

APPLIED ECOLOGY

Amy Dolan and Naomi Hoolahan
Itison
Itison House
29 Cochrane Street
Glasgow
G1 1HL

By email

21 November 2025

Dear Amy and Naomi.

Re: Ecological support for GlasGLOW 2025

Following the completion of our commission to supply ecological support for your GlasGLOW event in October-November 2025, I am writing today to provide a summary of our input for inclusion in your close-out documentation.

A summary of our input this year would be:

- First communications with us about the 2025 event were in April. Potential new hazards were brought to our attention, including the use of “slinkies”, a set of giant guitar strings and associated UV lighting.
- Advice given was that neither the slinkies or the strings were likely to present a night-time entanglement issue for bats, but could be so in the daytime for birds. The possibility of some form of day time wrapping was mooted.
- With regards to the UV lighting, our advice was that this should avoid the tunnel areas and the edge of the SINC. We provided a reminder that all lighting of sensitive areas (UV or otherwise) needed to comply with the ILP best practice.
- In May 2025, further advice was sought regarding the giant tap installation, as this would require the use of blue light. We determined that at ground level, blue lighting would not be a problem, but that blue lighting needed to be avoided at height.
- We were supplied with an [incomplete] production summary in early September 2025. On review, this included a number of new installations which had not yet been discussed, including at height lighting of the tea room, and a large television-type screen facing into the SINC. A sketch was provided by AEL to show the maximum permitted height of the lighting at the tea room (a precautionary response as it is not known whether or not bats use this building) and mitigation for the TV screen. It would have been preferable for the screen to be located so that its light cast away from the SINC rather than towards it, but the staging for this was already in place.
- During the pre-event walk arounds, a small number of issues were noted including that the lighting cut off point on the tea room needed correcting, there were blue lights in trees in sensitive areas and lights in one of the trees with bat roosting suitability. Itison was quick to respond to the feedback.
- The post-event close-out visit did not identify any residual issues.

Cont./

/cont.

As you start to plan the 2026 event, the following recommendations may be useful:

- (i) It may be beneficial for AEL to support you in your meeting with the community council. This could be instead of, or in addition to, the public consultation event.
- (ii) Earlier supply of complete design ideas and/or the production summary, to minimise the number of changes which may need to be made relatively late in the pre-event programme.
- (iii) An ecology visit on a random event night to provide confirmation that requested changes noted during the dress rehearsal have been implemented. This would strengthen itison's position with regards to adherence to the environmental protection principles.

Overall, we were satisfied that feedback given in advance of the opening of the event was taken on board, and given the time of year and location we were content that impacts and their effects were low. The additional recommendations made here would demonstrate an ongoing commitment to improving environmental performance wherever practicable.

With best wishes,

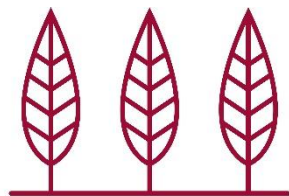
(by email)

Dr Rachel Hirst CEng CEnv MCIEEM

Director (Scotland)

On behalf of Applied Ecology Ltd

rachel.hirst@appliedecology.co.uk



GlasGLOW Post-event Check

19 November 2025

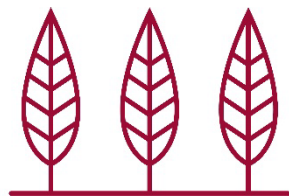
APPLIED ECOLOGY

Work Section	Reporting status ¹	Date	Observations	Recommendations/actions needed
Site-wide	Complete	19 November 2025	The ECoW undertook a post-event walkover in the section of the Botanic Gardens where the GlasGLOW event was held. All event equipment, lighting and installations had been removed from the Site and the ECoW noted no biodiversity-related issues or damage arising from the event. Areas of grass that had been covered by ground protection in the central part of the Site showed some yellowing, but it was considered likely that this would recover in the short to medium term; amenity grassland issues fall outwith the remit of the ecology support provided.	N/a

Ends.

¹ n/a; needs action; in progress; resolved or complete.





GlasGLOW Pre-event Check

22 October 2025

APPLIED ECOLOGY

Work Section	Reporting status ¹	Date	Observations	Recommendations/actions needed	Client/contractor informed (when/how/means)
Site-wide	In progress	22 October 2025	The ECoW undertook both a daylight and night time walkover in the section of the Botanic Gardens where the GlasGLOW event was being held. This allowed the ECoW to walk the route in clear daylight, as well as with the light and sound running.	n/a	n/a
Tree protection-Marshmallowland	Needs action	22 October 2025	During the day time walkover, the ECoW noted that one of the fire pits within the "Marshmallowland" section of the Site was positioned below a low-hanging willow branch. This was highlighted to Itison, who stated they would move the fire pit to a suitable position.	Re-position the fire pit away from low hanging vegetation to avoid risk of fire and tree damage.	Client informed on Site and via this report.
Lighting-Site-wide	Needs action	22 October 2025	During the night time walkover, the ECoW noted blue and white lighting in the tree canopies across Site (see picture below). As stated in the "Ecological Sensitivities and Opportunities Report" produced by Applied Ecology (AEL) in 2023, lights with blue components must not be used to light trees and/or key potential bat foraging or commuting features. Instead warm white sources (2700 Kelvin or lower) and peak wavelengths higher than 500 nm should be used. Blue and white lighting is acceptable at ground level and outwith suitable bat foraging and commuting habitat.	As outlined in previous reporting, white blue lighting should be removed from the sequences in established tree canopies, particularly those associated with likely bat commuting and foraging corridors. .	Client informed on Site and via this report.

¹ n/a; needs action; in progress; resolved.



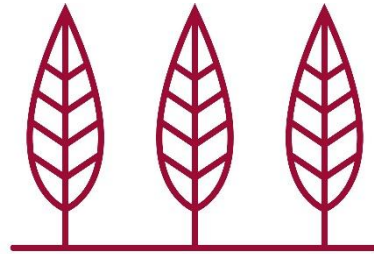
					
Lighting- PRFs	Needs action	22 October 2025	A tree, noted as having Bat Roost Suitability(BRS), within the “Tam Shepherd’s World of Magic” area was noted as lit with multi-coloured flood lighting (see picture below). This included blue and white lights, which are unsuitable for trees with roost features as they can “disturb” roosting bats. 	Blue and white lights should be removed from the tree to avoid potentially disturbing a bat roost. Red light would be the only suitable light colour for trees with BRS.	Client informed via this report.
Lighting- Railway tunnels	In progress	22 October 2025	The ECoW noted that moving spot lights were used to light the ground above the railway tunnels. These included blue lights. The ECoW spoke with Naomi Hoolahan (Itison), who stated that they would change the lighting colour.	Blue and white lights to be removed from the flood light directed towards the tunnel, to avoid potentially disturbing foraging and commuting bats.	Client informed on Site.



Lighting- SINC & colony bat box	Needs action	22 October 2025	The ECoW noted that the interactive television within the “Best Fans in the World” section of the event contained bright flashing blue and white lights. This caused adverse light to spill into the SINC and onto the tree which contained the colony bat box. As stated in the AEL report “Illuminating roost sites is generally considered to be “disturbance” in the context of the current legislation protecting bats in Scotland, as doing so can cause bats to desert a roost or potentially become entombed. If not dissuaded from using the roost, lighting a roost exit point can delay emergence times, thereby decreasing the available time for foraging”. The colony bat box on Site has been in situ for many years, and could be in use by roosting bats at this time of year.	Reduce light spill onto the SINC. No lighting be projected onto the colony bat box, particularly blue and white lights as this is likely to cause disturbance to a bat roost.	Client informed on Site and via this report.
Lighting – tea rooms	Needs action	22 October 2025	On 9 October 2025, Applied Ecology highlighted to Itison via email that the tea rooms was noted as potentially having bat roost suitability. Therefore, the plan for direct lighting of the tea rooms would not normally be acceptable. As a minimum, lighting would only be acceptable if the lighting line/spill does not extend into the soffit area. Although the roof itself was not lit, the ECoW noted that lighting extended to the soffit, and included lights with blue and white frequencies. 	Lighting of the building must be below the soffit area (as outlined in an email from Rachel Hirst to Itison on 9 October 2025).	Client informed on Site and via this report.

Ends.





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GlasGLOW

Bat Activity Studies

Produced for Itison Ltd

By Applied Ecology Ltd

April 2026

Project number: AELSC0850

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1.0	09 April 2026	Final - issue	DS	RAH	RAH

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1 Introduction

Background

- 1.1 In August 2023, Applied Ecology Ltd (AEL) was commissioned by itison to provide ecological support for their autumn sound and light event known as GlasGLOW ("the Event"), which is held in the Glasgow Botanic Gardens ("the Site"), in the West End of the City of Glasgow. A plan showing the location of the Site is provided in **Figure 1.1**.
- 1.2 GlasGLOW has run annually within the Botanic Gardens since 2018, and although sustainability has always been a consideration in the design and planning of the Event, since 2023 itison has appointed a dedicated sustainability specialist to advise on all stages of their event planning and delivery. As part of this, and recognising that the Event takes place within public greenspace with its own intrinsic sensitivities, Glasgow City Council (GCC) has also required itison to engage with an independent ecological consultant, to provide objective advice regarding how the GlasGLOW event can be designed and run so as to minimise its biodiversity impact. AEL has therefore been providing that ecological advice since 2023.
- 1.3 During the initial 2023 commission, a knowledge gap was identified regarding the quantity, location and type of bat activity within the parts of the Botanic Gardens in which the Event was to take place. A proposal was therefore put together for a bat monitoring study covering the late summer and pre-hibernation periods, including the nights which would be covered by the Event. The findings of that study can be found in full elsewhere¹, but in summary at least five species of bat were using the Gardens during the 2023 recording period, and at least three of these had not previously been formally recorded there. Bat activity was concentrated in the area in the vicinity the former Botanics railway station and it was thought likely that this was the entry location to a well-used roost of common and soprano pipistrelle bats. The nature of this roost, and whether or not this included hibernaculae, could not be determined. In general, the levels of recorded bat activity varied significantly between sampling locations and over time, and appeared to be determined by ambient temperatures rather than rainfall. Activity decreased throughout the autumn, levelling off in the first two weeks of October. No discernible effect of the Event could be detected in the 2023 data.
- 1.4 A number of limitations to the 2023 data collection were identified, including:
 - the potential effect of detector failures leading to breaks in the recording;
 - subjectivity of detector placement;
 - the representativeness of a single survey season.
- 1.5 Given these potential limitations, AEL was recommissioned by itison to repeat the sampling during the 2024 and 2025 GlasGLOW events.

¹



Purpose of this report

- 1.6 This report covers all three bat monitoring study periods undertaken within the Glasgow Botanic Gardens between September and November in 2023, 2024 and 2025. It includes an outline of the methods and sampling strategy adopted, a summary of the findings from all three years, and an evaluation of the implications of these, both in the context of the Event, and the Botanic Gardens more generally.

Report qualification

- 1.7 The surveys described here were undertaken in accordance with the best practice methodologies current at the time of commissioning. Site circumstances, scientific knowledge or methodological requirements can change during the course of a project, and these external factors may impact on the scope of subsequent work requirements.
- 1.8 AEL is an audited Chartered Institute of Ecology and Environmental Management (CIEEM) Registered Practice. All survey work and reporting were therefore undertaken by experienced and qualified ecologists in accordance with the Code of Professional Conduct of the Chartered Institute of Ecology and Environmental Management (CIEEM), as well as guidance produced by the Bat Conservation Trust (BCT) and that contained in BS 42020:2013 (Biodiversity).
- 1.9 All ecological surveys have an expected validity period, owing to the tendency of the natural environment to change over time. This validity period varies from feature to feature, and is also dependent on the degree of change in a site's management and overall landscape ecology. Where the potential for change is considered to be relevant to the Site, this is highlighted in the appropriate section.
- 1.10 This report does not purport to provide detailed, specialist legal advice. Where legislation is referenced, the reader should consult the original legal text, and/or the advice of a qualified environmental lawyer.



GlasGLOW Bat Study

Site Location

 Site boundary

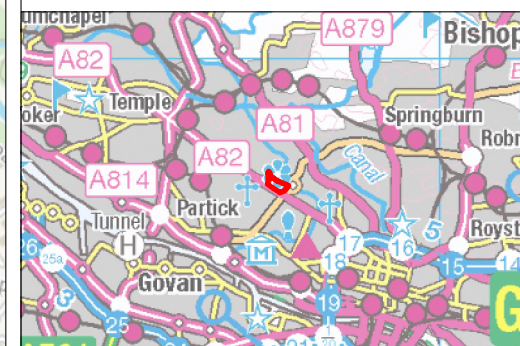


Figure 1.1

Map Scale @ A4: 1:15,000



Surveyed by: -

Survey date: -

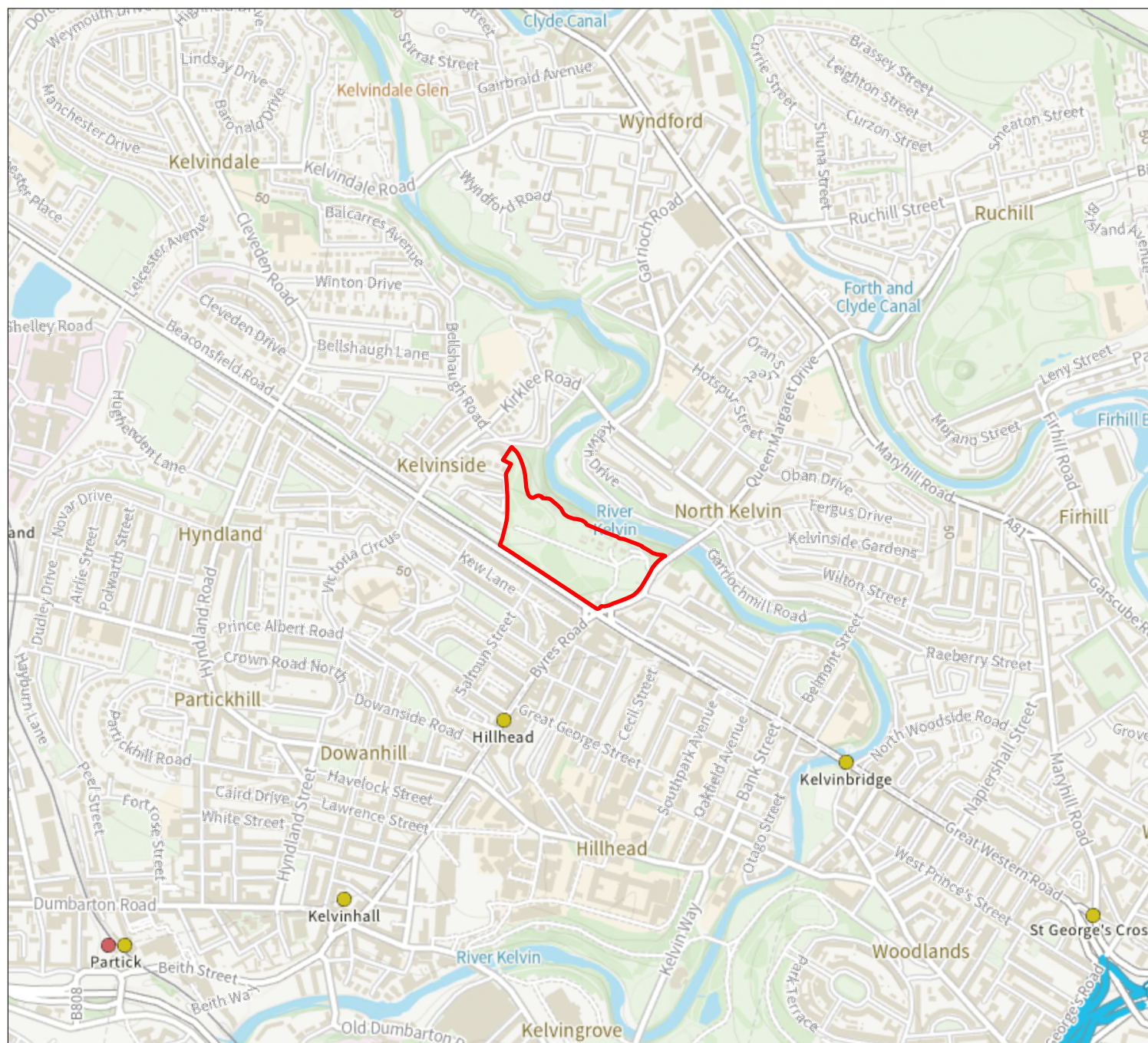
Drawn by: RAH

Checked by: DS

Status: Final



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2 Method

Sampling strategy

- 2.1 The sampling locations used in 2024 and 2025 were identical to those adopted in 2023. Sufficient budget was available for the use of up to five detectors, and deployment locations were selected based on:
- a need to sample a representative range of habitats within the Site;
 - availability of secure fixing points to reduce the risk of theft;
 - the presence of sufficient cover habitats to ensure concealment and reduce the probability of interference.
- 2.2 The final selected locations are shown in **Figure 2.1**, and are summarised in **Table 2.1** below.

Table 2.1: Description of detector deployment locations

Location	Easting	Northing	Habitat
1	256795	667404	Above exposed section of the old Botanic Gardens railway station.
2	256719	667512	Within rhododendron bush in area of mown lawn ² .
3	256615	667682	On unlit edge of Gardens, under mature tree canopies.
4	256689	667636	Opposite the colony bat box, within wooded unlit edge of Gardens.
5	256894	667506	Adjacent to tea rooms, and other buildings with bat roosting suitability.

