differences in species' presence locations.
- 4.6.2 The output shows many connected areas of suitable habitat within the 7km HSM survey area. The Proposed Development runs through areas of high and moderate habitat suitability for all bat species, where high connectivity pathways intersect the Proposed Development.
- 4.6.3 All the major rivers (Itchen, Meon, Hamble and Wallington) show high connectivity for bat species' movement across the Proposed Development.
- 4.6.4 The output shows areas of high habitat suitability, immediately adjacent to Section M of the Proposed Development, particularly the woodland linked to the River Itchen.
- 4.6.5 Fisher's Pond shows high to moderate connectivity between either side of Section L of the Proposed Development, both in a north-south and an east-west direction.
- 4.6.6 There is moderate connectivity across the Proposed Development footprint in the Lower Upham area, which joins areas of high connectivity from the south and west of the Proposed Development to areas of high connectivity to the north and east of the Proposed Development.
- 4.6.7 Waltham Chase shows high to moderate connectivity with connectivity from waterbodies such as Shawford's Lake to the west of Section J of the Proposed Development, to suitable habitat to the east of the Proposed Development.
- 4.6.8 There is high to moderate connectivity at Portsdown Road, west of Widley (Section E), showing a high connectivity pathway from bat populations in Staunton Country Park westwards past the urban areas of Purbrook.
- 4.6.9 High habitat suitability associated with Staunton Country Park (Section A) with very high north-south connectivity across the footprint.
- 4.6.10 There is a strip identified as mostly low suitability running parallel to and immediately south of Section D, Section E and Section F of the Proposed Development, between Wallington River and Purbrook.

Annex A Preliminary roost assessment

Table A-1 Preliminary roost assessment results

Building ID	Internal or External	Description	Bat roost suitability	Hibernation suitability	Confirmed roost
B352383	External	Wooden shed	None	None	No
B356328	External	Metal kiosk	None	None	No
B500333	External	Static caravan within prefabricated buildings	None	None	No
B502081	Internal and External	Small wood store with tin roof in open hay field	None	None	No
B647514	External	Two storey stone structure used for water treatment	None	None	No
B647515	External	Metal tanks and infrastructure used for water treatment	None	None	No
B647516	External	Metal tanks and infrastructure used for water treatment	None	None	No
B647517	External	Metal tanks and infrastructure used for water treatment	None	None	No
B647518	External	Temporary metal shipping container	None	None	No
B647519	External	Metal prefabricated building with gap between roof and wall	Low	None	No
B647520	External	Concrete chamber used as water treatment infrastructure	None	None	No
B647521	External	Concrete chamber used as water treatment infrastructure	None	None	No
B647522	External	Concrete chamber used as water	None	None	No

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Building ID	Internal or External	Description	Bat roost suitability	Hibernation suitability	Confirmed roost
		treatment infrastructure			
B647523	External	Concrete chamber used as water treatment infrastructure	None	None	No
B647524	External	Concrete chamber used as water treatment infrastructure	None	None	No
B647554	Internal and External	Lorry container with metal, flat roof and wooden cladded sides.	None	None	No
B647525	External	33ft trailer structure.	None	None	No
B647528	Internal and External	Shed with sides formed from the fencing underneath dense Leyland conifer hedging, and metal roof.	None	None	No
B647544	External	Mobile home with PVC windows and a wooden cladded base.	None	None	No
B647555	Internal and External	Open-sided log store with Heras fencing against the conifer hedge, tin corrugated roof with wooden beams.	None	None	No
B647538	External	Small stables structure with wooden cladded sides and metal corrugated roof lined with wooden boarding. Bat box on eastern aspect.	High	None	No
B647530	External	Small wooden shed with bitumen roof.	None	None	No

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Building ID	Internal or External	Description	Bat roost suitability	Hibernation suitability	Confirmed roost
B647552	External	Chicken pen with corrugated metal roof and chicken wire sides.	None	None	No
B647537	External	Small wooden shed with corrugated metal unlined roof.	None	None	No
B647535	External and Internal	Small timber open-sided shelter with flat corrugated metal roof.	None	None	No
B502082	External and Internal	Large open-sided agricultural with metal corrugated mono-pitch roof structure on wooden beams and large metal poles. Hay bale storage.	None	None	No
B647553	External	Metal container with bitumen roof.	None	None	No
B647551	External	Caravan.	None	None	No
B647526 B647527 B647531 B647532 B647533 B647534 B647536 B647539 B647540 B647541 B647542 B647543 B647545 B647546 B647549 B647550	External	A number of newly built chicken coops encased in chicken wire, and wooden shed-style buildings with interlocking cladding and corrugated metal roofs.	None	None	No

Annex B Emergence survey

Table B-1 Dusk emergence survey weather conditions

Tree ID	Date of survey	Feature	Sunset/sunrise	Survey start	Survey end	Weather conditions
T206004	30/07/24	Tree	20:53	20:35	22:23	24°C/23°C, clear and dry with a light breeze
T30025	05/08/24	Tree	20:44	20:29	22:14	19°C/18°C, clear and dry with light air
T30035	05/08/24	Tree	20:44	20:29	22:14	19°C/18°C, clear and dry with light air
T2507	06/08/24	Tree	20:42	20:27	22:12	18°C/14°C, overcast and dry with no wind
T16605	29/08/24	Tree	19:58	19:43	21:28	20°C/17°C, overcast and dry with no wind
T16204	09/09/24	Tree	19:32	19:18	21:02	15°C/12°C, clear and dry with a light breeze
T2507	11/09/24	Tree	19:27	19:12	20:57	15°C/9°C, overcast with no wind and light showers
T31182	12/09/24	Tree	19:26	19:11	20:56	13°C/9°C, clear and dry with no wind
T5119	16/09/24	Tree	19:15	19:00	20:45	17°C/14°C, clear and dry with no wind
T13807	30/09/24	Tree	18:44	18:29	20:14	14°C/12°C, overcast and dry with a gentle breeze
T18603	30/09/24	Tree	18:44	18:29	20:14	14°C/12°C, cloudy and dry with a gentle breeze

*Weather conditions with start temperature and end temperature

Table B-2 Emergence survey results

Tree ID	Survey date	Confirmed emergence (Yes/No)	Emergence species/ Individuals recorded	Bat activity
T206004	30/07/24	No	N/A	Common and soprano pipistrelle were recorded foraging. Noctule and serotine were recorded but not seen.
T30025	05/08/24	No	N/A	Common and soprano pipistrelle were recorded commuting south-west. Noctule and Leisler's bat were recorded but not seen.
T30035	05/08/24	No	N/A	Common pipistrelle, soprano pipistrelle, <i>Myotis</i> spp., noctule and serotine were recorded foraging and commuting.
T2507	06/08/24	Yes	Common pipistrelle/Two	One common pipistrelle emerged from a limb on the west aspect of T2507 at 20:51 and one common pipistrelle emerged from the east aspect at 21:01. Common pipistrelle were also recorded commuting.
T16605	29/08/24	No	N/A	Common pipistrelle, soprano pipistrelle, and unidentified pipistrelle species were recorded foraging and commuting.
T16204	09/09/24	No	N/A	Common pipistrelle were recorded foraging and commuting.
T2507	11/09/24	No	N/A	No bats recorded
T31182	12/09/24	No	N/A	Common pipistrelle, soprano pipistrelle, and unidentified pipistrelle spp. were recorded foraging and commuting.
T5119	16/09/24	No	N/A	Common were recorded foraging and commuting.
T13807	30/09/24	No	N/A	Common pipistrelle, soprano pipistrelle, and <i>Myotis</i> spp. Were recorded foraging and commuting.
T18603	30/09/24	No	N/A	Common pipistrelle, soprano pipistrelle, serotine, and barbastelle were recorded foraging and commuting.