- 2.3 A Permit to Use the Botanic Gardens for the study was provided by GCC for the sampling periods adopted in each year. In 2023, five Wildlife Acoustics Song Meter Mini Bat full spectrum detectors were used. Throughout the 2023 sampling, issues were experienced with exhaustion of batteries and/or data cards becoming full prior to the scheduled switchover dates. Therefore, in 2024, the Song Meter Mini Bat units at Locations 1 and 3 which saw the highest data loads were substituted for Wildlife Acoustics SM4+BAT FS detectors. SM4s run off a larger battery pack and have two data card slots, and it was hoped that these would be better suited to the now known high data needs of the sampling at the two locations where these units were deployed. Given the high cost of SM4 units, they are not preferentially deployed in urban situations where the risk of theft is higher.
- 2.4 Some data loss was experienced towards the end of some of the 2024 deployment periods, and surveyor availability meant that the 2024 sampling period was shorter than that in 2023, but generally intra deployment data loss was less than in 2023. Based on this outcome, and an apparent absence of equipment interference by the public, all five locations were sampled in 2025 using SM4 detectors. Whilst some evidence of equipment

² This location was more open than aerial imagery available online implies.



tampering was seen in 2025, overall the highest number of recording nights was achieved in that year, as summarised in **Table 2.2**.

Table 2.2: Summary of full detector deployment nights 2023-2025

Sampling year	Deployment date range	GlasGLOW dates	Location detector nights					Totals
			1	2	3	4	5	
2023	04 Sept– 30 Nov	27 Oct – 05 Nov	79	84	73	74	85	395
2024	07 Sept – 17 Nov	25 Oct – 03 Nov	71	70	71	63	69	344
2025	29 Aug – 01 Dec	24 Oct – 09 Nov	84	95	92	94	95	460
Totals			234	249	236	231	249	1199

- 2.5 All of the detectors in all sampling years were programmed to record from 30 mins before sunset each night, continuing until 30 mins after sunrise. They were deployed with the following settings:
- minimum frequency of 12 kHz;
 - sampling rate of 256 kHz;
 - trigger window of 2 secs.
- 2.6 A total of 1199 full recording nights were achieved; partial recording nights were removed from the data set.

Data analysis

- 2.7 All sound files recorded by the static detectors were downloaded after retrieval and processed using Kaleidoscope software. In 2023, an experienced bat ecologist reviewed the data in AnalookW, to classify and tag each call to species level wherever possible. In 2024 and 2025 the analysis software was switched to Kaleidoscope Pro, but this only changed the workflow and would not have influenced the classification. These methods of sound analysis are in line with current guidelines for data analysis (Collins, 2023³), which recommend the manual checking of all non-*Pipistrellus* calls when using automated methods. Sound files labelled as noise were not reviewed. Subsequent statistical analysis was carried out using Excel and/or Minitab. For the purposes of this report, a single bat pass was defined as an echolocation call separated from other calls by a minimum of 2 secs.

Potential limitations associated with the study

Breaks in recording

- 2.8 As shown in **Table 2.2** and described earlier, not all of the detectors recorded continuously. This meant that for some locations there was not a continuous timeline of data. In 2023, particular issues were experienced at Location 5 once the GlasGLOW event was up and

³ Collins, J. (2023) *Bat Surveys for Professional Ecologists: Good Practice Guidelines, 4th Edition*. Bat Conservation Trust, September 2023.



running, when it was noticed that the data card in that detector had become full of noise files relatively early into the deployment period covering the commencement of the Event. It was thought likely that this was as a result of ultrasonic pulses emitting from the Event installation close to this location. A decision was taken to check this detector more frequently, meaning its changeover dates from that point onwards did not correspond with those at the other locations. Other longer gaps in data collection arose when batteries or data cards had become exhausted; the use of larger equipment sought to minimise that in the subsequent years (see earlier).

- 2.9 It should be recognised that the standard approach to the sampling of bat activity, as per current guidelines (Collins, 2023), is based on six sampling periods each of 5 nights, within a 6 month period between May and September. The data collected far exceeded those requirements, albeit it outwith the traditional “bat active” period.

Subjectivity of deployment locations

- 2.10 The locations chosen for the deployment of detectors was by definition subjective, and it is possible that detectors placed in other locations may have generated a data set with different characteristics. However, the overall patterns observed (see **Chapter 3**) were relatively consistent, and it is therefore likely that the data were reasonable representative within the logistical constraints presented by the Site and budget.

Lack of weather data

- 2.11 Summary weather data were collated during the 2023 deployment period, to provide environmental context for the recorded bat activity. The 2023 weather data showed a significant correlation between the number of passes and temperature, but no relationship was found between the number of passes and rainfall levels. There was insufficient budget resource to allow for the 2024 and 2025 weather data to be collated. However, the patterns noted in 2023 would be expected to be repeated across years, and therefore this not considered to be a limitation to the survey.

Interpretation of calls

- 2.12 Caution is always required when interpreting bat calls recorded by static bat detectors. Each recorded call represents a pass of a bat within the range of the microphone. These data do not provide information about the actual number of bats present (a high number of passes could be a single bat repeatedly foraging for an extended period of time within the range of the microphone). However, static detector data provide invaluable information regarding relative levels of activity, and times of bat passes. Experienced operators of this equipment can use the data comparatively.
- 2.13 Similarly, it was not always possible to identify recorded bat calls to species level, and *Myotis* and *Nyctalus* bats were only classified to genus. However, all pipistrelle bats recorded were classified to species level.





GlasGLOW Bat Study

Sampling Strategy

- Site boundary
- Locations of static detectors

Figure 2.1

Map Scale @ A3: 1:2,000

Surveyed by: AEL
Survey date: Sept-Nov 2023-2025
Drawn by: RAH
Checked by: DS
Status: Final



3 Results

- 3.1 A summary of the pass data recorded by the detectors on a night-by-night basis is provided in **Appendix B**.

Total passes and species composition

- 3.2 A grand total of 156,327 bat passes were recorded over the three years of the study covered by this report, as summarised in **Table 3.1**. **Figure 3.1-3.3** and **Table 3.2** show that the vast majority of these were at Location 1, above the disused railway station and tunnel entrances. Of these, soprano pipistrelles were the most frequently recorded species in 2023 and 2024. However, in 2025 common pipistrelle passes were slightly more frequent than soprano pipistrelle in terms of percentage split (50.2 % common pipistrelle vs 49.4 % soprano pipistrelle). Location 3 had the highest proportion of common pipistrelle passes, being the dominant species at this location across all three years.
- 3.3 Overall, at least five species of bat were recorded during the monitoring, although on average 99.7 % were pipistrelles. A small number of brown long-eared (BLE) bat passes (four) were picked up at Location 1 in 2023, along with a low number of *Myotis* calls. The pattern of the *Myotis* calls was indicative of these being Daubenton's bats *M. daubentonii*. Low numbers of *Nyctalus* bats were picked up at all locations except Location 2 in 2023, but only two passes at Location 4 in 2024, and a single pass at Location 1 in 2025. The sonograms from these were suggestive of Leisler's bats *N. leisleri*.

Table 3.1: Summary of species composition of recorded bat passes

Sampling year	Brown long-eared bat	<i>Myotis</i> sp.	<i>Nyctalus</i> sp.	Common pipistrelle	Soprano pipistrelle	Total
2023	4	62	12	11858	19480	31416
2024	0	95	2	18987	41182	60266
2025	0	260	1	32467	31917	64645
Total	4	417	15	63312	92579	156327

Table 3.2: Number of recorded bat passes at each sampling location

Sampling year	Location					Total
	1	2	3	4	5	
2023	25430	642	2527	2390	427	31416
2024	44179	1877	5477	7732	1001	60266
2025	40519	3727	7118	11240	2041	64645
Total	110128	6246	15122	21362	3469	156327
% of total	70.4	4.0	9.7	13.7	2.2	100



Table 3.3: Percentage of species composition of recorded bat passes

Sampling year	Brown long-eared bat	<i>Myotis</i> sp.	<i>Nyctalus</i> sp.	Common pipistrelle	Soprano pipistrelle	Total
2023	0.01	0.20	0.04	37.75	62.01	100.00
2024	0.00	0.16	0.00	31.51	68.33	100.00
2025	0.00	0.40	0.00	50.22	49.37	100.00
Mean	< 0.01	0.25	0.01	39.83	59.90	100.00

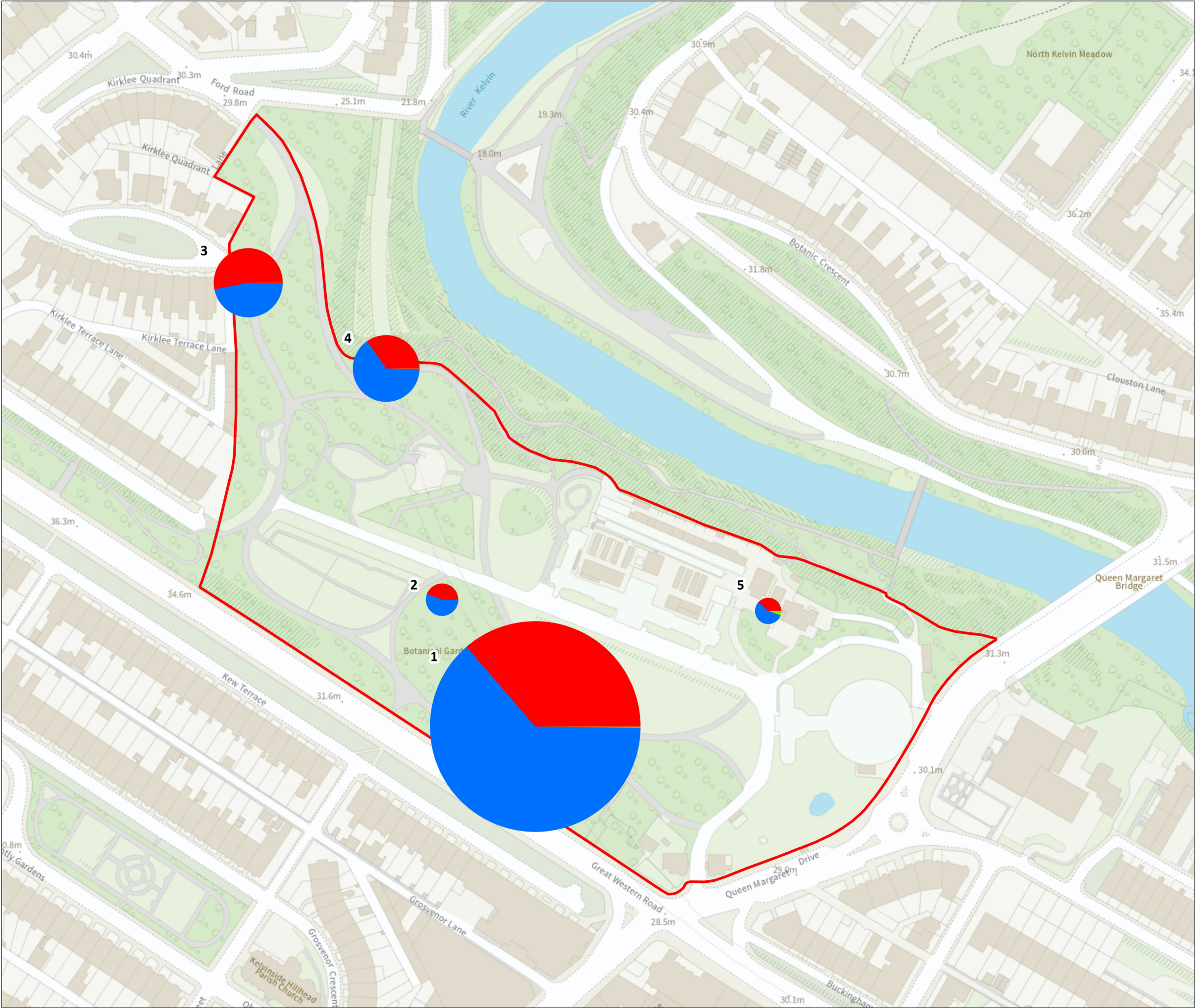
Seasonal patterns

- 3.4 A summary of activity levels throughout the sampling periods adopted in each year is shown in **Figures 3.1-3.4**, standardised across the locations through the use of passes per night (ppn). Separate charts for each sampling location are also provided in **Figure 3.5** and **Figure 3.6 (a-e)**. These charts also show the average activity rate as a solid green line, and a general trend line.
- 3.5 At all locations, and across all years, bat activity declined over the autumn months included in the sampling. This decline was more obvious at Locations 1, 2 and 5, with a more steady decline at Locations 3 and 4. In 2023, the main decrease in activity occurred around 18 October 2023, and after this time activity generally then remained low. In 2024 and 2025, activity had a notable spike around the 20 October in both years, before falling off slightly, but remaining at a level comparable to earlier in October. A second uptick in activity was then noted at Locations 3 and 4 on 06 November 2024, with activity at all locations in 2024 and 2025 reducing and remaining low from this date.

Between year variation

- 3.6 Activity levels appeared relatively consistent when comparing 2024 and 2025 data in terms of both peaks in activity, and overall pass numbers. Overall passes for 2023 were lower than in 2024 and 2025, particularly within October and November, and the same peaks in activity were not apparent in the data. The increase in activity between 2023 and 2024/2025 was mirrored across all locations.



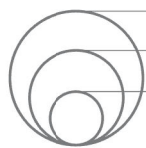


GlasGLOW Bat Study

2023 Results

Site boundary

Average passes per night (ppn):



The radius of each disc shown on the maps is proportional to the total number of ppn in the displayed recording period. The radii of the discs shown here in the legend represents the given number of ppn.

- Common pipistrelle
- Soprano pipistrelle
- Brown long-eared
- Myotis sp.
- Nyctalus sp.

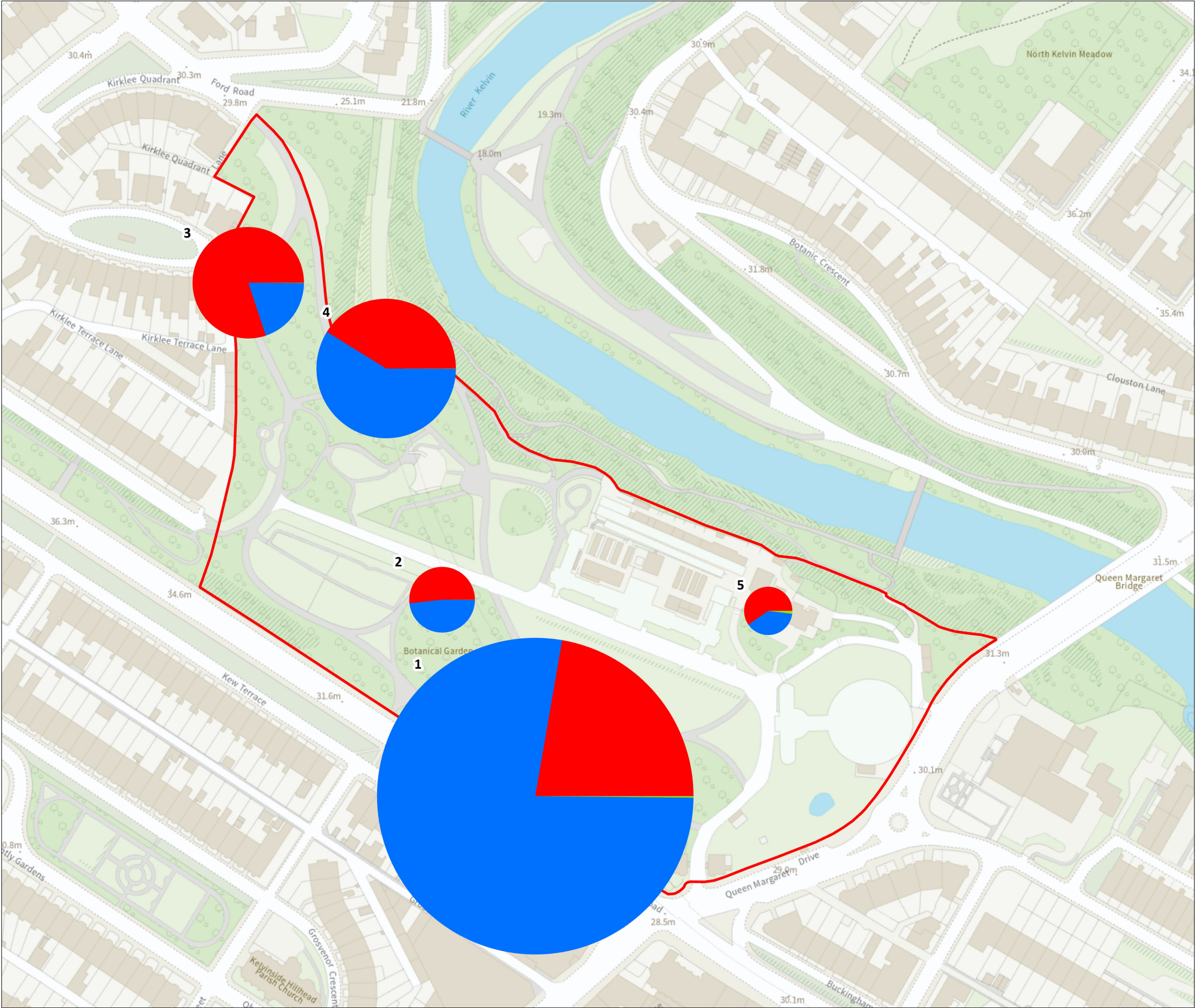
Figure 3.1

Map Scale @ A3: 1:2,000



Surveyed by: AEL
Survey date: Sept-Nov 2023
Drawn by: RAH
Checked by: DS
Status: Final



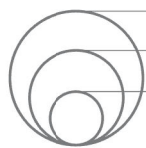


GlasGLOW Bat Study

2024 Results

Site boundary

Average passes per night (ppn):



The radius of each disc shown on the maps is proportional to the total number of ppn in the displayed recording period. The radii of the discs shown here in the legend represents the given number of ppn.

- Common pipistrelle
- Soprano pipistrelle
- Brown long-eared
- Myotis sp.
- Nyctalus sp.