Annex C Nighttime bat walkover

Table C-1 Nighttime bat walkover weather conditions

Transect	Date of survey	Sunset	Survey start	Survey end	Start Temp. (°C)	Weather conditions
WRP site - spring	30 May 2024	21:07	21:07	23:07	14	Overcast with a light breeze and brief drizzle
WRP site - summer	10 July 2024	21:15	21:15	22:51	16	Clear and dry with light air
Otterbourne - summer	29 July 2024	20:55	20:55	22:55	19	Clear and dry with light air
Wickham Park Golf Course - summer	30 July 2024	20:53	20:53	23:23	24	Clear and dry with no wind
Otterbourne - autumn	09 September 2024	19:32	19:32	21:41	15	Clear and dry with light air
Wickham Park Golf Course - autumn	10 September 2024	19:28	19:28	21:45	13	Overcast with a moderate breeze and a 30-minute shower

Table C-2 Water Recycling Plant site nighttime bat walkover results

Date	Time	Species	Number	Activity	Observation
30/05/24	21:41	Soprano pipistrelle	1	Foraging	Foraging over open grassland and nettles at 4m high
	21:45	Common pipistrelle	1	Commuting	Not seen
	22:03	Common pipistrelle	1	Commuting	Not seen
	22:05	Soprano pipistrelle	1	Commuting	Not seen
	22:07	Soprano pipistrelle	1	Commuting	Flying west at 3m high along tree line
	22:16	Soprano pipistrelle	1	Foraging	Not seen

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Date	Time	Species	Number	Activity	Observation
	22:27	Common pipistrelle	1	Foraging	Not seen
	22:37	Common pipistrelle	1	Commuting	Not seen
	22:42	Common pipistrelle	1	Commuting	Not seen
10/07/24	21:40	Common pipistrelle	1	Commuting	Not seen
	21:45	Common pipistrelle	1	Commuting	Not seen
	21:46	Noctule	1	Commuting	Commuting along boundary at 7m high
	21:47	Common pipistrelle	1	Foraging	Foraging over tree line at 17m high
	21:48	Common pipistrelle	1	Commuting	Not seen
	21:53	Common pipistrelle	1	Commuting	Not seen
	21:58	Common pipistrelle	1	Foraging	Foraging over scrub and tree line at 4m high
	22:02	Common pipistrelle	1	Foraging	Not seen
	22:05	Soprano pipistrelle	1	Commuting	Not seen
	22:07	Common pipistrelle	1	Commuting	Not seen
	22:16	Noctule	1	Commuting	Not seen
	22:25	Soprano pipistrelle	1	Commuting	Not seen
	22:26	Noctule	1	Commuting	Not seen
	22:34	Common pipistrelle	1	Commuting	Not seen
	22:38	Common pipistrelle	1	Commuting	Not seen
22:39	Common pipistrelle	1	Commuting	Not seen	

Table C-3 Wickham Park Golf Course nighttime bat walkover results

Date	Time	Species	Number	Activity	Observation
30/07/24	21:34	Soprano pipistrelle	1	Commuting	Not seen

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Date	Time	Species	Number	Activity	Observation
	21:38	Soprano pipistrelle	1	Commuting	Not seen
	21:40	Soprano pipistrelle	1	Commuting	Not seen
	21:45	Noctule	1	Commuting	Not seen
	21:46	Common pipistrelle	1	Commuting	Not seen
	22:16	Soprano pipistrelle	1	Foraging	Not seen
	22:34	Common pipistrelle	1	Commuting	Not seen
	22:36	Soprano pipistrelle	1	Commuting	Not seen
	22:43	<i>Myotis</i> spp.	1	Commuting	Not seen
	22:45	Soprano pipistrelle	1	Foraging	Not seen
	22:52	Soprano pipistrelle	1	Commuting	Not seen
	23:03	Soprano pipistrelle	1	Commuting	Not seen
	23:10	Noctule	1	Commuting	Not seen
	23:12	Common pipistrelle	1	Commuting	Not seen
10/09/24	19:50	Pipistrelle spp.	1	Commuting	Commuting along woodland edge and over grassland at 18m. No calls detected.
	19:59	Common pipistrelle	1	Commuting	Not seen
	20:03	Soprano pipistrelle	1	Foraging	Foraging along woodland edge at 4m.
	20:44	Common pipistrelle	1	Foraging	Not seen
	20:53	Common pipistrelle	1	Foraging	Foraging along tree line at 7m.
	20:53	Soprano pipistrelle	1	Foraging	Foraging along tree line at 7m.
	21:12	Soprano pipistrelle	1	Foraging	Not seen
	21:45	Soprano pipistrelle	1	Foraging	Not seen

Table C-4 Otterbourne nighttime bat walkover results

Date	Time	Species	Number	Activity	Observation
30/07/24	21:07	Noctule	1	Commuting	Not seen
	21:17	Soprano pipistrelle	1	Foraging	Foraging along tree line at 4m high
	21:21	Common pipistrelle	1	Commuting	Not seen
	21:25	Common pipistrelle	1	Foraging	Foraging along tree line at 5m high
	21:25	Noctule	1	Foraging	Foraging over grassland at 30m high
	21:27	Soprano pipistrelle	1	Commuting	Not seen
	21:29	Soprano pipistrelle	1	Foraging	Foraging within woodland canopy at 22m high
	21:33	Soprano pipistrelle	1	Foraging	Foraging within woodland canopy at 22m high
	21:36	<i>Myotis</i> spp.	1	Commuting	Not seen
	21:36	Common pipistrelle	1	Commuting	Not seen
	21:39	Soprano pipistrelle	1	Foraging	Foraging along hedge and tree line at 3m high
	21:40	Common pipistrelle	1	Commuting	Commuting along hedge and tree line at 2m high
	21:43	Common pipistrelle	1	Foraging	Foraging along hedge and tree line at 2m high
	21:52	Common pipistrelle	1	Commuting	Not seen
	21:53	Barbastelle	1	Commuting	Not seen
	21:55	Soprano pipistrelle	1	Commuting	Commuting over field at 15m high
	22:01	Soprano pipistrelle	1	Commuting	Not seen
	22:15	Soprano pipistrelle	1	Commuting	Not seen
	22:22	Common pipistrelle	1	Commuting	Not seen
	22:25	Common pipistrelle	1	Foraging	Foraging along tree line at 3m
22:37	Leisler's bat	1	Commuting	Not seen	
	19:50	Noctule	1	Commuting	Not seen

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Date	Time	Species	Number	Activity	Observation
09/09/24	20:12	Noctule	1	Commuting	Not seen
	20:27	Common pipistrelle	1	Foraging	Foraging along hedgerow at 3m.
	20:30	Soprano pipistrelle	1	Foraging	Not seen
	20:38	Common pipistrelle	1	Commuting	Commuting along hedgerow at 4m.
	20:46	Barbastelle	1	Commuting	Not seen
	20:47	<i>Myotis</i> spp.	1	Commuting	Not seen
	20:49	Soprano pipistrelle	1	Commuting	Not seen
	21:00	Common pipistrelle	1	Foraging	Not seen
	21:01	Soprano pipistrelle	1	Foraging	Not seen
	21:04	Common pipistrelle	1	Foraging	Not seen
	21:06	Noctule	1	Commuting	Not seen
	21:07	Soprano pipistrelle	1	Foraging	Not seen
	21:08	<i>Plecotus</i> spp.	1	Commuting	Not seen
	21:10	Common pipistrelle	1	Foraging	Foraging along woodland edge at 4m high.
	21:12	Soprano pipistrelle	1	Commuting	Not seen
	21:17	Soprano pipistrelle	1	Commuting	Foraging along hedgerow at 4m.
	21:20	Soprano pipistrelle	1	Foraging	Not seen
	21:22	Common pipistrelle	1	Foraging	Not seen
	21:28	Soprano pipistrelle	1	Commuting	Commuting along woodland edge at 3m.
	21:30	Common pipistrelle	1	Commuting	Commuting along woodland edge at 3m.
21:32	Soprano pipistrelle	1	Commuting	Commuting along hedgerow at 4m.	
21:38	Soprano pipistrelle	1	Commuting	Not seen	
21:40	Common pipistrelle	1	Commuting	Not seen	

Annex D Static detector survey

Table D-1 Static detector survey dates

Static Detector ID	Deployment date	End date
1	19/07/22	25/07/22
2	15/08/22	21/08/22
3	04/08/22	10/08/22
4	04/08/22	10/08/22
5	03/08/22	08/08/22
6	19/07/22	25/07/22
7	01/08/22	08/08/22
8	20/07/22	25/07/22
9	19/07/22	25/07/22
10	02/08/22	08/08/22
11	02/08/22	08/08/22
12	02/08/22	08/08/22
13	20/07/22	26/07/22
14	20/07/22	26/07/22
15	20/07/22	26/07/22
16	20/07/22	26/07/22
17	20/07/22	26/07/22
18	03/08/22	08/08/22
19	21/07/22	27/07/22
20	21/07/22	27/07/22
21	01/08/22	06/08/22
22	03/08/22	07/08/22
23	03/08/22	08/08/22
24	03/08/22	07/08/22
25	04/08/22	09/08/22
WRP site – spring	20/06/24	25/06/24
WRP site – summer	17/07/24	22/07/24
Otterbourne – summer	29/07/24	04/08/24
Wickham Park Golf Course – summer	30/07/24	04/07/24

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Static Detector ID	Deployment date	End date
Otterbourne – autumn	09/09/24	14/09/24
Wickham Park Golf Course – autumn	10/09/24	15/09/24

Table D-2 Static detector survey dates for habitat suitability modelling

Static Detector ID	Deployment date	End date
1	29/09/23	09/10/23
2	29/09/23	09/10/23
3	29/09/23	09/10/23
Static 1	04/07/24	18/07/24
Static 2	04/07/24	18/07/24
Static 3	04/07/24	18/07/24
Static 5	30/05/24	12/06/24
Static 8	22/07/24	05/08/24
Static 9	22/07/24	05/08/24
Static 10	13/05/24	28/05/24
Static 11	13/08/24	27/08/24
Static 13	17/06/24	01/07/24
Static 14	13/05/24	28/05/24
Static 15	30/05/24	12/06/24
Static 16	22/07/24	05/08/24
Static 17	04/07/24	18/07/24
Static 18	13/05/24	28/05/24
Static 19	04/07/24	18/07/24
Static 20	13/05/24	28/05/24
Static 21	04/07/24	18/07/24
Static 22	22/07/24	05/08/24
Static 23	04/07/24	18/07/24
Static 24	13/05/24	28/05/24
Static 25	30/05/24	12/06/24
Static 26	30/05/24	12/06/24
Static 27	13/05/24	28/05/24
Static 28	13/05/24	28/05/24

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Static Detector ID	Deployment date	End date
Static 29	22/07/24	05/08/24
Static 30	13/05/24	28/05/24
Static 32	13/05/24	28/05/24
Static 33	22/07/24	05/08/24
Static 34	30/05/24	12/06/24
Static 35	30/05/24	12/06/24
Static 36	17/06/24	01/07/24
Static 37	17/06/24	01/07/24
Static 40	04/07/24	18/07/24

Table D-3 Total bat passes during static detector surveys

Static Detector ID	Cpip	Spip	Pip spp.	Nnoc	Nlei	Eser	Bbar	Myo spp.	Ple sp.
1	3391	200	10	94	42	31	57	47	2
2	5133	655	0	111	24	78	157	171	31
3	10	281	0	0	0	0	0	37	5
4	1714	1382	249	65	17	35	5	44	13
5	10	5	0	0	0	0	0	1	0
6	411	71	4	19	0	13	0	6	2
7	4565	107	0	8	10	1	13	36	3
8	411	146	0	26	6	6	24	30	2
9	925	1024	0	9	33	5	0	12	2
10	1051	1370	0	38	14	11	16	112	11
11	1443	374	0	16	0	0	0	25	9
12	384	151	0	49	0	1	1	95	15
13	455	336	0	88	17	16	0	56	2
14	5157	33	0	26	4	6	0	107	2
15	3367	34	0	7	1	22	0	17	2
16	825	162	0	36	22	22	2	90	2
17	4189	139	1	40	0	43	0	18	2
18	1359	656	4	3	7	14	0	87	3
19	5425	228	0	18	3	27	0	47	2
20	2847	556	0	9	0	166	0	22	2
21	75	51	0	6	3	1	0	6	5

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Static Detector ID	Cpip	Spip	Pip spp.	Nnoc	Nlei	Eser	Bbar	Myo spp.	Ple sp.
22	721	608	0	35	1	35	4	52	10
23	1754	122	0	116	3	180	0	62	2
24	254	236	1	17	7	45	12	288	2
25	3377	347	0	3	0	16	0	115	2
WRP site - spring	705	12	0	9	1	0	0	3	0
WRP site – summer	805	135	0	25	23	0	0	0	0
Wickham Park Golf Course - summer	486	914	0	2	21	19	0	304	2
Wickham Park Golf Course – autumn	1029	943	0	0	25	17	0	401	0
Otterbourne - summer	357	210	0	54	90	4	94	53	31
Otterbourne - autumn	1967	351	0	12	0	0	202	101	24

Cpip = common pipistrelle, *Spip* = soprano pipistrelle, *Pip spp.* = *Pipistrellus* species, *Nnoc* = noctule, *Nlei* = Leisler's bat, *Eser* = Serotine, *Bbar* = barbastelle, *Myo spp.* = *Myotis* species, *Ple spp.* = *Plecotus* species.

Annex E Habitat suitability modelling

Table E-1 Environmental variables

Environmental variable	Feature	Source
Land cover	Deciduous woodland	UKCEH 2023 Land Cover Map
Land cover	Coniferous woodland	UKCEH 2023 Land Cover Map
Land cover	Arable	UKCEH 2023 Land Cover Map
Land cover	Improved grassland	UKCEH 2023 Land Cover Map
Land cover	Neutral grassland	UKCEH 2023 Land Cover Map
Land cover	Calcareous grassland	UKCEH 2023 Land Cover Map
Land cover	Acid grassland	UKCEH 2023 Land Cover Map
Land cover	Fen	UKCEH 2023 Land Cover Map
Land cover	Heather	UKCEH 2023 Land Cover Map
Land cover	Heather grassland	UKCEH 2023 Land Cover Map
Land cover	Bog	UKCEH 2023 Land Cover Map
Land cover	Inland rock	UKCEH 2023 Land Cover Map
Land cover	Saltwater	UKCEH 2023 Land Cover Map
Land cover	Freshwater	UKCEH 2023 Land Cover Map
Land cover	Suporlittoral rock	UKCEH 2023 Land Cover Map
Land cover	Supralittoral sediment	UKCEH 2023 Land Cover Map
Land cover	Littoral rock	UKCEH 2023 Land Cover Map
Land cover	Littoral sediment	UKCEH 2023 Land Cover Map
Land cover	Saltmarsh	UKCEH 2023 Land Cover Map
Land cover	Urban	UKCEH 2023 Land Cover Map
Land cover	Suburban	UKCEH 2023 Land Cover Map
Inland water	Inland Water	OS Open Zoomstack
Hedgerows	Hedgerows	UKCEH Land Cover Plus: Hedgerows 2016-2021
Light pollution	Light pollution	Version 4 DMSP-OLS Nighttime Lights Time Series