Figure 3.2

Map Scale @ A3: 1:2,000



Surveyed by: AEL

Survey date: Sept-Nov 2024

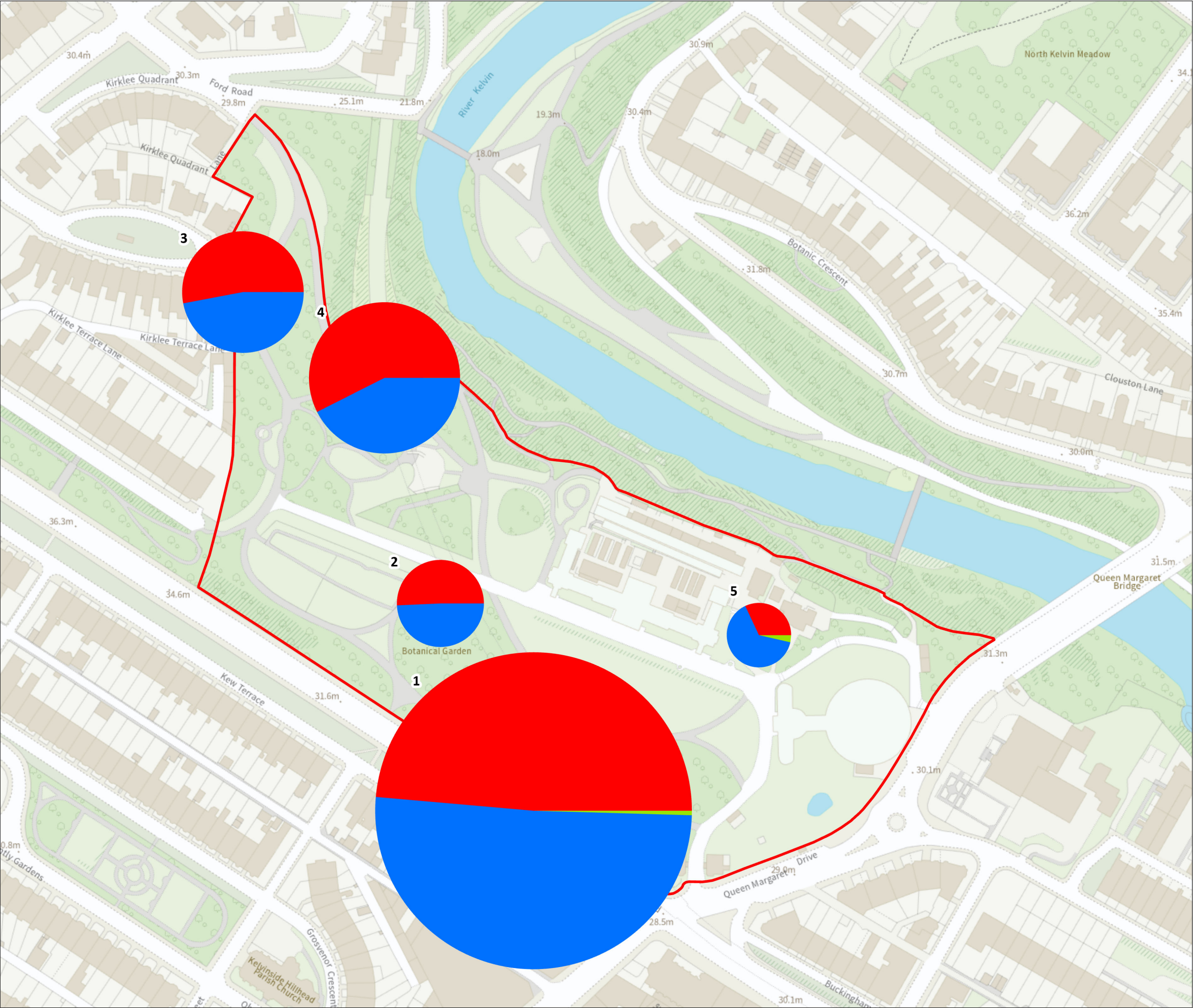
Drawn by: RAH

Checked by: DS

Status: Final



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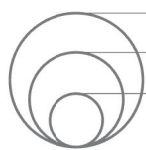


GlasGLOW Bat Study

2025 Results

Site boundary

Average passes per night (ppn):



The radius of each disc shown on the maps is proportional to the total number of ppn in the displayed recording period. The radii of the discs shown here in the legend represents the given number of ppn.

- Common pipistrelle
- Soprano pipistrelle
- Brown long-eared
- Myotis sp.
- Nyctalus sp.

Figure 3.3

Map Scale @ A3: 1:2,000



Surveyed by: AEL

Survey date: Sept-Nov 2025

Drawn by: RAH

Checked by: DS

Status: Final



APPLIED ECOLOGY

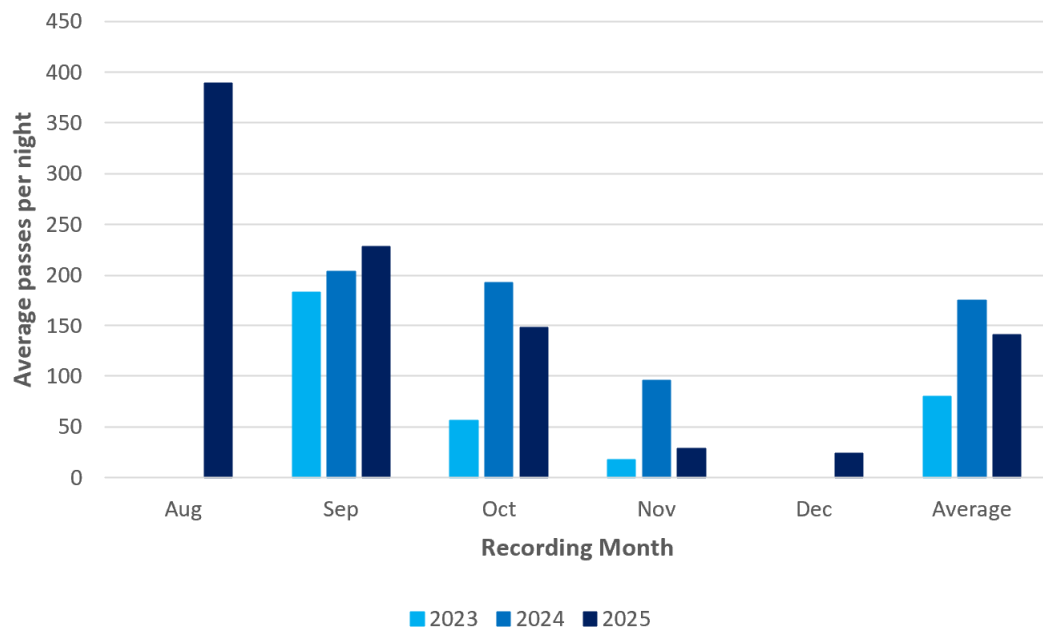
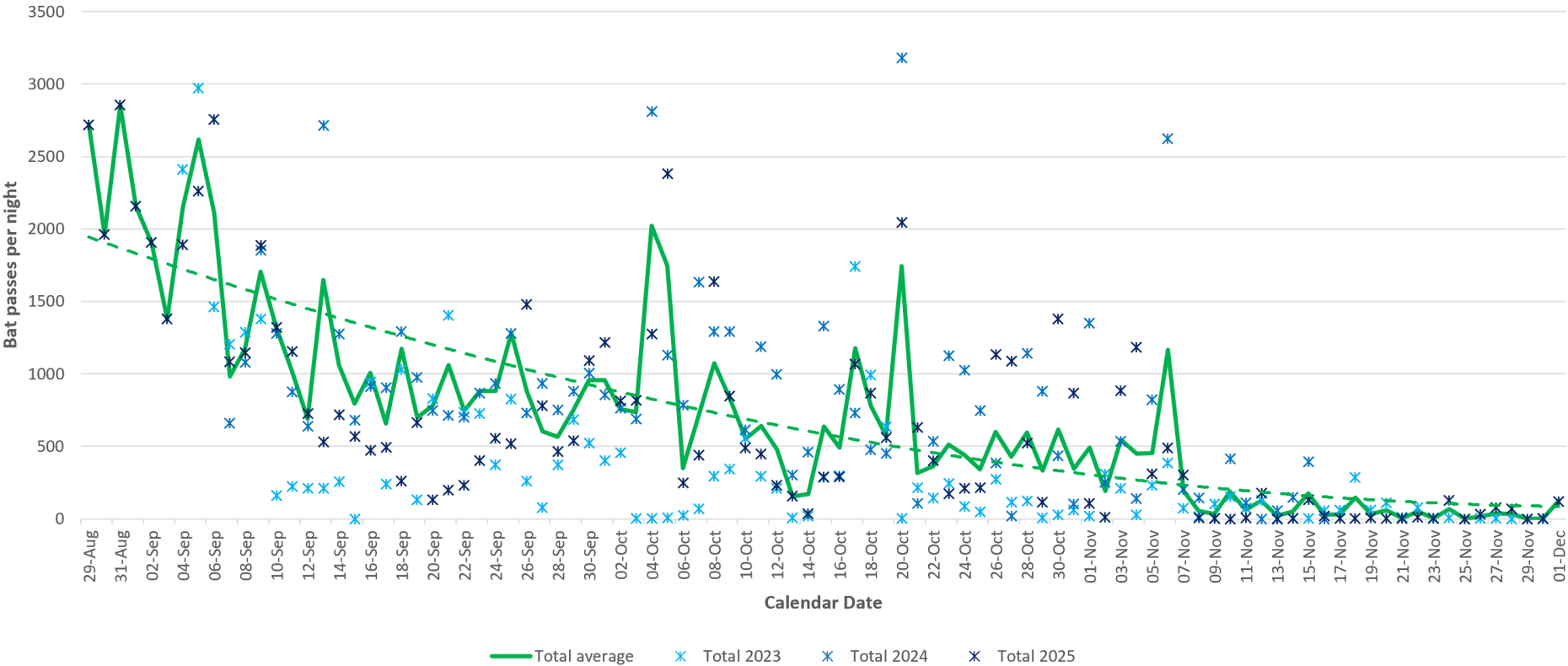
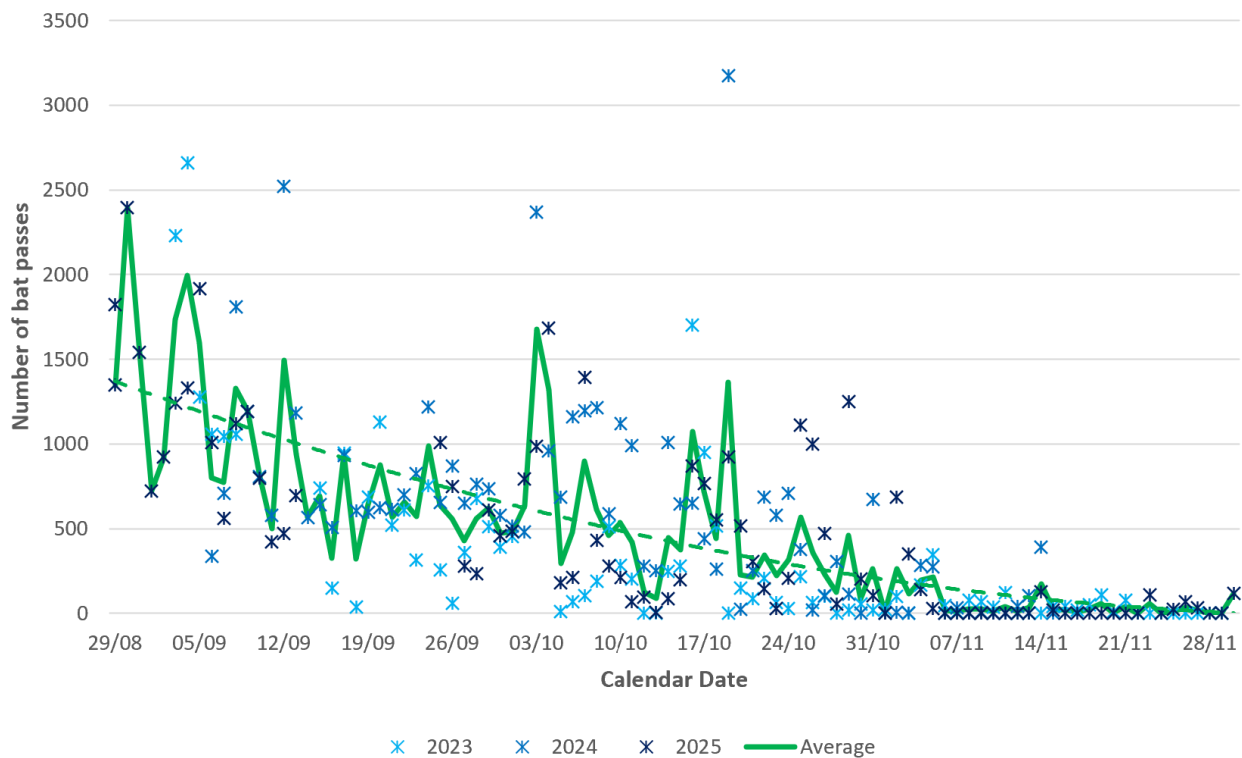
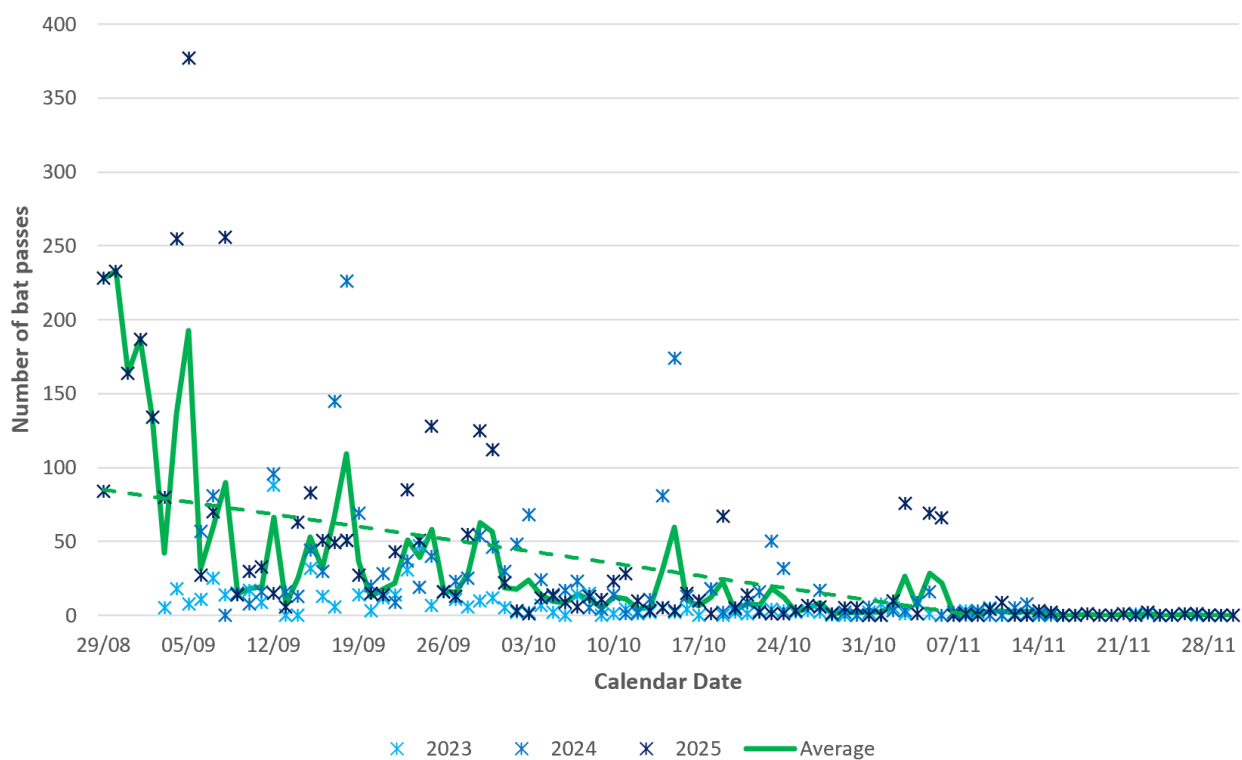
Figure 3.4: Average passes per night in each recording month for each recording year