Table E-2 KCLs within the Order Limits

KCL ID	KCL name	Description	Grid reference	Component section of the pipeline
A	Hermitage Stream	A tree-lined stream providing high connectivity from the saltwater inlets in the south, throughout the high-density urban area northwards to Havant.	SU 70469 06235	Section B
B	Brockhampton Mill Lake	A river leading from the saltwater inlet in the south, northwards under the A27 to the Havant area. This is a KCL for all species of bat using the inlet and watercourses to avoid the urban landscape.	SU 70319 05768	Section C
C	Portsdown Hill Road (East)	A hedgerow running north-south between arable fields and residential gardens.	SU 66658 06662	Section D
D	Portsdown Hill Road (West)	A copse to the west of the AGP showing high connectivity between suitable habitat to the south and northwards to large areas of woodland.	SU 66093 06595	Section E
E	Wallington River	The river provides a natural funnel between both sides of the Proposed Development where trenchless crossing is planned.	SU 58723 08528	Section F
F	Crockerhill (between Wickham Road and Forest Lane)	Poorly vegetated boundary to the west of the Proposed Development which could be enhanced to create better connectivity for bats moving east to west, alongside the mitigation for the hedgerow within the footprint.	SU 57743 09754	Section F
G	Crockerhill (between Wickham Road and Forest Lane)	Poorly vegetated boundary providing a KCL east-west across the Proposed Development.	SU 57885 09660	Section F
H	River Meon	The river provides a natural funnel between both sides of the Proposed Development	SU 56738 10792	Section G

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KCL ID	KCL name	Description	Grid reference	Component section of the pipeline
		where trenchless construction works are planned.		
I	Wickham Golf Club (Tanfield Lane)	High connectivity around the south-western boundary of Wickham Golf Club providing east-west connectivity across the Proposed Development.	SU 56285 10940	Section G
J	Prickett's Hill South	A mature tree line just north of Blind Lane, providing east-west connectivity across the Proposed Development.	SU 57117 12557	Section H
K	Prickett's Hill North	A hedgerow south of woodland on the east. Providing high connectivity between the woodland to the north and woodland to the south.	SU 57022 12894	Section H
L	Waltham Chase (Little Bull Lane)	Natural crossroads in mature tree-lined boundaries providing a KCL for bats travelling south-west to north-east and east-west.	SU 55905 14439	Section J
M	River Hamble	The river provides a natural funnel between both sides of the Proposed Development where trenchless construction works are planned.	SU 54111 15921	Section K
N	Winter's Hill	An area of parkland with mature trees where trenchless construction works are planned.	SU 52989 17891	Section K
O	Lower Upham (Scivier's Lane)	One mature tree line shows a KCL for all species.	SU 52478 18873	Section K
P	Park Hills Wood	A woodland strip north of Park Hills Wood, crossing the Proposed Development.	SU 50082 20377	Section L
Q	Fishers Pond (east of Winchester Road)	A mature tree line providing high connectivity north to south across the Proposed Development.	SU 49240 20331	Section L
R	Fishers Pond (Winchester Road)	A copse along the eastern side of Winchester Road.	SU 48854 20654	Section L

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KCL ID	KCL name	Description	Grid reference	Component section of the pipeline
S	Fishers Pond (Bow Lake)	A stream linking large areas of woodland to the east and a small lake to the west of the Proposed Development.	SU 48515 20783	Section L
T	River Itchen	The river provides a natural funnel between both sides of the Proposed Development where trenchless construction works are planned.	SU 46490 21820	Section M
U	Otterbourne (Kiln Lane)	A mature tree-lined country lane which shows high suitability for all bat species between the east and the west sides of the Proposed Development.	SU 46282 22717	Section M

Annex F Habitat suitability modelling detailed methodology

F.1 Introduction

- F.1.1 Circuitscape is a free and open-source software that uses algorithms from electronic circuit theory to predict connectivity in heterogeneous landscapes [22]. It helps in understanding patterns of movement, gene flow and genetic differentiation among plant and animal populations, aiming to translate resistance surfaces into estimates of functional landscape connectivity [23]. Because it focuses on connectivity, it may be more suited to aiding mitigation design than HSM methods which only consider cells independently of each other. It is implemented using the Julia programming language [24].
- F.1.2 Circuitscape has been demonstrated and discussed in a wide range of academic work, with the theoretical basis stretching back nearly 20 years. It has been applied to relevant use cases, most notably the study of declining populations of European forest bats [25].
- F.1.3 Analysis was performed on eleven species or species' groups, using a combination of data from static detector surveys and local records data:
1. Barbastelle *Barbastella barbastellus*
 2. Bechstein's bat *Myotis bechsteinii*
 3. Common pipistrelle *Pipistrellus pipistrellus*
 4. Greater horseshoe bat *Rhinolophus ferrumequinum*
 5. Leisler's bat *Nyctalus leisleri*
 6. Long-eared species *Plecotus* spp.
 7. *Myotis* species *Myotis* spp.
 8. Nathusius' pipistrelle *Pipistrellus nathusii*
 9. Noctule *Nyctalus noctula*
 10. Serotine *Eptesicus serotinus*
 11. Soprano pipistrelle *Pipistrellus pygmaeus*
- F.1.4 A Circuitscape map was produced for each species or genus, with the aim of identifying key connective routes between observations.

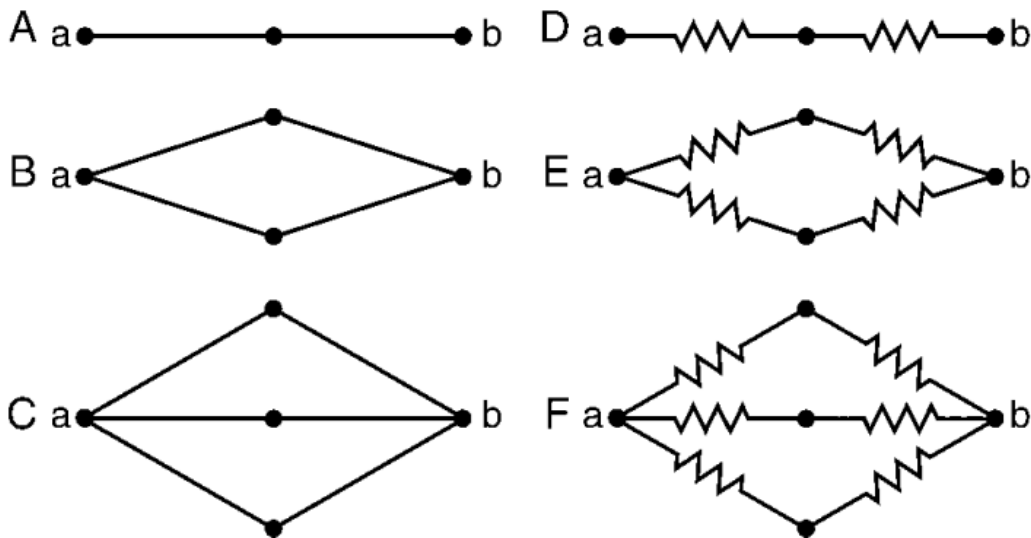
F.2 Circuitscape

Basic concepts

- F.2.1 Circuitscape applies connectivity models from circuit theory to mathematical graphs. Much of the text, and all the figures, below are adapted from the original academic outline [26]. The authors use the language of graph theory, which is therefore adopted here. Briefly, graphs are networks comprised of sets of nodes (in this case raster grid cells) connected by edges (Graphic F-1). Each edge has a weight corresponding to the strength of connection between nodes it connects. The weight can correspond to any relevant measurement, for example the ease of

movement between nodes. In the language of circuit theory, edges are resistors, and their weights represent conductance, the inverse of resistance. Graphic F-1 shows Graphs A, B, and C all connect points a and b with edges of weight 1. Graphs D, E, and F replace edges with unit resistors to create analogous circuits.

Graphic F-1 Creating analogous circuits with unit resistors.



Source: McRae, Dickson, Keitt, & Shah [26]

F.2.2 The effective resistance, analogous to the ecological term effective distance, is a measure of isolation between a pair of nodes. It incorporates multiple possible paths between nodes. Hence, the effective resistance does not reflect the distance travelled, or movement cost accrued by a single individual. Rather, it incorporates both the minimum movement distance or cost and the availability of alternative pathways. As additional links are added, individuals do not necessarily travel shorter paths but have more pathways available to them. The effective resistance decreases as more connections are added: it is small when two nodes are connected by many paths with low resistance (high conductance) edges and large when there are few paths with high resistance. In Graphic F-1, the effective resistance decreases from 2, to 1, and then to $\frac{2}{3}$ when going from top to bottom.