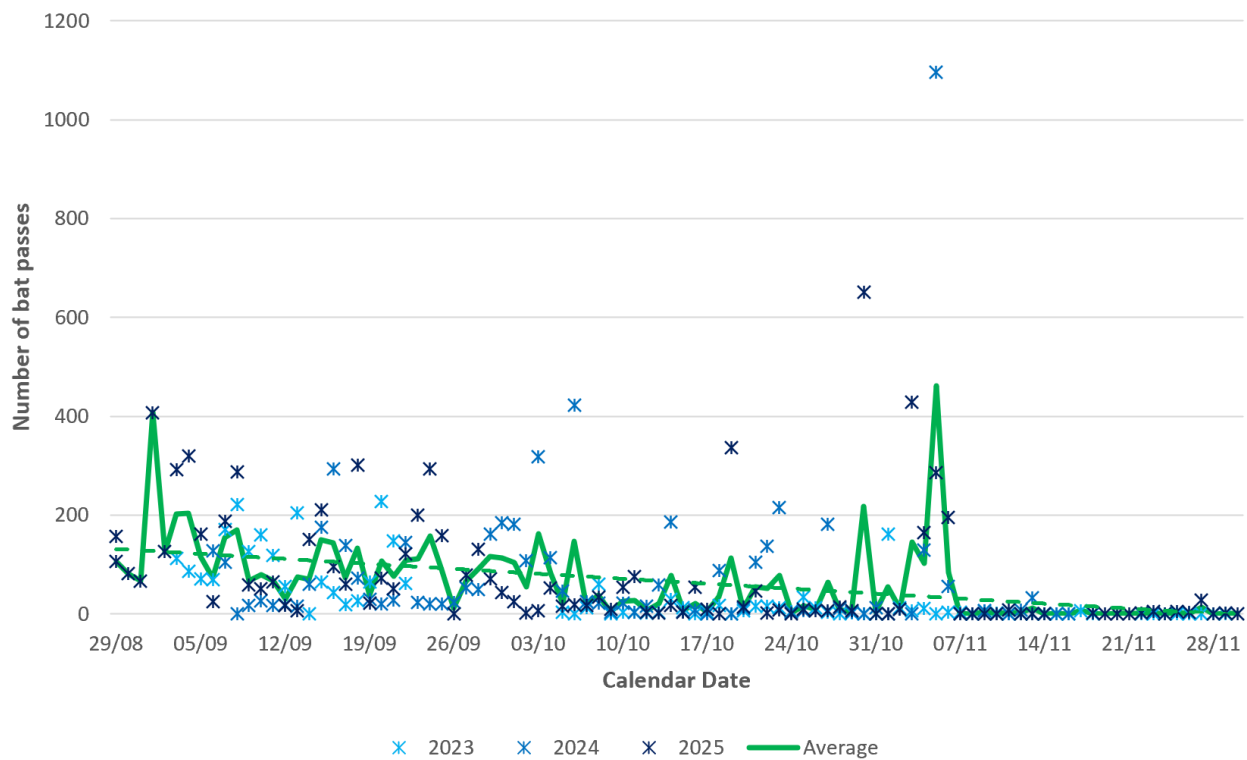
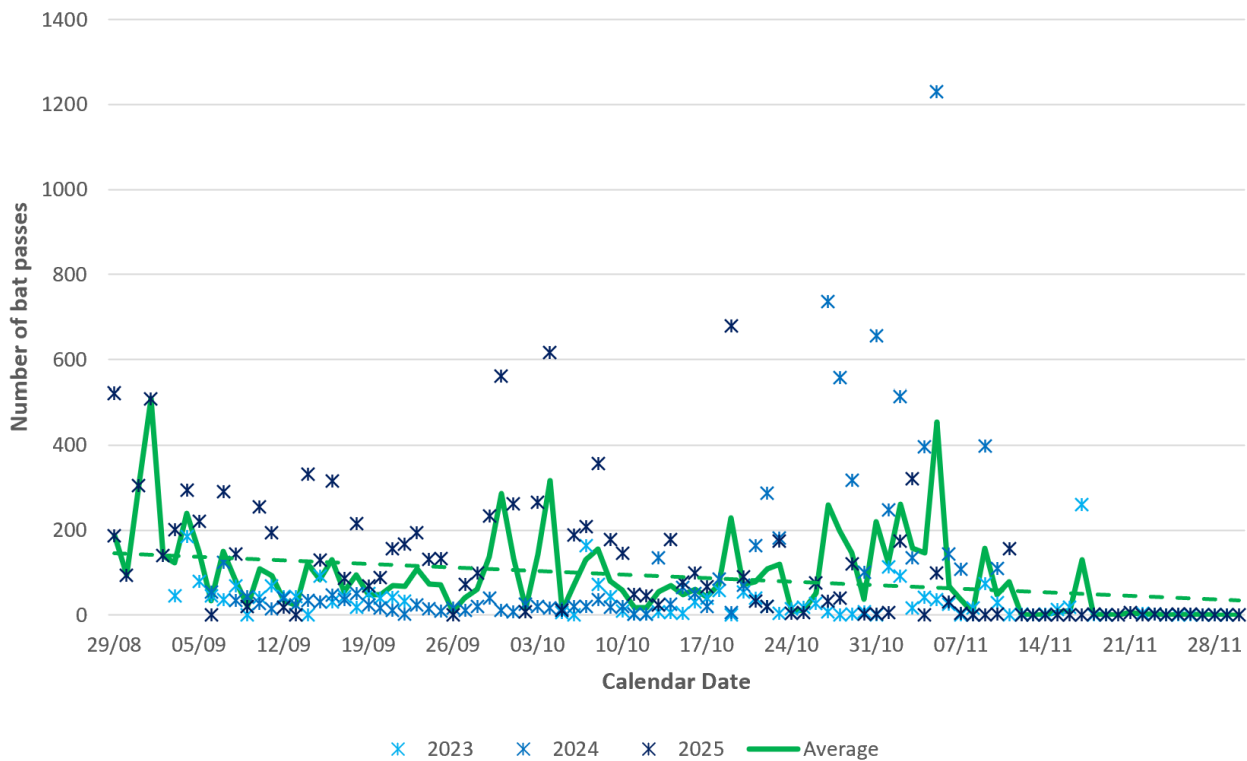
Figure 3.5: Summary of all sampled bat activity 2023-2025⁴

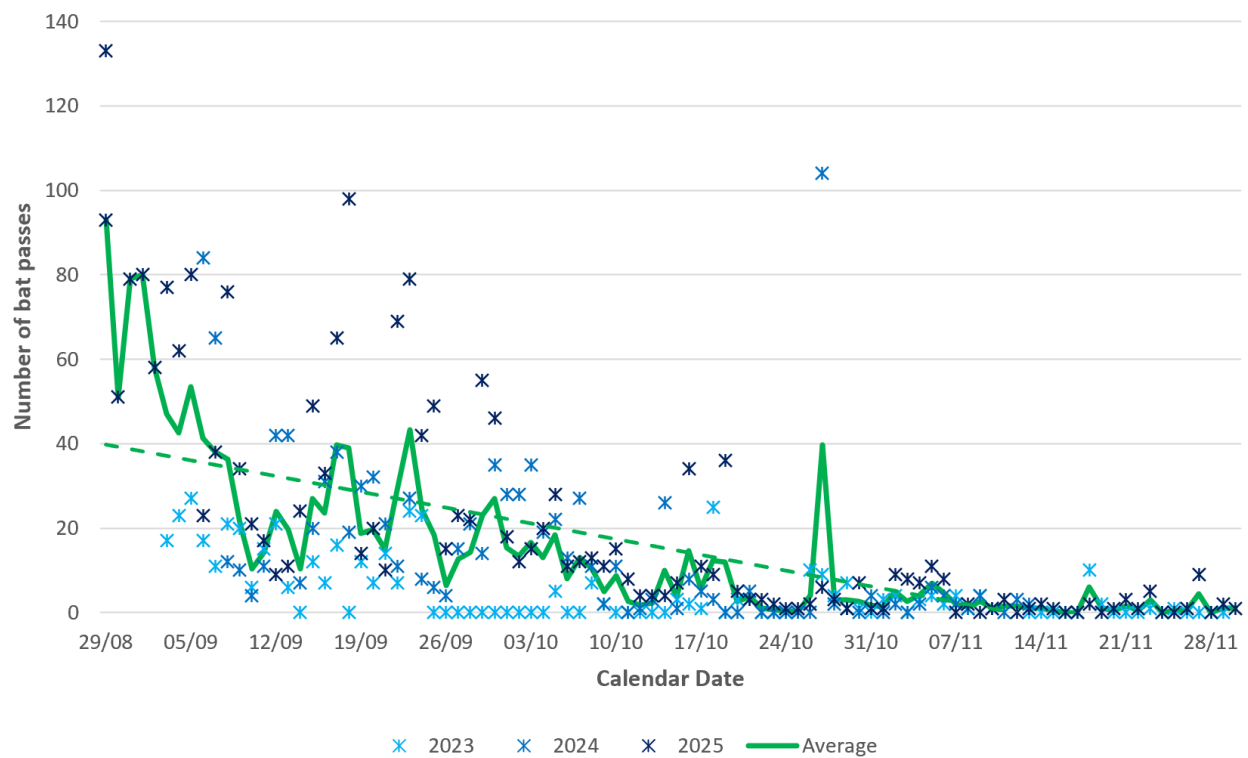


⁴ Dashed green line represents trendline



Figure 3.6: Bat activity at each sampling location 2023-2025⁵**(a) Location 1****(b) Location 2**⁵ Dashed lines represent trendline.

(c) Location 3**(d) Location 4**

(e) Location 5

4 Discussion

Species composition

- 4.1 The sampling reported here has confirmed that a wider range of bat species regularly utilise the Site during autumn and early winter than previously thought. The most active species appeared to be soprano pipistrelle, although 2025 data suggested higher common pipistrelle activity at the Site compared to previous years of recording.
- 4.2 Soprano pipistrelle bats tend to be more frequent in this part of Scotland than common pipistrelles, and therefore this finding is not unexpected. Both species are common and widespread, and they are classified as Not Threatened (Hutson 1993⁶). In 2013, population estimates in Scotland⁷ were 352,000 for common pipistrelle and 198,000 for soprano pipistrelle. It is accepted that this is likely significantly lower than the true figure. They are crevice roosters, and as such have adapted to finding roosting spaces in built features, and are potentially less affected by environmental constraints of urban areas, such as street-lighting. Pipistrelles are fast-flying species and there is some evidence to suggest that they congregate around artificial lighting to hawk insects attracted to the lights.
- 4.3 Of the three other species/genus of bats which were recorded in much lower numbers than the pipistrelles, *Myotis* bats were the most frequent. The sonograms recorded were suggestive of these being Daubenton's bats, and these have previously been recorded in the Gardens. Daubenton's are well adapted to hunting over water surfaces and this is probably the reason why they are associated with the River Kelvin corridor. It is also possible that the railway tunnels represent a roost location for this species, and further analysis of the first and last pass times could provide more information regarding this.
- 4.4 With regards to the 2023 BLE passes, it is useful to have it confirmed that this species is occasionally present in the general location of the Site, but as the Site and its environs do not represent preferred habitat for either roosting or foraging for this species, it is not unexpected that so few passes were recorded. BLE is typically a species which roosts in older buildings, barns, churches and trees, preferring cavities rather than crevices, and preferably a "warm up" space for use immediately prior to commencing and evening's hunting. Preferred foraging habitats are open deciduous and coniferous woodlands, parkland and gardens, and in combination these roosting and foraging habitats are not commonplace around the Site. However BLEs are also "quiet" bats and their calls are harder for all types of detector to pick up. The actual number of BLE passes may therefore be greater than the figures presented here suggest.
- 4.5 The *Nyctalus* passes recorded are interesting, as these species are thought to be at their northernmost limit in Scotland, although their distribution is becoming better known through the use of static detector studies such as this. In the UK, Leisler's bats are classed as Vulnerable: scarce (except in Ireland) and with a poorly known conservation status

⁶ Hutson, A.M. (1993). *Action plan for the conservation of bats in the United Kingdom*. Bat Conservation Trust, London

⁷ JNCC (2013). *Individual Species Reports - 3rd UK Habitats Directive Reporting 2013*.



(Hutson, 1993). However, a study in 2017⁸ stated that the population of Leisler's bat in Scotland may actually be in the region of many thousands. *Nyctalus* species are early emerging bats, typically leaving a roost 0-30 mins after sunset and sometimes even earlier. They are able to fly long distances (up to 20 km) quickly after emerging (Jones *et al.*, 2009)⁹. It is thought unlikely that a *Nyctalus* roost is present in close proximity to the Site, but closer analysis of first- and last-pass times may provide greater insight into this.

Trends in activity

- 4.6 The data collected during this study show the general pattern of bat activity tailing off during the autumn, in the weeks leading up to hibernation.

2023

- 4.7 Activity was most notably reduced after the first week in October in 2023, which in that year corresponded with the first sub-zero air temperatures for this part of Glasgow. A lack of a relationship between bat activity and rainfall was interesting, as it may be that, to a certain extent, bats in the West of Scotland are habituated to some level of night time precipitation given the prevailing weather conditions in this part of the UK. However, it may also be because the rainfall data used here were not at a sufficiently fine resolution to allow within-night correlations.
- 4.8 The trend lines for the whole data set, and those derived for each individual recording location, all show the drop off in activity as plateauing in mid-October 2023. The GlasGLOW event commenced on 27 October 2023 and lasted until 12 November 2023, and none of the trend lines showed an accelerated decrease in activity within the time period of the Event.

2024

- 4.9 In contrast to 2023, activity notably spiked on 20 October, before maintaining comparable levels of activity to earlier in October for the remainder of the month and into early November. A last notable spike in activity occurred on 06 November at certain locations, before remaining low for the remainder of the monitoring period. The GlasGLOW event commenced on 25 October 2024 and lasted until 03 November 2024, with trend lines showing no accelerated decrease in activity within the time period of the Event. Furthermore, the maintained levels of foraging at the Site throughout late October and early November may indicate that the Event could prolong bat activity levels associated with the Site, potentially linked with invertebrate resources attracted to the artificial lighting. It is also possible that milder weather may have occurred in the late October/early November period, allowing bats to remain more active later in the year compared to 2023. Correlations with that year's prevailing weather patterns would be a useful further area for investigation.

⁸ Newson, S.E., Evans, H.E., Gillings, S., Jarrett, D. & Wilson, M.W. (2017). *A survey of high risk bat species across southern Scotland*. Scottish Natural Heritage Commissioned Report No. 1008.

⁹ Jones, G., Cooper-Bohannon, R., Barlow, K. and Parsons, K. (2009). *Scoping and Method Development Report: Determining the potential ecological impact of wind turbines on bat populations in Britain*. University of Bristol and Bat Conservation Trust.



2025

- 4.10 In 2025, activity again notably spiked on 20 October, but less so than in 2024. Activity levels for the remainder of the month then remained fairly consistent with those seen in 2024, except no second spike in early November was recorded, with activity instead tailing off from 05 November 2025. The GlasGLOW event commenced on 24 October 2025 and lasted until 09 November 2025, with trend lines yet again showing no accelerated decrease in activity within the time period of the Event. As with 2024, levels of foraging activity at the Site were maintained throughout the majority of the Event, and this may also indicate that bats have become accustomed to the opportunities that this presents. It is also possible that milder weather may have again occurred in the late October/early November period in 2025, but this activity pattern repeated across two years does seem to suggest that either 2023 was an outlier year, or that bats are adapting how they use the Site during the time of year captured in this study.

Roosting bats

- 4.11 The high level of bat activity at Location 1 is likely to confirm the hypothesis that the railway tunnel system contains roosting locations, at least for common and soprano pipistrelles. It is not possible to determine conclusively from these data the size of these roosts, whether they are summer or hibernation roosts or both, and/or whether any of the activity recorded may represent an autumn swarming pre-hibernation location for pipistrelles. However, given the time of year covered by the recording period, it is reasonable to infer that the railway tunnels may indeed represent an important autumn swarming location for pipistrelles. Further study on classifying the roosting status of the tunnels could be an area for further study.

Areas for further investigation

- 4.12 The bat activity data presented here are interesting because they have focussed on a time period of bat activity which is less well studied. Due to budget (i.e. time input) constraints, it has not been possible to undertake all of the potential analyses which the data offer, and further work, particularly on comparing existing data to weather patterns, as well as examining within-night activity patterns within the timespans of the events, could be undertaken if opportunities were found to undertake these. Points for further study could include *inter alia*:
- continued liaison with the University of Glasgow regarding use of the existing dataset by a BSc, MSc or MRes student as part of a dissertation or thesis¹⁰;
 - further analysis on existing data to collate weather data for 2024/2025;
 - further data analysis to look at within-night activity patterns between 2023-2025 during the timespan of the Event;

¹⁰ Collaboration on data analysis was offered to the University of Glasgow in both 2024 and 2025, but none of the relevant postgraduate cohort opted for the offered project.



- manual surveys with observers and targeted roost emergence surveys at the railway tunnels, to add qualitative data regarding bat behaviour at this location to the quantitative data collected during this investigation;
- manual nocturnal transect surveys during the Event, to observe bat foraging and commuting behaviour to add qualitative behaviour data to the quantitative data collected;
- completion of additional 3 month recording periods (e.g. Dec-Feb, May-July) for a fuller understanding of bat usage of the Botanic Gardens;
- completion of similar studies for other events which take place in the Botanic Gardens, in particular those occurring in the summer months.

4.13 Following advice given by AEL to itison prior to the commencement of the 2023 GlasGLOW event, some changes to the sound and light installations were made, to take into consideration potential impacts on bats. Similar advice was provided for the 2024 and 2025 events. There are no historical data which could be used to determine whether or not the bat activity recorded during the Event period differed to that seen in pre-Event years, but the analyses presented here do not appear to indicate that during the adopted study periods there is any detectable negative effect on bat activity that might be attributable to anthropogenic sourced disturbance.



5 Summary and Conclusions

- 5.1 Throughout late autumn and early winter in 2023, 2024 and 2025, bat activity monitoring was undertaken within the Glasgow Botanic Gardens. Within the study period, the GlasGLOW event took place in the gardens, comprising between 10 and 17 nights of a sound and light installation.
- 5.2 The monitoring data have revealed that at least five species of bat use the Gardens, and at least three of these had not previously been formally recorded there. Bat activity was concentrated in the area in the vicinity the former Botanics railway station and it was thought likely that this was the entry location to a well-used roost of common and soprano pipistrelle bats. The nature of this roost, and whether or not this included hibernaculae, could not be determined.
- 5.3 In general, the levels of recorded bat activity varied significantly between sampling locations and over time. Activity decreased throughout the autumn; in 2023 it levelled off in the first two weeks of October, but in 2024 and 2025 was relatively sustained throughout that month before levelling off after the Event. No discernible decrease in activity during the timings of the Event could be detected in the between-night data.
- 5.4 This was a snapshot study which has provided useful insights into a less well studied period of the bat annual cycle, despite a number of difficulties associated with sampling “real world” environments where a range of variables cannot be controlled, and scope of recording and analysis is limited by resource allocation. Potential further lines of enquiry have been highlighted which would provide valuable additional information for understanding bat activity within this time period in this location.



Appendix A

List of Initialisms, Acronyms and Abbreviations Used in this Report



Short form	Full terminology
AEL	Applied Ecology Ltd
BCT	Bat Conservation Trust
BLE	Brown long-eared bat
CIEEM	Chartered Institute of Ecology and Environmental Management
EPS	European Protected Species
GCC	Glasgow City Council
PPN	Passes Per Night



Appendix B

Summary Bat Activity Data



Appendix B1: Summary bat activity data (September – November 2023)

Night start date	Total number of passes recorded					
	Common pipistrelle	Soprano pipistrelle	Brown long-eared bat	<i>Myotis</i> sp.	<i>Nyctalus</i> sp.	Total
04/09/2023	1506	899	0	6	1	2412
05/09/2023	1305	1659	0	5	3	2973
06/09/2023	708	747	2	5	0	1462
07/09/2023	588	613	0	2	0	1203
08/09/2023	614	670	0	1	4	1289
09/09/2023	526	850	0	3	2	1381
10/09/2023	120	146	0	0	0	266
11/09/2023	92	132	0	0	0	224
12/09/2023	108	104	0	0	0	212
13/09/2023	51	157	0	1	0	209
14/09/2023	77	177	0	0	0	254
15/09/2023	*	*	*	*	*	*
16/09/2023	501	439	0	1	0	941
17/09/2023	134	105	0	2	0	241
18/09/2023	283	744	0	4	0	1031
19/09/2023	49	84	0	0	0	133
20/09/2023	322	501	0	6	0	829
21/09/2023	327	1077	0	1	0	1405
22/09/2023	266	466	0	2	0	734
23/09/2023	136	586	0	3	0	725
24/09/2023	104	265	0	2	0	371
25/09/2023	473	346	0	5	0	824
26/09/2023	121	139	0	2	0	262
27/09/2023	43	34	0	0	0	77
28/09/2023	173	198	0	1	0	372
29/09/2023	205	480	0	0	0	685
30/09/2023	132	388	0	3	0	523
01/10/2023	113	286	0	2	0	401
02/10/2023	144	312	0	0	0	456
03/10/2023	0	2	0	0	0	2
04/10/2023	0	2	0	0	0	2
05/10/2023	1	6	0	0	0	7
06/10/2023	5	16	0	3	0	24
07/10/2023	1	67	0	0	0	68
08/10/2023	187	104	0	1	0	292
09/10/2023	168	175	0	0	0	343
10/10/2023	226	329	0	1	0	556
11/10/2023	117	177	0	0	0	294
12/10/2023	51	160	0	0	0	211
13/10/2023	3	5	0	0	0	8



Night start date	Total number of passes recorded					
	Common pipistrelle	Soprano pipistrelle	Brown long-eared bat	<i>Myotis</i> sp.	<i>Nyctalus</i> sp.	Total
14/10/2023	7	8	2	0	0	17
15/10/2023	62	224	0	0	0	286
16/10/2023	30	268	0	0	0	298
17/10/2023	325	1415	0	0	0	1740
18/10/2023	172	821	0	0	0	993
19/10/2023	130	504	0	0	0	634
20/10/2023	0	1	0	0	0	1
21/10/2023	29	184	0	0	0	213
22/10/2023	52	92	0	0	0	144
23/10/2023	61	182	0	0	0	243
24/10/2023	31	53	0	0	0	84
25/10/2023	38	11	0	0	0	49
26/10/2023	144	127	0	0	0	271
27/10/2023	41	73	0	0	0	114
28/10/2023	38	85	0	0	0	123
29/10/2023	3	3	0	0	0	6
30/10/2023	23	5	0	0	1	29
31/10/2023	52	9	0	0	0	61
01/11/2023	3	16	0	0	0	19
02/11/2023	278	31	0	0	0	309
03/11/2023	85	126	0	0	0	211
04/11/2023	14	12	0	0	0	26
05/11/2023	41	190	0	0	0	231
06/11/2023	6	380	0	0	0	386
07/11/2023	32	43	0	0	0	75
08/11/2023	8	6	0	0	0	14
09/11/2023	11	90	0	0	0	101
10/11/2023	75	79	0	0	0	154
11/11/2023	17	54	0	0	0	71
12/11/2023	24	101	0	0	0	125
13/11/2023	0	3	0	0	0	3
14/11/2023	2	1	0	0	0	3
15/11/2023	1	2	0	0	0	3
16/11/2023	3	54	0	0	1	58
17/11/2023	0	59	0	0	0	59
18/11/2023	3	282	0	0	0	285
19/11/2023	14	48	0	0	0	62
20/11/2023	12	100	0	0	0	112
21/11/2023	0	9	0	0	0	9
22/11/2023	0	77	0	0	0	77
23/11/2023	5	1	0	0	0	6
24/11/2023	5	3	0	0	0	8



Night start date	Total number of passes recorded					
	Common pipistrelle	Soprano pipistrelle	Brown long-eared bat	<i>Myotis</i> sp.	<i>Nyctalus</i> sp.	Total
25/11/2023	0	0	0	0	0	0
26/11/2023	1	0	0	0	0	1
27/11/2023	0	1	0	0	0	1
28/11/2023	0	0	0	0	0	0
29/11/2023	0	0	0	0	0	0
30/11/2023	0	0	0	0	0	0

Appendix B2: Summary bat activity data (September – November 2024)

Night start date	Total number of passes recorded					
	Common pipistrelle	Soprano pipistrelle	Brown long-eared bat	<i>Myotis</i> sp.	<i>Nyctalus</i> sp.	Total
07/09/2024	391	259	0	8	0	658
08/09/2024	421	655	0	5	0	1081
09/09/2024	90	1764	0	1	0	1855
10/09/2024	378	901	0	0	0	1279
11/09/2024	394	478	0	2	0	874
12/09/2024	113	521	0	4	0	638
13/09/2024	1241	1472	0	2	0	2715
14/09/2024	372	902	0	3	0	1277
15/09/2024	236	441	0	5	0	682
16/09/2024	488	418	0	6	0	912
17/09/2024	343	558	0	6	0	907
18/09/2024	551	736	0	4	0	1291
19/09/2024	422	551	0	2	0	975
20/09/2024	213	534	0	1	0	748
21/09/2024	276	435	0	1	0	712
22/09/2024	155	547	0	0	0	702
23/09/2024	150	714	0	4	0	868
24/09/2024	336	594	0	4	0	934
25/09/2024	43	1229	0	8	0	1280
26/09/2024	36	691	0	3	0	730
27/09/2024	91	840	0	1	0	932
28/09/2024	122	629	0	2	0	753
29/09/2024	220	654	0	5	0	879
30/09/2024	461	542	0	3	0	1006
01/10/2024	296	556	0	3	0	855
02/10/2024	250	509	0	3	0	762
03/10/2024	267	419	0	2	0	688
04/10/2024	701	2111	0	0	0	2812
05/10/2024	255	874	0	2	0	1131
06/10/2024	302	481	0	0	0	783



Night start date	Total number of passes recorded					
	Common pipistrelle	Soprano pipistrelle	Brown long-eared bat	<i>Myotis</i> sp.	<i>Nyctalus</i> sp.	Total
07/10/2024	558	1075	0	0	0	1633
08/10/2024	309	983	0	0	0	1292
09/10/2024	30	1260	0	0	0	1290
10/10/2024	9	603	0	2	0	614
11/10/2024	62	1125	0	0	0	1187
12/10/2024	8	987	0	0	0	995
13/10/2024	17	284	0	0	0	301
14/10/2024	199	260	2	0	0	459
15/10/2024	693	635	0	0	0	1328
16/10/2024	670	220	0	1	0	891
17/10/2024	136	593	0	0	0	729
18/10/2024	70	403	0	2	0	475
19/10/2024	200	252	0	0	0	452
20/10/2024	7	3174	0	0	0	3181
21/10/2024	71	36	0	0	0	107
22/10/2024	243	291	0	0	0	534
23/10/2024	652	480	0	0	0	1132
24/10/2024	854	173	0	0	0	1027
25/10/2024	139	634	0	0	0	773
26/10/2024	10	374	0	0	0	384
27/10/2024	0	17	0	0	0	17
28/10/2024	517	623	0	0	0	1140
29/10/2024	194	684	0	0	0	878
30/10/2024	130	305	0	0	0	435
31/10/2024	77	25	0	0	0	102
01/11/2024	421	930	0	0	0	1351
02/11/2024	99	152	0	0	0	251
03/11/2024	150	385	0	0	0	535
04/11/2024	64	75	0	0	0	139
05/11/2024	305	516	0	0	0	821
06/11/2024	2002	620	0	0	2	2624
07/11/2024	80	123	0	0	0	203
08/11/2024	136	6	0	0	0	142
09/11/2024	1	1	0	0	0	2
10/11/2024	82	332	0	0	0	414
11/11/2024	60	52	0	0	0	112
12/11/2024	0	0	0	0	0	0
13/11/2024	43	13	0	0	0	56
14/11/2024	57	92	0	0	0	149
15/11/2024	18	374	0	0	0	392
16/11/2024	0	0	0	0	0	0
17/11/2024	0	0	0	0	0	0



Appendix B3: Summary bat activity data (September – November 2025)

Night start date	Total number of passes recorded					
	Common pipistrelle	Soprano pipistrelle	Brown long-eared bat	<i>Myotis</i> sp.	<i>Nyctalus</i> sp.	Total
29/08/2025	1335	1369	0	14	0	2718
30/08/2025	778	1165	0	19	0	1962
31/08/2025	1455	1374	0	25	0	2854
01/09/2025	1119	1027	0	9	0	2155
02/09/2025	1067	837	0	2	0	1906
03/09/2025	605	763	0	10	1	1379
04/09/2025	1072	812	0	5	0	1889
05/09/2025	1225	1032	0	5	0	2262
06/09/2025	1764	980	2	11	0	2755
07/09/2025	556	524	0	4	0	1084
08/09/2025	722	419	0	4	0	1145
09/09/2025	1122	759	0	5	0	1886
10/09/2025	198	1107	0	16	0	1321
11/09/2025	435	701	0	20	0	1156
12/09/2025	338	380	0	10	0	728
13/09/2025	69	452	0	8	0	529
14/09/2025	83	624	0	10	0	717
15/09/2025	619	325	0	2	0	946
16/09/2025	267	203	0	2	0	472
17/09/2025	270	223	0	1	0	494
18/09/2025	110	149	0	1	0	260
19/09/2025	272	392	0	1	0	665
20/09/2025	58	73	0	0	0	131
21/09/2025	107	87	0	2	0	196
22/09/2025	133	97	0	1	0	231
23/09/2025	246	153	0	1	0	400
24/09/2025	329	225	0	3	0	557
25/09/2025	216	299	0	3	0	518
26/09/2025	977	498	0	3	0	1478
27/09/2025	369	406	0	5	0	780
28/09/2025	249	212	0	4	0	465
29/09/2025	279	259	0	1	0	539
30/09/2025	675	413	0	5	0	1093
01/10/2025	850	361	0	8	0	1219
02/10/2025	385	422	0	6	0	813
03/10/2025	0	811	0	5	0	816
04/10/2025	589	678	0	7	0	1274
05/10/2025	1261	1114	0	8	0	2383
06/10/2025	99	148	0	0	0	247
07/10/2025	217	220	0	2	0	439



Night start date	Total number of passes recorded					
	Common pipistrelle	Soprano pipistrelle	Brown long-eared bat	<i>Myotis</i> sp.	<i>Nyctalus</i> sp.	Total
08/10/2025	980	651	0	5	0	1636
09/10/2025	442	400	0	3	0	845
10/10/2025	260	227	0	1	0	488
11/10/2025	247	200	0	0	0	447
12/10/2025	165	65	0	0	0	230
13/10/2025	96	61	0	0	0	157
14/10/2025	17	19	2	0	0	36
15/10/2025	106	184	0	0	0	290
16/10/2025	124	164	0	0	0	288
17/10/2025	307	762	0	0	0	1069
18/10/2025	268	598	0	0	0	866
19/10/2025	269	289	0	3	0	561
20/10/2025	1581	462	0	0	0	2043
21/10/2025	301	329	0	0	0	630
22/10/2025	179	223	0	0	0	402
23/10/2025	39	133	0	0	0	172
24/10/2025	96	116	0	0	0	212
25/10/2025	10	206	0	0	0	216
26/10/2025	287	845	0	0	0	1132
27/10/2025	184	903	0	0	0	1087
28/10/2025	44	479	0	0	0	523
29/10/2025	39	76	0	0	0	115
30/10/2025	524	856	0	0	0	1380
31/10/2025	679	190	0	0	0	869
01/11/2025	3	105	0	0	0	108
02/11/2025	1	8	0	0	0	9
03/11/2025	419	467	0	0	0	886
04/11/2025	907	277	0	0	0	1184
05/11/2025	296	15	0	0	0	311
06/11/2025	381	110	0	0	0	491
07/11/2025	206	95	0	0	0	301
08/11/2025	2	3	0	0	0	5
09/11/2025	1	2	0	0	0	3
10/11/2025	0	0	0	0	0	0
11/11/2025	4	3	0	0	0	7
12/11/2025	21	155	0	0	0	176
13/11/2025	0	0	0	0	0	0
14/11/2025	0	3	0	0	0	3
15/11/2025	126	5	0	0	0	131
16/11/2025	19	1	0	0	0	20
17/11/2025	3	0	0	0	0	3
18/11/2025	0	1	0	0	0	1



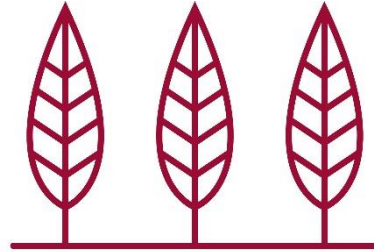
Night start date	Total number of passes recorded					
	Common pipistrelle	Soprano pipistrelle	Brown long-eared bat	<i>Myotis</i> sp.	<i>Nyctalus</i> sp.	Total
19/11/2025	1	6	0	0	0	7
20/11/2025	1	0	0	0	0	1
21/11/2025	1	1	0	0	0	2
22/11/2025	3	8	0	0	0	11
23/11/2025	2	1	0	0	0	3
24/11/2025	102	23	0	0	0	125
25/11/2025	0	0	0	0	0	0
26/11/2025	14	16	0	0	0	30
27/11/2025	10	67	0	0	0	77
28/11/2025	60	10	0	0	0	70
30/11/2025	5	0	0	0	0	5
01/12/2025	115	4	0	0	0	119



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APPLIED ECOLOGY

GlasgGLOW 2023

Ecological Sensitivities and Opportunities Report

Produced for itison

By Applied Ecology Ltd

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1 Introduction

Background

- 1.1 In August 2023, Applied Ecology Ltd (AEL) was commissioned by itison to provide ecological support for their autumn sound and light event known as GlasGLOW ("the Event"), to be held in October and November 2023 within the Glasgow Botanic Gardens ("the Site"), in the West End of the City of Glasgow. A plan showing the location of the Site is provided in **Figure 1.1**.
- 1.2 GlasGLOW has run annually within the Botanic Gardens since 2018. Although sustainability has always been a consideration in the design and planning of the Event, in 2023 itison has taken this further with the appointment of a dedicated sustainability specialist to advise on all stages of their event planning and delivery. In parallel with this, and as part of recognising that the Event takes place within public greenspace with its own intrinsic sensitivities, Glasgow City Council (GCC) has required itison to engage with an independent ecological consultant to provide objective advice regarding how the 2023 GlasGLOW event could be designed and run so as to minimise its biodiversity impact.

Purpose of this report

- 1.3 This report provides details of the likely ecological sensitivities and opportunities arising from the 2023 GlasGLOW event in the Botanic Gardens. It provides a description of the approach taken to identify those sensitivities, an evaluation of the possible biodiversity impacts that could arise as a result of the Event, and details of the mitigation hierarchy that should be put into place to avoid those impacts in the first instance, and then to mitigate any residual effects where it is not possible to design them out. It also provides recommendations relating to the opportunities presented by the Event and the Site in which it occurs, to offer enhancements for biodiversity wherever practicable.
- 1.4 The purpose of this appraisal is not to provide an exhaustive review of the potential effects of sound and lighting events in urban areas. A brief synopsis of key findings relating to this topic area is however provided, with signposting to bodies of academic research where more information can be found.

Report qualification

- 1.5 The ecological work described here was undertaken in accordance with the best practice methodologies current at the time of commissioning. Site circumstances, scientific knowledge or methodological requirements can change during the course of a project, and these external factors may impact on the scope of subsequent work requirements.
- 1.6 All survey work and reporting was undertaken by experienced and qualified ecologists in accordance with the Code of Professional Conduct of the Chartered Institute of Ecology and Environmental Management (CIEEM), as well as guidance provided by the Bat Conservation Trust (BCT) and that contained within BS 42020:2013 (Biodiversity).



- 1.7 All ecological surveys have an expected validity period, owing to the tendency of the natural environment to change over time. This validity period varies from feature to feature, and is also dependent on the degree of change in a site's management and overall landscape ecology. Where the potential for change is considered to be relevant to the Site, this is highlighted in the appropriate section.
- 1.8 This report does not purport to provide detailed, specialist legal advice. Where legislation is referenced, the reader should consult the original legal text, and/or the advice of a qualified environmental lawyer.





GlasGLOW 2023

Site Location

 Site boundary

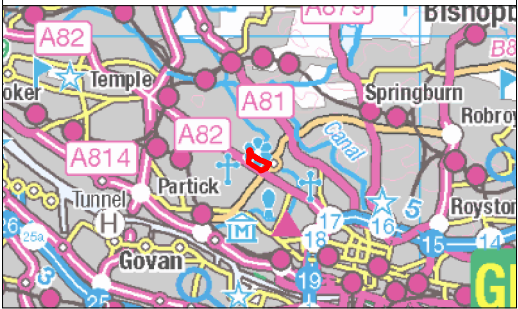


Figure 1.1

Map Scale @ A3: 1:15,000



Surveyed by: -	 APPLIED ECOLOGY
Survey date: -	
Drawn by: RAH	
Checked by: SH	
Status: Final	

2 Methodology

Pre-existing data records

Designated sites

- 2.1 Details of nearby statutory sites designated for nature conservation were obtained from the NatureScot Natural Spaces website¹ and plotted in a Geographical Information System (GIS). Sites listed on the NatureScot Ancient Woodland Inventory (AWI) were also obtained from this source and plotted in GIS. GCC maintains a register of local non-statutory designated sites known as Sites of Importance for Nature Conservation (SINCs), and these were transcribed from an online database² into GIS. The boundaries of Scottish Wildlife Trust (SWT) reserves were also obtained from an online resource³.

Other biological records

- 2.2 The Biological Records Centre (BRC) for Glasgow City, run out of the Glasgow Museums Resource Centre (GMRC), is currently not providing a data record supply service. Pre-existing biological data relevant to the Site were therefore searched for online, and in online databases to which the authors had access and for which there were no issues associated with their use in a commercial setting. These were augmented by lists of records obtainable online, although the copyright status of some of these resources could not be ascertained.