Moving across the landscape

F.2.3 In Circuitscape, an individual chooses to move to a neighbouring cell with probability equal to the edge’s conductance as a proportion of the other edge’s conductance values. This choice is then repeated at each subsequent step. There is therefore a relationship between effective resistance and random-walk times. Chandra, Raghavan, & Ruzzo [27] showed that the effective resistance between a pair of nodes is precisely related to the commute time between the nodes, i.e. the expected time for a random walker to move from one node to the other and back again. The commute time between any pair of nodes u and v can be calculated, where R_{xy} is the resistance of the resistor connecting nodes x and y and n is the number of nodes in the network using the following formula:

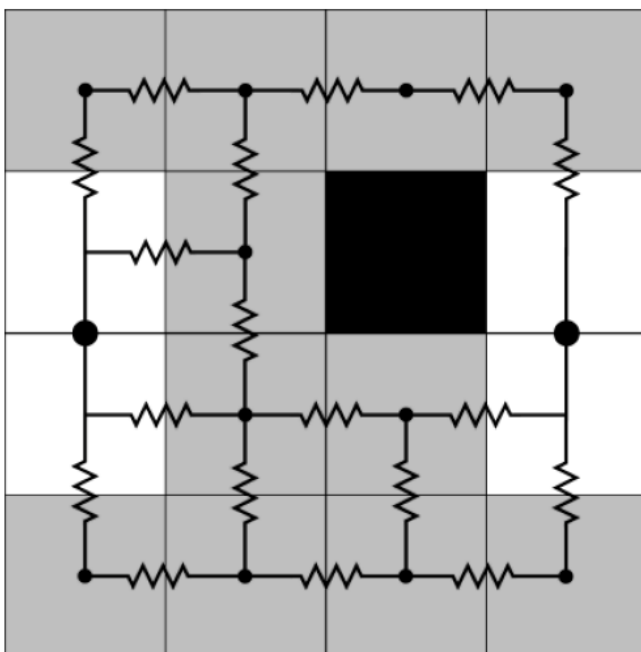
$$\text{Commute time} = R^{uv} \sum_{x=1}^n \sum_{y=1}^n \left(\frac{1}{R_{xy}} \right)$$

F.2.4 Used as an ecological distance metric, the effective resistance provides a conceptual complement to commonly used least-cost distances in two important ways. First, it integrates all possible pathways into distance calculations, whereas least-cost distances are measured along a single optimal pathway. Second, it offers a measure of isolation assuming a random walk, whereas least-cost distances presumably reflect the route of choice if a disperser has complete knowledge of the landscape it is traversing. Furthermore, the two metrics taken together can provide a measure of redundancy. When two identical and independent pathways connect a pair of nodes in parallel, the resistance distance will be half the least-cost distance of an alternative single pathway. The ratio of the two measures is therefore indicative of the number of parallel pathways that are available between nodes.

Raster grids as circuits

F.2.5 Preparing a raster grid for use with Circuitscape involves first assigning resistances to different habitat types in the grid. Graphic F-2 shows a simple example with three different habitat types: assigned unit, infinite and zero resistance. To represent a grid as a circuit, cells with finite resistances are converted to nodes (grey), whereas cells with infinite resistance (i.e. those representing complete barriers, black) are dropped. Adjacent nodes are connected by resistors, with resistances reflecting a function (typically the mean) of the resistances of the cells they connect. Adjacent cells with zero resistance (open) are consolidated into a single node that is then connected by resistors to all nodes adjacent to the zero-resistance patch. The example landscape contains two contiguous patches of zero-resistance cells (open), dispersal habitat of finite resistance (grey) and one “barrier” cell with infinite resistance (black). Cells with finite resistance are replaced with nodes (small dots) and adjacent nodes are connected by resistors. Patches of cells with 0 resistance are each consolidated into a single node (large dots).

Graphic F-2 A simple landscape represented as both a grid and a circuit.

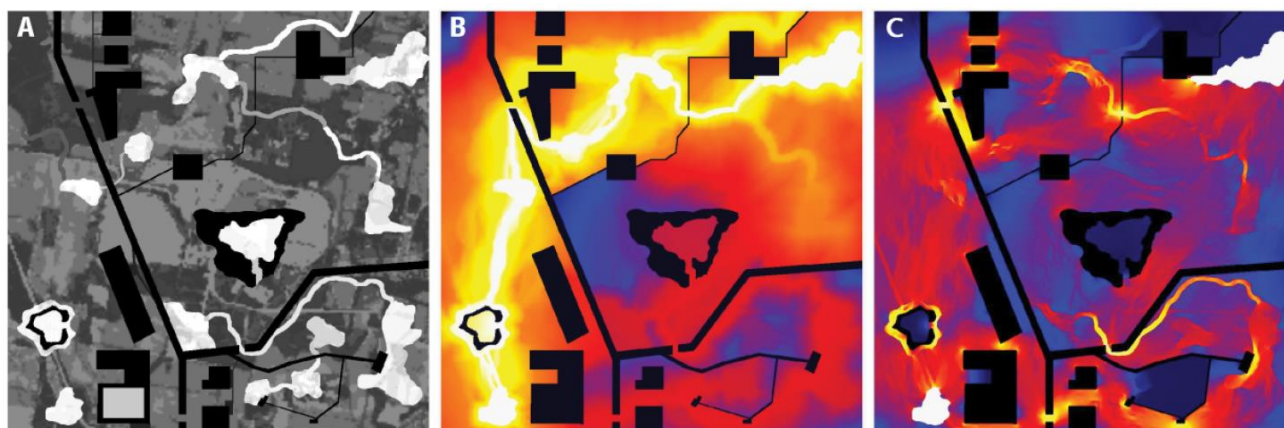


Source: McRae, Dickson, Keitt, & Shah [26]

Calculation and example output

- F.2.6 To perform efficient calculations, nodal analysis is used in matrix form to deduce voltages at each node. Once these are known, Ohm's law¹ can be used to calculate currents passing through individual resistors or nodes. These currents are what is reported in Circuitscape's output rasters.
- F.2.7 Graphic F-3 shows an example output from both a traditional least-cost model and a circuit-based model. The habitat patches of interest are indicated in white in the bottom left and top right corners. The three sub-graphics show:
1. Map of the landscape, with resistances ranging from 1 (light grey) to 100 (dark grey) to infinite (black).
 2. Results from least-cost modelling. The value assigned to each cell indicates the cost accumulated moving along the most efficient possible route that passes through the cell from one habitat patch to the other.
 3. Current map between the same two habitat patches. Higher current densities indicate cells with higher net passage probabilities for random walkers moving from one patch to the other.
- F.2.8 The map highlights "pinch points," or critical habitat connections, between the two patches.

Graphic F-3 Connective elements identified using least-cost path and circuit models in a complex landscape.



Source: McRae, Dickson, Keitt, & Shah [26]

- F.2.9 The number of pairs to be calculated amongst n nodes is $n(n - 1)/2$. It follows that Circuitscape scales quadratically with the number of nodes. From project experience, each pair takes approximately 1 second to compute on a normal desktop computer. It follows that a 2000 node sample takes approximately 23 days to compute.

¹ Ohm's law states that when a voltage V is applied across a resistor, the amount of current I that flows through the resistor depends on (1) the voltage applied and (2) the resistance R , such that $I = V/R$.

F.3 Data preparation

Data inputs

- F.3.1 Circuitscape requires two key data inputs. First, it needs a resistance layer, which describes areas of the landscape a species is more or less likely to move through. Second, it needs a list of point locations, between which to draw paths of least resistance. Details of how these datasets were produced are provided below.