Extended Scottish EUNIS habitat survey

- 2.3 NatureScot has adopted EUNIS, the European Nature Information System, as the standard habitat classification scheme for terrestrial habitat data and mapping in Scotland⁴. A habitat survey of the Site was therefore undertaken in August 2023 using Scottish EUNIS, during which all habitats present within the Site were classified and mapped according to the standard EUNIS categories. Habitat patches were mapped as polygon features, and linear features (such as walls and fences) as lines where this provided added value and if sufficient space on the map. Point features were recorded where there were notable isolated trees or scrub. Target notes were used to describe areas of both typical and unique botanical character. Plant species abundance was noted using the DAFOR⁵ system, and the minimum mappable unit (MMU) was 10 x 10 m except where features marked on the base map allowed mapping to be more precise.
- 2.4 The standard habitat survey approach was "extended" to include a search for evidence of or potential for the presence of protected species or species of nature conservation

¹ <https://sitelink.nature.scot/home> accessed July 2023.

² <https://glasgowgis.maps.arcgis.com/apps/webappviewer/index.html?id=f8a6a37c9c324f268f896dd59fcd6477> access July 2023.

³ <https://scottishwildlifetrust.org.uk/our-work/our-evidence-base/our-data/> Accessed July 2023.

⁴ Strachan, I.M. (2017) *Manual of terrestrial EUNIS habitats in Scotland*. Version 2. Scottish Natural Heritage Commissioned Report No. 766.

⁵ DAFOR: whereby species occurrence may be classified as being **d**ominant, **a**bundant, **f**requent, **o**ccasional or **r**are. Rare in the context of a DAFOR score should not be confused with species rarity in the more widely accepted meaning of general scarcity.



interest within the Site. This was not a detailed survey for such species, but included noting the presence of habitats suitable to support such species, and where seen, any evidence of presence such as droppings, mammal tracks and footprints, shelters (or nests/roosts), hair caught on fence-wire, foraging signs, and so on.

Potential limitations of the Scottish EUNIS habitat survey

- 2.5 The walkover survey was undertaken within the core botanical survey period, and the majority of the Site was accessible without any restrictions. There were therefore no limitations to the survey.

Other relevant sources of information

- 2.6 A range of information sources were consulted during the preparation of this appraisal, including:
- The Bat Conservation Trust and the Institute of Lighting Professional (2023) Bats and Artificial Lighting at Night. Guidance note 08/23, available online at www.theilp.org.uk
 - Brownlie, S., Bull, J.W. and Stubbs, D. (2020). Mitigating biodiversity impacts of sports events. Gland, Switzerland: IUCN. xiv+80 pp.
 - GCC (undated). Glasgow Botanic Gardens Management Plan 2011-2016. Land and Environmental Services, Glasgow.
 - Echoes Ecology Ltd (2016) Humpback Bridge – Ecological Constraints Survey. Unpublished contract report produced for Covanburn Contracts, November 2016.
 - Weddle, R.B. (undated) Bats in the West End of Glasgow (Chiroptera: *Pipistrellus* sp., *Myotis daubentonii*, *Plecotus auritus*). The Glasgow Naturalist, 25 p. unknown.
 - GCC (undated) Glasgow Local Biodiversity Action Plan. Available online at <https://www.glasgow.gov.uk/biodiversity> (accessed August 2023).
- 2.7 Information was also collected informally from Botanic Garden staff and biodiversity personnel at Glasgow City Council.



3 Findings

Pre-existing data records

Sites designated for nature conservation

- 3.1 A map showing the location of designated sites within 2 km of the Site is provided in **Figure 3.1**.
- 3.2 The closest statutorily designated site to the Site is the Hamiltonhill Clay Pits Local Nature Reserve (LNR), which is 1.2 km to the east of the Site at its closest point. The Event is not anticipated to have any impacts on sites at such a distance, and therefore statutorily designated areas are not considered here any further.
- 3.3 However, in terms of non-statutory designations, the River Kelvin City-Wide SINC overlaps the Site boundary along its north-eastern edge.

Habitats

- 3.4 The Scottish EUNIS habitat map is shown in **Figure 3.2**. A summary of the habitats recorded is provided in **Table 3.1** below, and target notes can be found in **Appendix B**. A selection of habitat survey photographs can be found in **Figure 3.3**.

Built environment

- 3.5 Just over 30 % of the Site was **built** features, being either buildings, or roads, paths or other areas of **hard standing**.

Grasslands

- 3.6 Two main grassland types were identified within the Site, and the majority of these were **improved (amenity)** swards as would be expected for a managed garden. These were regularly mown, short and species-poor habitats, dominated by grass species typical of lawns such as perennial rye-grass *Lolium perenne* and red fescue *Festuca rubra*, with occasional herbs such as white clover *Trifolium repens*, common chickweed *Stellaria media*, common mouse-ear *Cerastium fontanum* and black medick *Medicago lupulina*.
- 3.7 Less intensively managed areas of grass, which had been allowed to grow taller with a relaxed mowing regime, occurred around the edges of the Site and were classified as **permanent mesotrophic grasslands**. The majority of these areas, whilst more species-rich than the formally managed lawn, were still grass-dominated habitats, with abundant Yorkshire fog *Holcus lanatus*, perennial rye-grass and common bent *Agrostis capillaris*, but a number of herbs were occasional, including common hogweed *Heracleum sphondylium*, creeping buttercup *Ranunculus repens*, meadow buttercup *R. acris*, ribwort plantain *Plantago lanceolata*, common ragwort *Jacobaea vulgaris*, common bird's-foot-trefoil *Lotus corniculatus*, common hawkweed *Hieracium vulgatum*, perfoliate St John's-wort *Hypericum perforatum* and rarely spikes of common spotted orchid *Dactylorhiza fuchsii*.



- 3.8 However, along the western boundary of the Site there was an area of neutral grassland which was being managed in order to maximise its suitability for pollinators. This sward also had abundant Yorkshire fog, but other grasses were frequent, including cock's-foot *Dactylis glomerata*, crested dog's-tail *Cynosurus cristatus*, Timothy *Phleum pratensis*, and common bent. There was a wide range of herbs conspicuous at the time of survey, including fox-and-cubs *Pilosella aurantiaca*, common knapweed *Centaurea nigra*, yellow rattle *Rhinanthus minor*, tufted vetch *Vicia cracca*, white clover, common bird's-foot-trefoil, red clover *Trifolium pratense*, common cat's-ear *Hypochaeris radicata*, curled dock *Rumex crispus*, ribwort plantain, meadow buttercup and germander speedwell *Veronica chamaedrys*.

Woodland, tree-ed and scrub habitats

- 3.9 The majority of the tree-ed habitats within the Site were classified as **small anthropogenic woodlands**. These areas supported a range of mature trees but were clearly of plantation origin having been established as a key feature of the Botanic Gardens. Many of the trees were therefore non-native specimens, although a number of native species did also occur. Although of plantation origin, the age of some of these trees meant that the close canopy areas where the field layer was not under regular mowing management had a semi-natural character, and these areas typically occurred around the periphery of the Site.
- 3.10 A small area of **mixed native woodland** fell within the Site boundary, along the strip of the northern boundary where the River Kelvin SINC entered the Site (see above). The native woodland category was used even though beech *Fagus sylvatica* was a frequent species here (western Scotland would be considered outwith the normal native range for beech and most stands in this geographical area are likely to be plantation in origin). Other species present included lime *Tilia x europaea*, and holly *Ilex aquifolium*, with abundant non-native rhododendron in the shrub layer, broad buckler fern *Dryopteris dilatata*, pendulous sedge *Carex pendula* and a garden privet *Ligustrum ovalifolium* hedge along the fenceline.
- 3.11 Being a botanic garden, **ornamental shrubs** were frequent throughout the central, more intensively managed garden areas. **Individual trees** were also frequent, including topiaried specimens along the main paths, and well managed mature specimens throughout (see also *anthropogenic woodlands* above).
- 3.12 Small areas of native scrub were restricted to the edges of the Site. These were dominated by bramble *Rubus fruticosus* agg. and saplings of tree species such as alder *Alnus glutinosa*, ash, a species of *Ribes*, birches *Betula* spp., *Prunus* sp. and horse-Aesculus *hippocastanum*.

Other habitats

- 3.13 Just over 5 ha of the Site comprised formal **garden** areas with herbaceous borders and beds, some of which also contained ornamental shrubs (see earlier).

Non-native plant species

- 3.14 The Site was a botanical garden. To that end, non-native shrubs occurred throughout the Site, along with specimen non-native trees, and non-native herbaceous displays. During the walkover survey, the only invasive non-native species seen was Japanese knotweed *Reynoutria japonica*, although it is well known that the Kelvin corridor to the north has



extensive infestations of Himalayan balsam *Impatiens glandulifera*, both Japanese and giant knotweed *R. sachalinensis*, and giant hogweed *Heracleum mantegazzianum*.

Table 3.1: Summary of habitat types recorded on the Site

Habitat types	Area within Site (ha)	% of Site
C1.2: Mesotrophic pond	0.01	0.2
E2.1: Permanent mesotrophic grassland	0.75	10.6
E2.6: Improved (amenity) grassland	2.10	29.8
F3: Dense scrub	0.05	0.7
FB.3: Ornamental shrubs	0.46	6.6
G1.A: Mixed native woodland	0.05	0.7
G5: Small anthropogenic woodland	0.90	12.8
I2: Cultivated areas of gardens and parks	0.40	5.6
J2: Buildings and other structures	0.71	10.0
J4: Roads, paths and other hard standing	1.47	20.9
Not surveyed	0.15	2.1
Total	7.05	100.0

Faunal sensitivities

Mammals

- 3.15 The Site supported a range of woodland habitats which may have had some suitability for **badger** sett creation. However, no signs of setts were seen during the survey, and there are no pre-existing records for this species within the Botanic Gardens. It was considered more likely that setts would be present within the adjacent River Kelvin corridor. The amenity grasslands within the Site would present good foraging habitat for badger, but again no signs of foraging, or any other evidence of badger presence (such as latrines) were seen. It was thought likely that badger was absent from the Site but present in the wider area, and unlikely to be a sensitivity in the context of the Event.
- 3.16 **Otter** is known to be present on the River Kelvin, and it was possible that shelters associated with this species would be present within the less accessible parts of the wooded corridor to the north and east of the Site. Given the high levels of use of the Kelvin Walkway, including for the exercising of dogs (of which otter are particularly intolerant), any otter holding territory along this part of the River Kelvin would be habituated to a degree of anthropogenic disturbance. Otter is unlikely to be a sensitivity in the context of the Event.
- 3.17 There were no habitats on the Site or within appropriate buffers of it which would be suitable for **water vole**, neither riparian water vole nor fossorial. There are no pre-existing records of this species for the Botanic Gardens. This species is unlikely to be a sensitivity in the context of the Event.



- 3.18 The Site contained both structures and trees considered to have suitability for roosting **bats**. A large maternity-style bat box was noted in the north-east of the Site, although no information could be provided by GCC regarding whether or not roosting bats were known to be using it. The exposed sections of the underground station within the Botanic Gardens were considered unlikely to support bat roosts, being well lit in daylight hours. However, the darker recesses, and the covered tunnel system would have high suitability for both summer roosts, and hibernation. Both Daubenton's bat and common pipistrelle have been recorded in flight in or close to the Site, and it was thought likely that soprano pipistrelle would also be present.
- 3.19 Bats should be treated as a sensitivity on the Site in the context of the Event.
- 3.20 The mosaic of lawns and dense scrub within the Site provided high suitability for **hedgehog**, and there are recent records of the species as being present in the Botanic Gardens. Hedgehog should therefore be considered a sensitivity in the context of the Event.
- 3.21 Evidence or sightings of **fox** and **grey squirrel** indicated that they were present within the Site, and it was thought likely that other common mammal species would also be resident, such as **rabbit**, **field vole**, **wood mouse** and **brown rat**. However, none of these species are specially protected or of notable conservation importance. They will not be considered any further in this appraisal.

Birds

- 3.22 A number of common bird species were seen or heard during the walkover, including **woodpigeon**, **carrion crow**, **magpie**, **chaffinch**, **pied wagtail**, **robin**, **blue tit**, **great tit**, **wren** and **blackbird**. It is possible that a wider range of species would be recorded during the core nesting bird season, and if a wider variety of habitats was included (e.g. the River Kelvin corridor). These common species are only specially protected during the breeding season (see **Chapter 4** for more information), and the Event will occur well outwith that key time. There are recent records for **tawny owl** for the Site, which is a species known to be well adapted to living in urban parks and gardens and which would be expected to be active during the hours in which the Event will operate. However, it is not clear as to whether these records refer to hunting or resident birds⁶. There was a general lack of dead wood features within the Site suitable for tawny owl, and those that were seen were occupied by grey squirrel. More extensive suitable habitat for this species would be expected to occur along the River Kelvin. Nevertheless, best practice would dictate a number of considerations in relation to minimising the potential impacts on birds as a result of the Event, and to that end they should be treated as a sensitivity in the context of this appraisal.

Herpetofauna

- 3.23 There were no habitats suitable for common reptile species present within the Site, and generally these species are accepted as being absent from the densely built-up areas of Glasgow. Similarly, specially protected amphibian species such as great crested newt (GCN) are also absent from this locality. There was suitability however for common amphibians

⁶ Pre-existing records for tawny owl are usually of calling birds, and these would indicate territoriality. It is likely that a tawny owl territory therefore at least overlaps the Gardens.

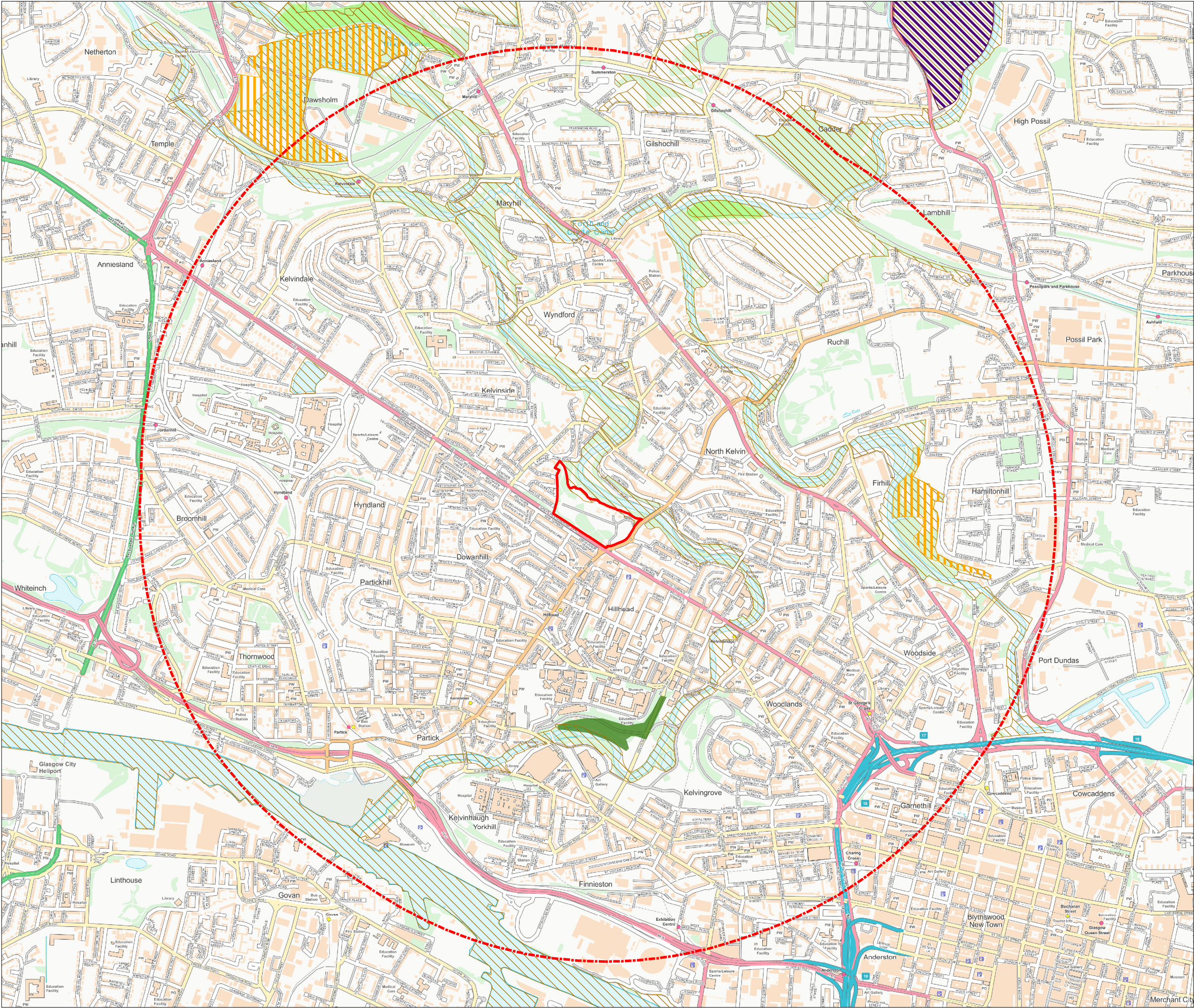


such as **common frog** and **common toad**, in particular in composting areas and piles of brash. Although not subject to any special protection, best practice would be to consider these species to be sensitivities in the context of this appraisal.

Invertebrates

- 3.24 Detailed invertebrate survey would be beyond the scope of this assessment, but it was thought likely that the mosaic of woodland, grassland and herbaceous plantings would support a relatively high diversity of invertebrates for such an urban location, including butterflies and bees (and other pollinators), and day- and night-flying moths. Although the Event will occur at a time towards the end of the flying period of these species, climate change is altering the phenology of autumn events, and to that end invertebrates should, in generic terms, be considered a sensitivity in the context of this appraisal.





GlasGLOW 2023

Sites Designated for Nature Conservation

- Site boundary
- 2 km from Site boundary
- SSSI
- LNR
- GCC SINC

Ancient Woodland Inventory:

- Ancient (semi-natural origin)
- Long-established (plantation origin)

SSSI, LNR and AWI data Copyright NatureScot.
Contains Ordnance Survey data © Crown copyright
and database right (2023).