Resistance layers

- F.3.2 Circuitscape requires a habitat file that describes the environment through which the species migrate [28]. This was provided as a series of raster resistance layers that contained information about habitat suitability. Raster cells with high values represented habitats bats were less willing or able to move through. As such, those areas were considered to have a high 'resistance' to bat migration. A separate raster layer was created for each of the ten bat species and genera considered in our analysis. Each layer had a resolution of 50mx50m and captured habitat information within a 7km buffer of the proposed construction boundary.
- F.3.3 Habitat 'resistance' was derived by combining four separate environmental layers: land cover type, inland water, hedgerows and light pollution. A description of these layers, and how they were combined is summarised below.

UK Centre for Ecology & Hydrology Land Cover Map

- F.3.4 Most habitat types were captured using the UKCEH 2023 Land Cover Map [29]. This is a raster layer derived from satellite data that classifies all land in the UK as one of 21 land cover types. Columns 1 and 2 of Table F-1 below provide the ID and description respectively of these land cover types. For a given species, we assigned resistance scores for each land cover type, as shown in columns 3 to 13 of Table F-1. These resistance scores (between 1-100) were assigned by a bat ecologist, based on each species' habitat preferences as set out in the literature. A score of 1 reflected a highly suitable habitat and 100 highly unsuitable habitat. Scores were assigned based on academic literature provided in Bat Conservation Trust guidelines [30] and the Favourable Conservation Status guidance for both barbastelle [31] and Bechstein's [32].
- F.3.5 These resistance scores were used to make land cover resistance layers for the entire study area, as illustrated in Graphic F-4. In this example, an area of land contains deciduous woodland (1), arable (3) and urban (20) land cover types. The resistance scores for common pipistrelle (column 4 in Table F-1) were then used to create a species-specific resistance layer that reflects this species' habitat preferences.

Graphic F-4 Illustration of using UKCEH land cover type to generate land cover resistance layers for common pipistrelle.

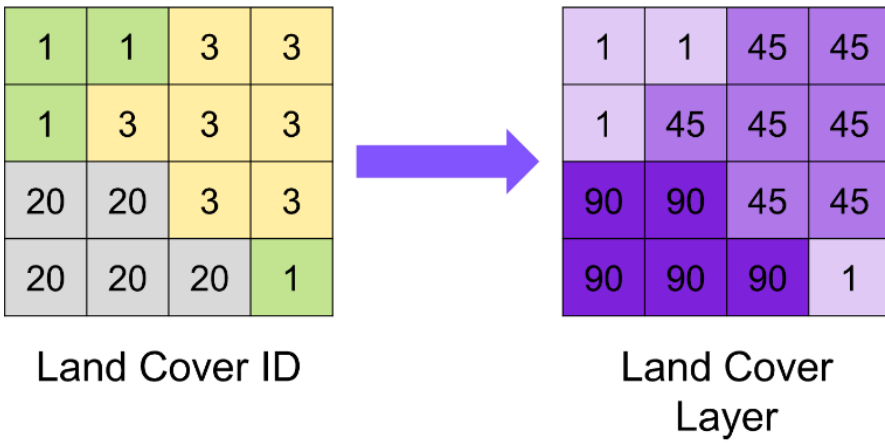


Table F-1 Summary of species resistance score for all UKCEH land cover types

Land Cover ID	UKCEH Land Cover Class	Barbastelle	Common pipistrelle	<i>Myotis</i> sp.	Long-Eared sp.	Soprano pipistrelle	Nathusius' pipistrelle	Serotine	Leisler's bat	Noctule	Bechstein's bat	Greater horseshoe bat
1	Deciduous woodland	1	1	1	1	1	1	1	1	1	1	1
2	Coniferous woodland	50	45	25	10	25	25	25	10	10	5	50
3	Arable	75	45	75	70	45	45	60	35	35	50	75
4	Improved grassland	70	40	70	70	40	40	40	45	45	40	70
5	Neutral grassland	70	15	50	40	15	15	15	15	15	70	70
6	Calcareous grassland	70	15	50	40	15	15	15	15	15	70	70
7	Acid grassland	70	15	50	40	15	15	35	15	15	70	70
8	Fen	50	20	20	40	20	20	20	30	30	50	50
9	Heather	25	10	15	15	10	10	10	15	15	25	25
10	Heather grassland	70	15	50	40	15	15	15	15	15	70	70
11	Bog	50	20	20	40	20	20	20	30	30	50	50
12	Inland rock	100	90	95	99	90	90	90	80	80	100	100
13	Saltwater	10	5	15	25	5	1	10	10	10	15	10
14	Freshwater	50	20	10	20	20	20	15	10	10	50	50
15	Supralittoral rock	10	10	20	30	10	5	10	10	10	30	10
16	Supralittoral sediment	10	10	20	30	10	5	10	10	10	30	10
17	Littoral rock	10	10	20	30	10	5	10	10	10	30	10
18	Littoral sediment	10	10	20	30	10	5	10	10	10	30	10
19	Saltmarsh	10	10	20	30	10	5	10	10	10	30	10
20	Urban	100	90	95	99	90	90	90	80	80	100	100
21	Suburban	95	15	85	90	15	30	95	30	30	15	95

Inland water, hedgerows and light pollution

- F.3.6 Three other landscape features were also used to create the final resistance layer: inland water, hedgerows and light pollution. These features were included as they are all known to significantly influence bat species' presence.
- F.3.7 Inland water provides both a drink and invertebrate prey source for foraging bats, while rivers and streams act as natural commuting corridors. Species such as Daubenton's bat, show strong affiliations with standing bodies of water where they glean prey off the surface. Noctule and Nathusius' pipistrelle are also regularly associated with waterbodies. Similarly, hedgerows provide sheltered commuting corridors for bats, reducing their risk of predation and attracting prey species such as moths. Species such as barbastelle and Bechstein's are known to favour hedgerows in pastoral landscapes and gaps or disturbance (i.e. noise or light pollution) of linear features can significantly impair bat movement in the landscape. Lastly, it is well documented that all species of bat are impacted by high light levels, with some species entirely avoiding well-lit areas for roosting, foraging and commuting (Collins, 2023; Reason & Wray, 2023).
- F.3.8 As these features are not captured in the UKCEH Land Cover Map, they were included in additional layers which were combined with the land cover layer to create a final resistance layer (see Section 0). The rest of this section describes how the inland water, hedgerows and light pollution layers were created.

Inland water and hedgerows

- F.3.9 Inland water was derived from a waterlines and surface water vector layers within the OS Open Zoomstack dataset [33], while hedgerows were obtained as a single vector layer from UKCEH Land Cover Plus: Hedgerows 2016-2021 [34]. These were used to generate inland water and hedgerow rasters for each species. For a given raster, each cell was assigned a species-specific weighting between 0 and 1 if it intersects with a vector feature. Otherwise, it was assigned a value of 1. Weightings close to 0 indicate preferred habitat and vice versa. These weightings are summarised in the first six rows of Table F-2 and, similarly to the land cover resistance scores, were based on literature within Table 3.2 of the Bat Conservation Trust 2023 guidelines [30] and the Favourable Conservation Status guidance for both barbastelle and Bechstein's (Zeale & Natural England, 2024; Natural England, 2024).
- F.3.10 An illustration of this process is provided in Figure 3-5, which shows an area of landscape containing rivers (blue lines) and hedgerows (green lines). These were used to create inland water and hedgerows rasters for common pipistrelle. Each cell that intersects with a river or hedgerow vector was assigned a weighting of 0.2 and 0.1 (see Table F-2). All other cells were assigned 1.

Graphic F-5 Illustration of using inland water and hedgerow features to create resistance layers for common pipistrelle.

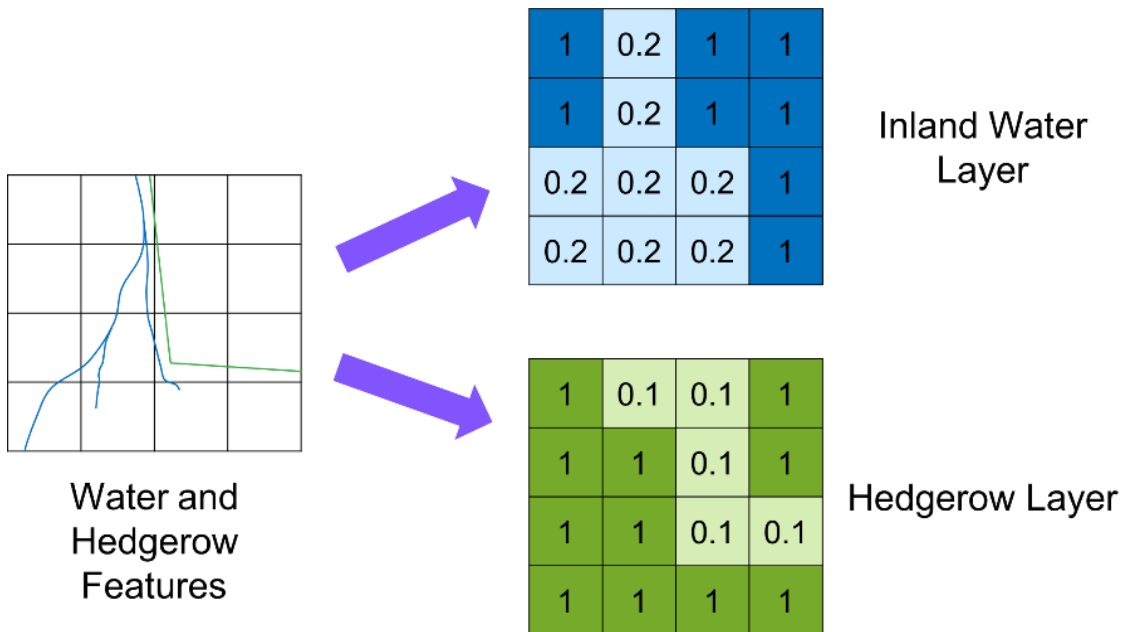


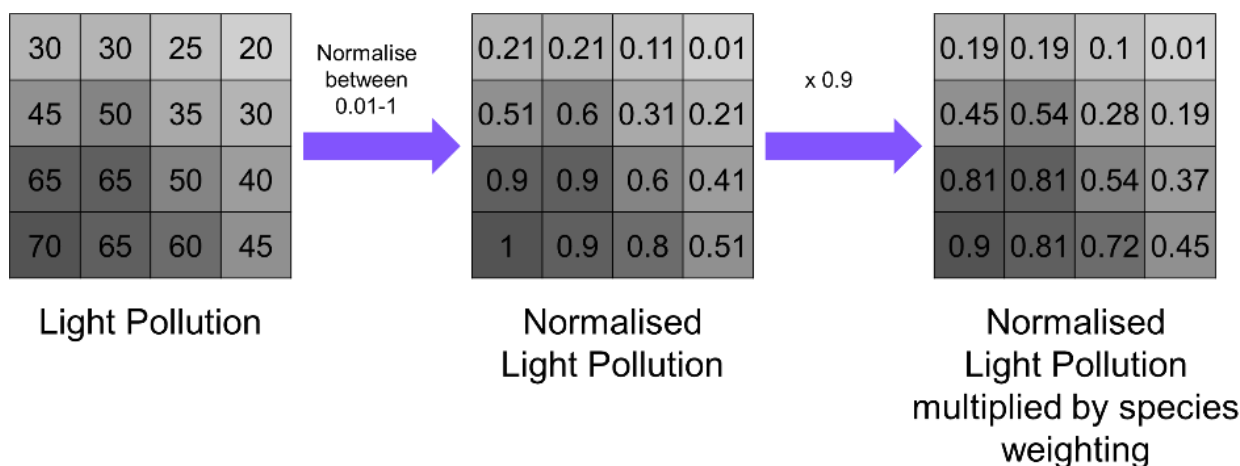
Table F-2 Summary of species resistances weightings for inland water, hedgerows and light pollution.

Habitat Feature	Barbastelle	Common pipistrelle	Myotis sp.	Long-Eared	Soprano pipistrelle	Nathusius' pipistrelle	Serotine	Leisler's bat	Noctule	Bechstein's bat	Greater horseshoe bat
Inland Water ¹											
Yes	0.6	0.2	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.6	0.6
No	1	1	1	1	1	1	1	1	1	1	1
Hedgerows ¹											
Yes	0.15	0.1	0.15	0.15	0.1	0.1	0.15	0.15	0.15	0.05	0.15
No	1	1	1	1	1	1	1	1	1	1	1
Light pollution											
Weighting	1	0.9	0.95	0.99	0.9	0.9	0.9	0.8	0.8	1	1

Light pollution

- F.3.11 Light pollution was obtained from F18 2013 raster layer, within the Version 4 DMSP-OLS Nighttime Lights Time Series dataset [35]. Information about light pollution within this layer was derived to night-time satellite imagery collected by the U.S. Air Force Defense Meteorological Satellite Program.
- F.3.12 To create the species resistance layers, the light pollution values were first normalised between 0.01 and 1 and then multiplied by species-specific weighting², reflecting how sensitive each species is to light pollution. These weightings are shown in the final row of Table F-2 and, similarly to the other weightings, were based on literature within Table 3.2 of the Bat Conservation Trust 2023 guidelines [30] and guidelines for bat mitigation on roads [36].
- F.3.13 An example of this process for common pipistrelle is provided in Figure 3-6. Light pollution values are first normalised between 0.01 and 1, then multiplied by a weighting of 0.9 (see Table F-2) to create a light pollution resistance layer.

Graphic F-6 Illustration of using light pollution raster to create a resistance layer for common pipistrelle