SWT boundary data © Scottish Wildlife Trust (2023)

Ancient Woodland data may exclude some woodlands
present on 1st Edition OS maps.

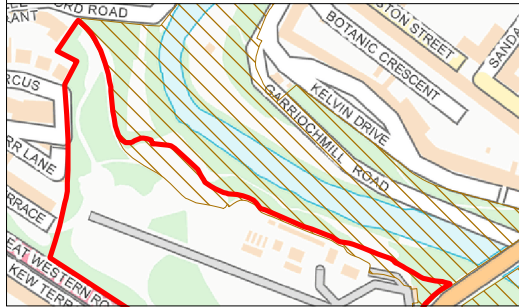


Figure 3.1

Map Scale @ A3: 1:18,000

Surveyed by: -
Survey date: -
Drawn by: RAH
Checked by: SH
Status: Final



Scottish EUNIS Habitat Map

- Site boundary
- Scottish EUNIS habitat types:
- C1.2: Mesotrophic pond
- E2.1: Permanent mesotrophic grassland
- E2.6: Improved (amenity) grassland
- F3: Dense scrub
- FB.3: Ornamental shrubs
- G1.A: Mixed native woodland
- G5: Small anthropogenic woodland
- I2: Cultivated areas of gardens and parks
- J2: Buildings and other structures
- J4: Roads, paths and other hard standing
- Not surveyed
- Individual tree (indicative location)
- Target notes

Figure 3.2

Map Scale @ A3: 1:2,000

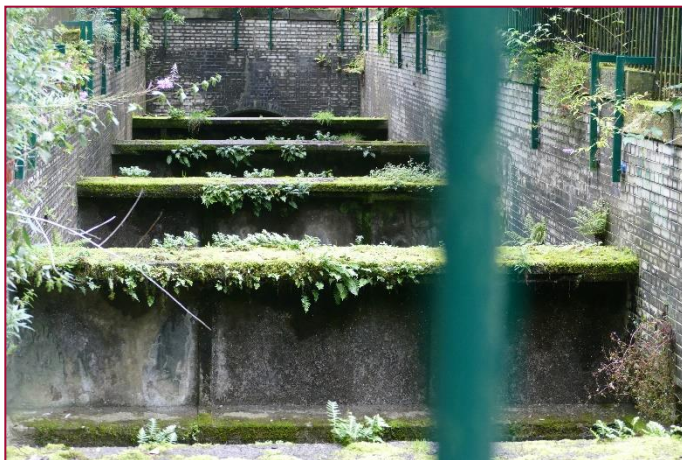
Surveyed by: AEL	APPLIED ECOLOGY
Survey date: August 2023	
Drawn by: RAH	
Checked by: SH	
Status: Final	



Figure 3.3: Selection of ecological appraisal photographs



(a) Buildings of traditional construction containing potential (bat) roost features.



(b) The disused underground station, with suitability for roosting bats.



(c) Remnant spikes of common spotted orchid in unmown grassland west of the underground station.



(d) Compost heaps with suitability as refuges for hedgehog and common amphibians.



(e) Broad-leaved helleborine in scrubby undergrowth.



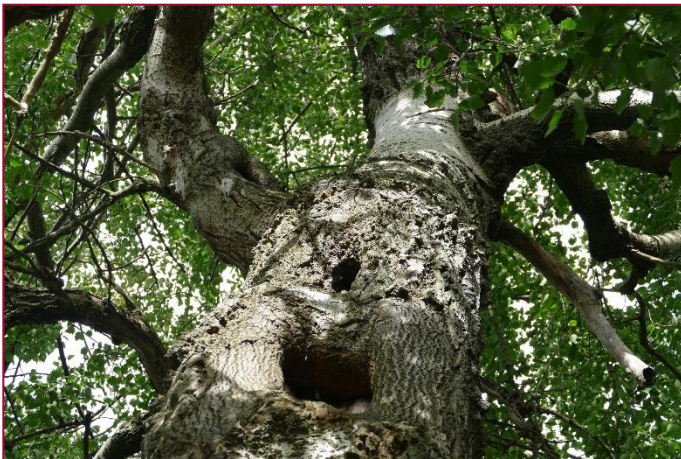
(f) Remnants of former ash trees. No PRFs remaining.



(g) Species-rich meadow area in north of the Gardens.



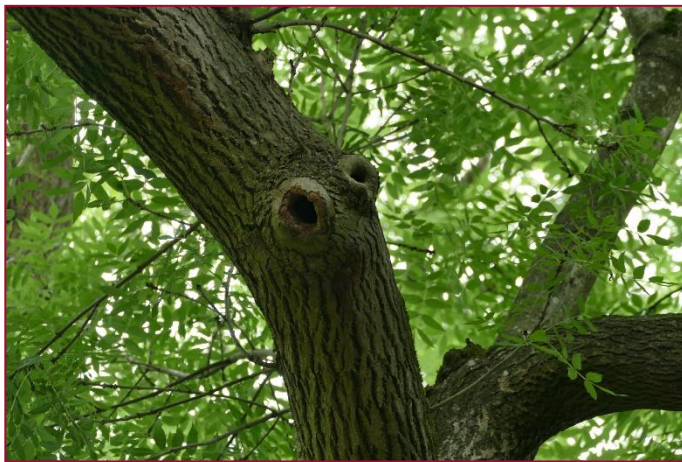
(h) Bird box and compost heap along northern boundary of Gardens.



(i) Potential roost features in white poplar on north-eastern edge of the Gardens.



(j) Large colony bat box on Scots pine in north-eastern edge of Gardens.



(k) Potential roost features in ash tree in centre of the Fern Garden.



(l) Hard standing areas and glasshouses, with limited intrinsic biodiversity importance.

4 Discussion and Recommendations

Identifying Important Ecological Features

- 4.1 The sensitivity, value or importance of ecological features can be related to a wide range of ecosystem services that they can provide to the environment, people or wider society. These benefits can include the conservation of genetic diversity, people's enjoyment or understanding of biodiversity, or the health benefits of biodiversity. A summary of an approach to evaluating the importance of ecological features in Scotland can be found in the table provided in **Appendix C**. The Appendix shows how ecological importance can be ascertained using a combination of statutory measures (legally protected sites and species) and non-statutory but widely accepted measures, such as the presence of notable habitats and species listed in biodiversity lists of local Biodiversity Action Plans (LBAPs). Use can also be made of the Ratcliffe assessment criteria for the selection of sites with nature conservation value (Ratcliffe, 1977⁷) and certain protected species have their own frameworks for the assessment of the importance of on-site populations. All these criteria can vary at different geographical scales.

Ecological sensitivities at the Glasgow Botanic Gardens

- 4.2 A summary of the main generally areas of ecological sensitivity within the Site is provided in **Figure 4.1**.

Designated sites

- 4.3 Glasgow City has 95 SINC's within its administrative area. These are considered to be the best areas for wildlife within the city, and although not meeting the criteria for statutory designation (for example as a Site of Special Scientific Interest – SSSI) they are all notable for having one or more of ecological, scientific, recreational or educational value. SINC's such as the River Kelvin are also important wildlife corridors, and play a crucial role in maintaining functioning integrated habitat networks throughout the city.
- 4.4 The River Kelvin SINC is therefore not only important for the river itself, but its associated riparian woodland and grassland within the predominantly built up environment of the West End. It is also important for the protected species it supports, such as otter, kingfisher and various type of bat. These species are present in part due to the non-built nature of the SINC, and low levels of artificial night time lighting.
- 4.5 Care has therefore been taken to locate the Event in parts of the Site which are outwith the SINC. None of the designated area will be directly lit, and those locations on its periphery which will border ground through which there will be footfall associated with the Event represent the marginal buffer zones which regularly experience pedestrian disturbance. It

⁷ Ratcliffe, D.A. (1977) *A Nature Conservation Review: Volume 1: The Selection of Biological Sites of National Importance to Nature Conservation in Britain*, Cambridge University Press, Cambridge, UK.



is therefore considered highly unlikely that the Event will result in negative impacts on the SINC and this area can be discounted as an IEF in the context of this appraisal.

Habitats and flora

- 4.6 The habitat mosaic within the Site is predominantly composed of improved (amenity) grasslands, long-history planted woodland and trees, and ornamental shrubberies and herbaceous planting. Areas immediately outwith the Site, in particular to the north-east into the SINC (see above) have significant issues with invasive non-native species (INNS), including Japanese knotweed, Himalayan balsam and giant hogweed. However, these species are generally scarce within the Site. Based on the information sources inspected, there are no Nationally Scarce or Rare native species within the Site which would need special attention during the Event.
- 4.7 Some infrastructure for the Event will however be located in and amongst non-hard standing habitats, including props, cabling, lights, speakers and staging, and specific sections of the Event route will result in pedestrian access over existing lawns. Disturbance could result in localised soil compaction or erosion, or direct damage to ground vegetation or shrubs/scrub. Vegetation and soils will be less resilient to disturbance during and after rainfall. To this end, habitats should be considered to be IEFs needing consideration.

Trees

- 4.8 The Glasgow Botanic Gardens are well known for their mature tree resource, and the lighting of some of these trees forms a part of the aesthetics of the Event. However, whilst the lighting or use of sound in the vicinity of a tree is unlikely to harm it *per se*, BS5837:2012 requires consideration of other aspects of trees, such as canopy spread and root protection zones (RPZs). Trees that have taken many decades to grow to a significant size, can be unwittingly damaged through misjudged movement of plant, or compaction of soil in RPZs. Younger trees are less resistant to damage, as relatively small magnitude events can result in significant damage or death. There is a risk that branches or stems of trees may be damaged during the installation and subsequent removal of in-canopy lighting, and root plates damaged through repeated trafficking of personnel, or the temporary storage or equipment.

Bats

- 4.9 The precise nature of the bat population in the Botanic Gardens appears not to have been quantified via a static detector survey. Even if not resident in roosts, at least two species of pipistrelle (common and soprano) have been recorded foraging within the Gardens, as well as Daubenton's bat closer to the River Kelvin. A colony bat box is located within the Site, but no formal monitoring data was available for this. Bats should therefore be considered a sensitivity in the context of this appraisal.

Relevant legislation

- 4.10 All British bats are EPS, protected in Scotland by the Conservation (Natural Habitats &c.) Regulations (1994) (as translated into domestic legislation post-Brexit) and the Wildlife and Countryside Act (1981, as amended). This legislation makes it an offence to capture, harass, injure or kill a bat; obstruct access to, damage or destroy a breeding or other resting



place of a bat; disturb bats in such a way as is likely to affect their distribution or abundance, or disturb bats in such a way as is likely to impair their ability to survive or breed. Each of these actions is considered to be an offence whether the action is deliberate or reckless, except in the case of damaging or destroying a breeding site or resting place which is a strict liability offence. A licence is required for all developments which will affect areas known to contain bat roosts.

- 4.11 A bat roost is defined as any structure or place which is used for shelter or protection by bats, irrespective of whether or not bats are resident. Buildings and trees may be used by bats for a number of different purposes throughout the year including resting, sleeping, breeding, raising young and hibernating. Roost use depends on bat age, sex, condition and species as well as the external factors of season and weather conditions. A roost used during one season is therefore protected throughout the year whether or not bats are actually present at the time of inspection, and any proposed works that may result in disturbance to bats, or loss, obstruction of or damage to a roost are licensable.

Habitat requirements

- 4.12 Different bat species have different habitat requirements at different times of year. Classic foraging and commuting habitat requires connected networks of invertebrate-rich open greenspace, preferably unlit and with water sources close by for drinking. However, some species (see below) successfully persist in built up areas where these features are scarce. Breeding roost locations need to have sufficient space for a number of female bats (10-1000s) to gather and birth/bring up their young. Non-breeding roosts used by males (usually less than 10 bats, often singletons), as well as opportunistically used or transient roosts, can be much smaller features. Many bats have adapted to roosting in the built environment, preferring crevices in stonework or under tiles/slates; and others in open loft spaces. Equally, many species are still found in tree roosts, although often in smaller numbers than those found in roosts in buildings. It is not possible therefore to be highly prescriptive about bat habitat requirements, although the conventions provided by the Bat Conservation Trust⁸ for the assessment of habitats for bats provide a useful framework (see **Table 4.1**). Using these criteria, the Site would be considered to represent **High** suitability foraging/commuting habitat for bats, and **Moderate** suitability for roosting.
- 4.13 The tree resource within the Site offered surprisingly few PRFs for bats, outwith the dedicated bat box. This was likely to be because the status of the Site as a well-used public space and curated garden means that potential rot or broken tree features which would normally be utilised by tree-roosting bats need in this instance to be removed or managed for health and safety reasons.

⁸ Collins, J. (2016) *Bat Surveys: Good Practice Guidelines, 3rd Edition*. Bat Conservation Trust.



Table 4.1: Categories of habitat suitability for bats (after Collins, 2016)

Suitability	Description of roosting habitats	Description of commuting and foraging habitats
Negligible	Negligible roosting features likely to be used by roosting bats.	Negligible habitat features likely to be used by commuting or foraging bats.
Low	A structure with one or more potential roost sites that could be used by individual bats opportunistically. 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 or hibernation). A tree of sufficient size and age to contain potential roost features, but with none seen from the ground, or the features seen have only very limited roosting potential.	Habitat that could be used by small numbers of commuting bats such as a gappy hedgerow or unvegetated stream, but is isolated i.e., not well connected to the surrounding landscape by other habitat. Suitable, but isolated habitat that could be used by small numbers of foraging bats such as a lone tree (not in a parkland situation) or a patch of scrub
Moderate	A structure or tree with one or more potential roost sites that could be used by bats, due to its size, shelter, protection, conditions and surrounding habitat, but unlikely to support a roost of high conservation status (with respect to roost type only – the assessments in this table are made irrespective of species conservation status, which is established after presence is confirmed).	Continuous habitat connected to the wider landscape that could be used by bats for commuting, such as lines of trees and scrub, or linked back gardens. Habitat that is connected to the wider landscape that could be used by bats for foraging, such as trees, scrub, grassland or water.
High	A structure or tree with one or more potential roost site(s) that is/are obviously suitable for use by larger numbers of bats on a more regular basis and potentially for longer periods of time due to its/their size, shelter, protection, conditions and surrounding habitat.	Continuous, high-quality habitat that is well connected to the wider landscape which is likely to be used regularly by commuting bats, such as river valleys, streams, hedgerows, lines of trees and woodland edges. High-quality habitat that is well-connected to the wider landscape and which is likely to be used regularly by foraging bats, such as broad-leaved woodland, tree-lined watercourses and grazed parkland. Site is close to and connected to known roosts.



Potential impacts on bats – lighting

- 4.14 Bats are nocturnal animals and therefore tend not to be active during the day. This is primarily thought to be a predation avoidance strategy, as well as being related to niche availability and an adaptative preference for foraging on insects that are active at night.
- 4.15 Illuminating roost sites is generally considered to be “disturbance” in the context of the current legislation protecting bats in Scotland, as doing so can cause bats to desert a roost or potentially become entombed. If not dissuaded from using the roost, lighting a roost exit point can delay emergence times, thereby decreasing the available time for foraging.
- 4.16 With respect to foraging and commuting, the relationship between bat behaviour and lighting is more complex. Many night-flying insects on which bats feed are attracted to light sources, in particular those with an ultraviolet component or a high blue spectral content. Fast-flying species such as pipistrelle bats can therefore congregate around these types of white light sources, hawking the insects attracted to the lights. Being fast-flying, these bats trade off being conspicuous with predator avoidance and the hunting benefits of these areas. In contrast, slower-flying broad-winged bat species, such as Daubenton’s bat avoid commuting or foraging in areas lit in these ways, being more vulnerable to predation. Consequently they are at a foraging disadvantage in lit environments which can then affect fitness and breeding success. A single light source in an otherwise unlit environment can therefore create a vacuum effect which benefits the faster flying species over the broad-winged species, the latter often being species of particular conservation concern. It has also been shown that for some species (which may not be relevant in the context of the Site under consideration here), dense tree cover above the height of street lighting without UV components (e.g. LEDs) provided some mitigation for lighting situated below the canopy.
- 4.17 As indicated above, the spectrum of the light is also a consideration when determining potential impacts on bats. The likely harmful impacts on blue-spectrum lighting has been known for a number of years, but other aspects of the colour spectrum are now becoming better understood. Research in the Netherlands has shown that slower-flying species such as *Myotis* bats avoid white and green spectrum light sources, but that faster flying species such as pipistrelles were more abundant in these conditions⁹. However, both groups of species were found to be equally abundant where red spectrum lighting was utilised, consisting of light above 600 nm and with an RA value of 60. The same effect has been observed in Daubenton’s bats in Scotland¹⁰.

Potential impacts on bats – noise and vibration

- 4.18 The BCT states that noise or vibration in the vicinity of a bat roost may disturb bats and therefore should be avoided¹¹. However, empirical evidence for this is lacking, in part

⁹ Barré, K., Kerbiriou, C., Ing, R., Bas, Y., Azam, C., Le Viol, I. & Spoelstra, K. (2021). Bats seek refuge in cluttered environment when exposed to white and red lights at night. *Movement Ecology*. 9. 10.1186/s40462-020-00238-2.

¹⁰ Gemma Grossart and Neil Middleton. The impact of different lighting colours on the foraging activity of Daubenton’s bat, *Myotis daubentonii*, at a site in Midlothian, Scotland. British Island Bats Volume 2 https://cdn.bats.org.uk/uploads/pdf/Resources/Bat-Groups/Accessing-journals/BritishIslandsBats_VolTwo_2021.pdf?v=1625915928 Accessed September 2023.