Creating resistance layers

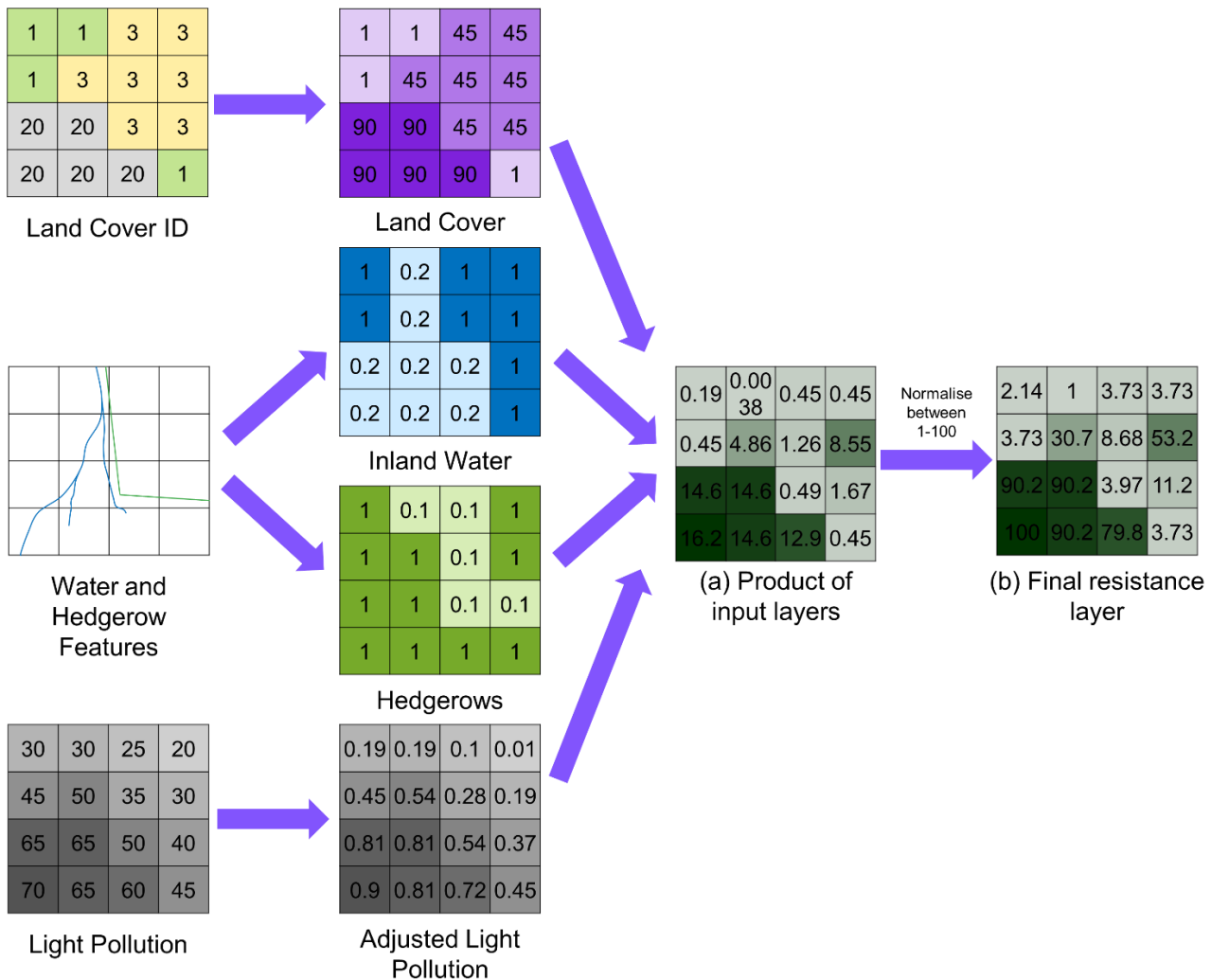
- F.3.14 The land cover, inland water, hedgerows and light pollution layers were combined to create a final set of species resistance layers. This was done by multiplying the input layers together such that each cell in the final layer was the product of the corresponding cell values within the four input layers. These composite layers were then normalised between 1 and 100, for ease of interpretation.
- F.3.15 Multiplying these layers together acts as a weighting system, which adjusts the initial resistance within in the land cover layer based on the presence of other relevant features in the landscape. The presence of inland water and hedgerows causes a cell’s resistance to be reduced, reflecting the fact that bats show a preference for these habitat types. Similarly, the light pollution layer causes darker areas to be reduced more than brighter areas. As Circuitscape is only sensitive to the relative size of cell values (i.e. it looks for the path of least resistance,

² Normalising between 0 and 1 was avoided because this would have given the cells in the study area with the lowest light pollution a final resistivity of 0 (see paragraph F.3.15 for an explanation of how the layers were combined). That is, a value of 0 within the light pollution layer would cause that same cell to have a final resistivity of 0. Areas of the landscape with no resistivity to migration were considered unrealistic, therefore, the normalisation of light pollution was adjusted to avoid this outcome.

regardless of how large the numbers are) this has the effect of adding additional resistivity to areas with high light pollution. By varying the resistance scores (Table F-1) and weightings (Table F-2), the final resistance layer can therefore be adjusted for each species to reflect its known habitat preferences.

F.3.16 An example of this aggregation process is shown for common pipistrelles in Graphic F-7. Here, the four input layers shown in Graphic F-4 to Graphic F-6 were multiplied together to create a single composite layer (a). This was then normalised to produce a final resistance layer (b).

Graphic F-7 Illustration of combining the land cover, inland water, hedgerows and light pollution layers to create a final resistance layer for common pipistrelle.



F.3.17 To illustrate this process for a single cell, Graphic F-4 shows that the top-left location started with an initial land cover resistance of 1, reflecting the fact that it is a suitable habitat for common pipistrelle (deciduous woodland). It contained no rivers or hedgerows, so was not affected by these layers, but was in a relatively dark area, resulting in an overall resistance of 0.19 (1 x 1 x 1 x 0.19). This was then normalised to 1.25. Conversely, the top-right cell was arable land with a much higher initial resistance of 45. However, very low levels of light pollution resulted in a similar composite resistance of 0.45 (45 x 1 x 1 x 0.01), normalised to 1.54.

F.3.18 The final resistance layers are shown in the following figures (Document reference 6.3, DCO Volume 6):

1. ES Figure 8.22, Habitat suitability modelling output for *Myotis* species, Volume III
2. ES Figure 8.23, Habitat suitability modelling output for long-eared bats, Volume III
3. ES Figure 8.24, Habitat suitability modelling output for Bechstein’s bat, Volume III
4. ES Figure 8.25, Habitat suitability modelling output for greater horseshoe bat, Volume III
5. ES Figure 8.26, Habitat suitability modelling output for common pipistrelle, Volume III
6. ES Figure 8.27, Habitat suitability modelling output for Nathusius’ pipistrelle, Volume III
7. ES Figure 8.28, Habitat suitability modelling output for soprano pipistrelle, Volume III
8. ES Figure 8.29, Habitat suitability modelling output for barbastelle, Volume III
9. ES Figure 8.30, Habitat suitability modelling output for serotine, Volume III
10. ES Figure 8.31, Habitat suitability modelling output for Leisler’s bat, Volume III
11. ES Figure 8.32, Habitat suitability modelling output for noctule, Volume III

Observed presence locations

F.3.19 Observations were generated by combining static monitoring data with historical desk study data. The sample size for each species is shown in Table F-3. As the runtime of Circuitscape increases quadratically with the number of observations, it was necessary to cut down the number of observations to avoid infeasible execution times. To maximise the number of species that retained their full sample size, both common pipistrelle and soprano pipistrelle were down-sampled such that their sample size equalled that of the next most populous species – *Myotis* sp.

Table F-3 Table of sample sizes used for each species.

Species	Original sample size	Reduced sample size
Barbastelle	108	108
Bechstein	156	156
Common pipistrelle	2169	713
Greater horseshoe bat	5	4
Leisler’s bat	78	78
Long-eared bat	513	513
<i>Myotis</i> sp.	713	713
Nathusius pipistrelle	130	130
Noctule	542	542
Serotine	509	509
Soprano pipistrelle	1594	713

- F.3.20 The down-sampling method prioritised removing points from areas with a high concentration of observations. The steps involved in this down-sampling were as follows.
1. Check if current sample size is larger than the desired sample size (i.e., 713). If it is:
 - a. Identify the pair of points with the smallest Euclidean (i.e., geographical) distance. This is determined using Easting and Northing grid references.
 - b. Measure the distance of these two points to their second closest neighbour.
 - c. Delete the point with the closest second neighbour.
 - d. Return to the check in step 1.
 2. If current sample size is equal to the desired sample size (i.e., 713), end the down-sizing process.
- F.3.21 The reason for this approach was to maximise the retention of unique information within our reduced sample. For example, if a large number of observations are concentrated a small area (e.g. a woodland), they can be said to contain the same essential information (i.e. that the species is found in that woodland). As a result, each observation in this area contains less unique information compared to a single observation in a different part of the landscape. To maximise the retention of uniquely useful information, the priority was to remove points from areas with a high concentration of existing observations.

F.4 Model parameters

- F.4.1 There are various configuration parameters to be chosen when using Circuitscape. These ensure Circuitscape functions as expected, but they cannot be ‘tuned’ to improve performance [37].
- F.4.2 Three modelling modes are available when using raster data: Pairwise, one-to-all and all-to-one. The modelling mode defines how Circuitscape plots paths between nodes. The pairwise mode was used as one-to-all and all-to-one are used for plotting migration to and from a specific ‘hub’, so are not appropriate for this case.
- F.4.3 The habitat suitability inputs were framed in terms of resistance, rather than conductance. This is the most common usage of Circuitscape and is the default behaviour.
- F.4.4 Circuitscape provides the option to connect to the four or eight nearest neighbours of each cell. Eight were chosen in the interest of achieving the most accurate and granular outputs.
- F.4.5 The output format selected was a single cumulative current map.

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from
Southern
Water. 

The logo graphic for Southern Water, featuring three stylized, white, wavy lines that resemble water or a flame, positioned to the right of the word "Water".