¹¹ [https://www.bats.org.uk/advice/im-concerned-about-bats/events-and-bats#:~:text=Excessive%20noise%20and%20vibration%20\(such,to%20help%20us%20protect%20bats.](https://www.bats.org.uk/advice/im-concerned-about-bats/events-and-bats#:~:text=Excessive%20noise%20and%20vibration%20(such,to%20help%20us%20protect%20bats.) Accessed September 2023.



because experimentally it would require licensing and could have negative conservation consequences. However, a PhD looking at these issues is due to commence at the University of the West of England in October this year¹². It is recognised that many bat roosts do occur in very noisy environments (e.g. church belfries, or electrical substations), where presumably the benefits of the place of shelter outweigh the drawbacks of noise. However, the effect of the introduction of noise into otherwise quiet environments is not well understood; to date the precautionary principle has been adopted and this type of disturbance is generally avoided wherever possible.

- 4.19 There has been a larger body of work investigating the effects of noise on foraging and commuting bats, and it has generally been shown that bats avoid environments with regular noise, such as busy roads, and/or have lower foraging success in these areas¹³. This may be because of acoustic conflict with echolocation techniques, or because bats become distracted by the noise source. However, autocorrelation with other factors such as light pollution and decreases in air quality mean that these relationship can be quite complex.

Hedgehog

Relevant policy and legislation

- 4.20 Hedgehogs are native and widespread across the UK. They require a mixture of habitats for foraging, nesting and mating, and a connected landscape through which they can move to reach their required habitats. Hedgehogs are currently rapidly declining, with at least a third lost from Britain since 2000 (State of Britain's Hedgehogs Report, 2022¹⁴). They appear to be faring better in urban areas rather than rural locations, with urban populations potentially improving. They are one of the few animals well adapted to surviving alongside humans, actually preferring gardens and amenity grassland habitats, and therefore, enhancing and connecting urban and suburban areas is key to enabling this species to survive.
- 4.21 Hedgehog is listed on the Scottish Biodiversity List (SBL) as a species of principal importance in Scotland, for which there is a watching brief on its conservation status. It receives limited protection under Section 6 of the Wildlife and Countryside Act (1981, as amended), namely that it is illegal to kill or capture hedgehog using certain methods. They are also protected in Britain under the Wild Mammals Protection Act (1996), prohibiting cruelty and mistreatment.

Potential impacts on hedgehogs

- 4.22 Hedgehogs are relatively mobile animals that tend to move away from disturbance sources. However, the timing of the Event is such that it will occur at a time of year when these animals are seeking or have sought shelter for a winter hibernation. The peripheries of the Site, as well as areas of stacked brash and leaf and compost heaps, would provide good

¹² <https://www.uwe.ac.uk/research/postgraduate-research-study/how-to-apply/studentship-opportunities/the-impacts-of-anthropogenic-noise-on-bats> Accessed September 2023.

¹³ Finch, D., Schofield, H. and Mathews, F. (2020) Traffic noise playback reduces the activity and feeding behaviour of free-living bats. *Environmental Pollution*, 263.

¹⁴ Wembridge, D., Johnson, G. Al-Fulaij, N. and Langton, S. (2022) The State of Britain's Hedgehogs 2022. Online publication available at <https://www.britishhedgehogs.org.uk/> Accessed September 2023.



locations for hedgehogs to shelter. Although unlikely to be significantly bothered by sound or light at this time, physical disturbance of hibernation sites could seriously affect these animal's subsequent survival through the winter. In addition to disturbance of places of shelter, cabling, barriers and other potential sources of entanglement at ground level could present hazards to hedgehogs moving around the Site. It should be noted that similar impacts and effects would also be relevant to **common amphibians**.

Birds

Relevant legislation

- 4.23 All wild birds in the UK, their nests and their eggs are protected by the Wildlife and Countryside Act 1981, (as amended). Under this legislation it is an offence, with certain exceptions, to:
- intentionally or recklessly kill, injure or take any wild bird;
 - intentionally or recklessly take, damage or destroy the nest of any wild birds while it is in use or being built;
 - intentionally or recklessly take or destroy the egg of any wild bird.
- 4.24 A number of bird species have been highlighted as priorities for bird conservation in the UK (Stanbury *et al.*, 2021¹⁵), and allocated Red or Amber status. All other species not of conservation concern are considered to be Green-listed. Certain bird species also have additional protection under the terms of the EC Birds Directive, and may be local priorities for conservation action via local BAPs.

Habitat requirements

- 4.25 Given the timing of the Event, disturbance or destruction of nest sites is not a consideration, as set up, operation and dismantling the Event will all occur outwith the key nesting bird season. Leaf-drop will be in progress, and some deciduous trees and bushes will likely to have lost the majority of their leaves, reducing their cover value for birds. However, more dense areas of scrub and woodland on the edges of the Site, in particular those with evergreen species, could continue to provide some cover for birds throughout the autumn and winter months, although this is unlikely to include bird species considered to be of conservation concern. Nevertheless, props and cabling in habitats utilised by birds during the autumn and winter months could result in undesirable disturbance or entanglement.

Potential impacts on birds – lighting

- 4.26 The impacts of artificial light at night (often abbreviated to ALAN in academic literature) on birds is fairly well researched, including both point-sources (e.g. street lighting) and skyglow as a result of broader-scale light pollution in some urban environments. Song birds have

¹⁵ Stanbury, A., Eaton, M., Aebischer, N., Balmer, D., Brown, A., Douse, A., Lindley, P., McCulloch, N., Noble, D., and Win I. (2021). The status of our bird populations: the fifth Birds of Conservation Concern in the United Kingdom, Channel Islands and Isle of Man and second IUCN Red List assessment of extinction risk for Great Britain. *British Birds* 114: 723-747.



been found to alter their patterns of song behaviour in response to elevated light levels^{16,17}, and there have been high profile cases of mortality caused by collision with event or structure lighting, such as ceilometers or the stationary “search beams” used to light the September 11th monument in New York^{18,19}. However, research to date has generally focussed on long-term implications of increased background levels of lighting, on changed response in the dawn chorus, and with respect to migratory bird collisions relating to search beams and other night-sky lighting.

- 4.27 None of these situations are directly transferable to the Event under consideration here. Lighting impacts on birds as a result of GlasGLOW will be, comparatively speaking, short-term, time-limited and in a location and at a time of year not associated with the movement of flocks of migratory birds or species of conservation concern. Birds residing around the south, east and western parts of the Site are likely to have behaviour patterns that are influenced by close proximity to artificially lit streets and vehicle lights. The Event is timed within the hours of darkness, and this is not a time when birds would typically be active within the parts of the gardens which will be utilised by the Event. Nocturnal species such as tawny owl will be more likely to hunt along the less disturbed, darker areas where longer grass habitats will have a high small mammal population. Impacts on hunting success are therefore unlikely to occur.

Potential impacts on birds – noise and vibration

- 4.28 Different bird species have different tolerance levels for a response to noise disturbance, and a distinction is usually drawn between the volume and distance from the noise source sufficient to put a bird on “alert”, and that which causes movement away. The Botanic Gardens is a well used public space, and birds which choose to utilise the more heavily frequented areas for foraging will have become accustomed to the presence of humans, dogs and various other noise sources. Those which reside in the more peripheral areas of the Site will be less tolerant of noise, but in all cases these are not species which would be expected to be active at night.
- 4.29 Notwithstanding the above, a precautionary approach to the use of music and the placing of noise generating plant should be adopted during the design of the Event.

Nesting birds

- 4.30 Although the Event will take place well outside the core bird breeding season woodpigeon is present on the Site and it is not uncommon for this species to have an extended breeding season into October, sometimes with nestlings into November. Woodpigeon are very tolerant of human presence in urban settings, and frequently nest in gardens and close to buildings and footpaths. Therefore disturbance is not likely to be a major issue if this species is nesting. Nevertheless, the legislation relating to nesting birds (see above) would

¹⁶ Da Silva, A., Samplonius, J.M., Schlicht, E., Valcu, M. and Kempenaers, B. (2014) Artificial night lighting rather than traffic noise affects the daily timing of dawn and dusk singing in common European songbirds. *Behavioural Ecology* **25**(5), pp1037-1047.

¹⁷ Dickerson, A.L., Hall, M.I. and Jones, T.M. (2022) The effect of natural and artificial light at night on nocturnal song in the diurnal willie wagtail. *Science of the Total Environment*, **808**, 151986.

¹⁸ Van Doren, B.M., Horton, K.G., Dokter, A.M., Klinck, H., Elbin, S.B., Farnsworth, A. (2017) High-intensity urban light installation dramatically alters nocturnal bird migration. *Proceedings of the National Academy of Science*, **114**, pp.11175–80.

¹⁹ <https://www.nytimes.com/2019/09/09/nyregion/911-tribute-birds.html> Accessed September 2023



still be relevant and checks for the presence of active nests at locations where key Event infrastructure is to be erected would be recommended (see below).

Invertebrates

- 4.31 Although many invertebrates found in the Botanic Gardens are not nocturnal, and are associated with soil habitats and vegetation, a large proportion of its known invertebrate assemblage would be expected to be night-flying, including moths and other insects. As with birds and bats, much of the available research into the effects of night lighting on this group is focussed on long-term trends associated with ALAN in urban or street-lit semi-rural areas. There is little information on whether or not significant impacts on survival or population numbers is affected by shorter periods of elevated lighting. Generally however, recent research has shown that moths in particular spend less time feeding in lit environments²⁰, although the effects are dependent on the intensity and signal colour of the lighting in question²¹.
- 4.32 The timing of the Event, in late October and early November, is not a key time for night flying invertebrates, when night time air temperatures are falling and the first ground frosts occur. Ground- and soil-dwelling species will be seeking safe locations in which to over-winter. Although some species will certainly still be active, it is unlikely that the Event will have any significant effects on these taxa if the sensitivities associated with other nocturnal species are given appropriate consideration.

²⁰ van Langevelde, F., van Grunsven, R. H. A., Veenendall, E. and Fijen, T. P. M (2017) Artificial night lighting inhibits feeding in moths. *Biol. Lett.* **13**: 20160874. <http://dx.doi.org/10.1098/rsbl.2016.0874>

²¹ Briolat, E.S., Gaston, K.J., Bennie, J., Rosenfeld, E.J & Troscianko, J. (2021) Artificial nighttime lighting impacts visual ecology links between flowers, pollinators and predators. *Nature Communications*, **12**, 4163, <https://doi.org/10.1038/s41467-021-24394-0> | www.nature.com/naturecommunications



General Areas of Ecological Sensitivity

- Site boundary
- Ecological sensitivity

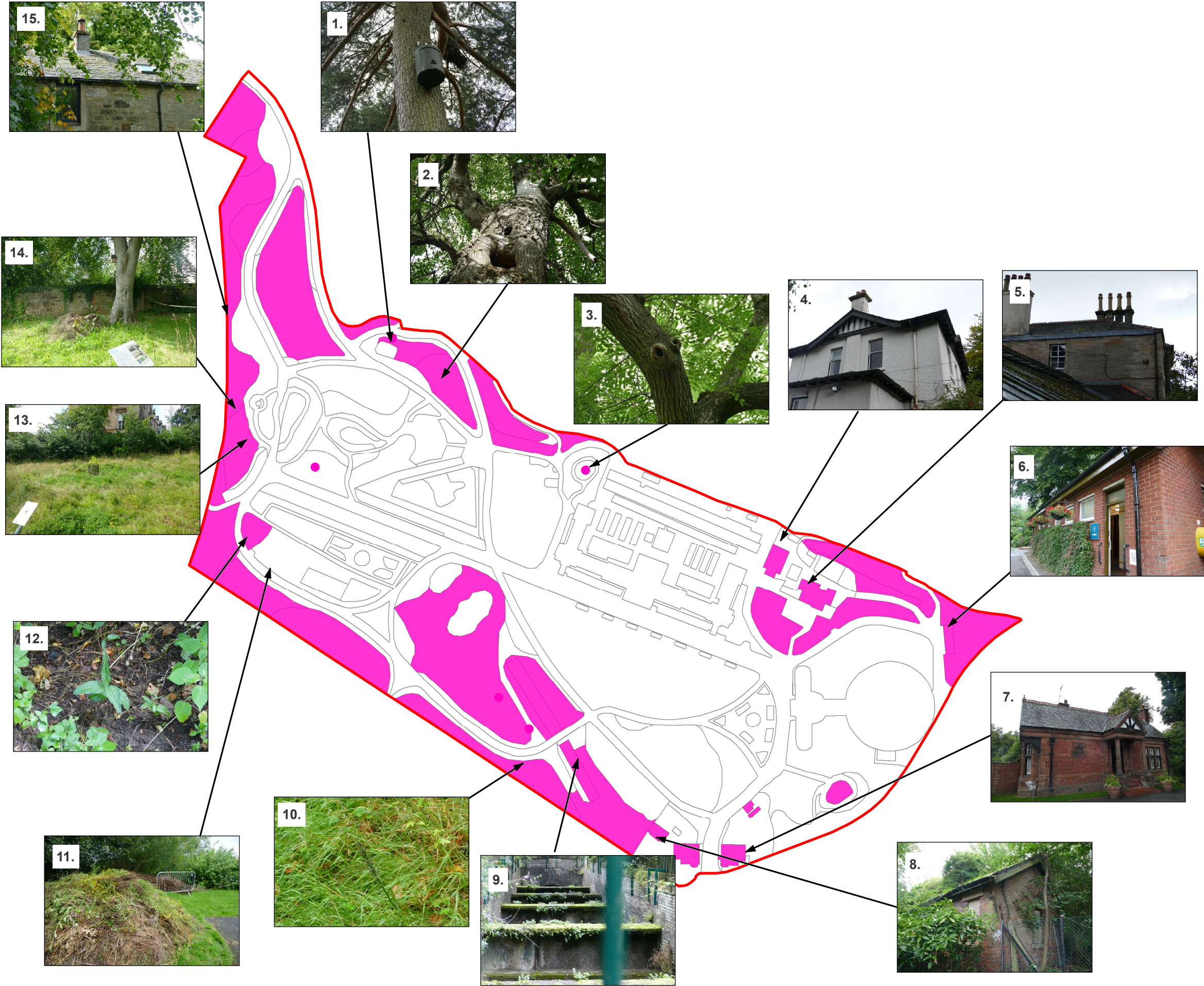
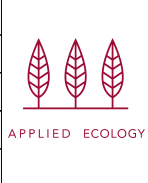
- 1: Colony bat box.
- 2: Potential bat roost features (PRFs) in trees.
- 3: PRFs in trees.
- 4: Buildings of traditional construction including slate roofs that have PRFs.
- 5: Buildings of traditional construction including slate roofs that have PRFs.
- 6: Buildings of traditional construction including slate roofs that have PRFs.
- 7: Buildings of traditional construction including slate roofs that have PRFs.
- 8: Derelict buildings with PRFs.
- 9: PRFs in derelict station, including hibernation potential.
- 10: Less intensively managed grassland areas with higher species diversity e.g. common spotted orchid.
- 11: Compost heaps - shelter for hedgehog and common amphibian species.
- 12: Base of dense scrub habitats - suitability for hedgehog and birds, plus some plant species interest e.g. broad-leaved helleborine.
- 13: Species-rich grassland.
- 14: Compost heap and tree-mounted bird box.
- 15: PRFs in adjacent properties.

Figure 4.1

Map Scale @ A3: 1:2,000



Surveyed by: AEL
Survey date: August 2023
Drawn by: RAH
Checked by: SH
Status: Final



Recommendations for key IEFs

Habitats and trees

Design phase

- 4.33 The following considerations relating to habitats and trees should be made during the design of the Event:
- the Event route must be planned so as to keep footfall within areas of hard standing. Where this is not possible, artificial surfaces should be utilised in key areas where soil compaction and/or erosion is likely;
 - sufficient provision must be made for fencing and/or barriers to prevent peripheral disturbance of habitats adjacent to the path network, including that arising from “short-cutting” or creating desire lines;
 - avoidance of Event infrastructure within habitats considered to be of greater biodiversity importance, including ground within the River Kelvin SINC, species-rich neutral grassland and under scrub habitats containing notable flora;
 - where Event features are proposed within longer grass (non-lawn) areas, formal marking of routes for installation and maintenance/operation should be pre-planned and marked on maps and on the ground, to ensure peripheral disturbance is minimised;
 - use of pyrotechnics in the north of the Site must be at sufficient distance from tree canopies so as to avoid scorching;
 - event infrastructure must be kept outwith the root protection zone of trees;
 - calculation of likely worst case scenario for habitat restoration, based on experience gained in previous years, to ensure that sufficient materials are pre-ordered and available for remediation works during close-out.

Event set up

- 4.34 During the setting out phase of the Event, the planned items described above from the Design Phase should be implemented in full. In particular, due attention must be paid to:
- **briefing Site personnel regarding the biodiversity protection measures which will be adopted for the Event, during set-up, operation and close-out;**
 - the need to keep tree root protection zones clear of plant and equipment, including the temporary storage of materials;
 - ensuring that the planned fencing off of non-hard standing habitats is implemented during set-up, so that personnel, vehicles and equipment are restricted to hard standing areas wherever practicable, to avoid peripheral disturbance of edge habitats;
 - ensuring cabling and other “hidden” Event infrastructure does not disturb undergrowth habitats with notable flora, brash or compost heaps;
 - discreet marking of maintenance/set up routes through longer grassland areas to prevent widespread disturbance.



Event operation

- 4.35 If the Design and Set-up phases of the Event have been executed as described above, there should be few, if any, habitat and tree concerns during the actual Event. The main actions to note would be:
- adhering to any set routes for maintenance or feature operation which have been determined in order to minimise peripheral disturbance of habitats;
 - prohibition of maintenance plant within root protection zones;
 - any notable issues involving habitats and trees should be noted in a Biodiversity Register. The Register should include details regarding issue location, date and time, personnel involved, likely cause(s) and adopted solution.

Event close-out

- 4.36 After the close of the Event, all cabling, staging, props and other infrastructure should be removed using the same precautionary measures as outlined above for set up.
- 4.37 All potential areas of habitat or tree sensitivity should be reinspected and the pre-agreed strategies for restoration implemented as planned.
- 4.38 The information contained within the Biodiversity Register should be reviewed and then filed with the Health and Safety documentation for the Event, for reference in future years.

Bats

Design phase

- 4.39 The majority of potential impacts on bats can be designed out during the Design Phase of the event. This would include:
- no new direct lighting of potential roost features, including the upper floors and roofs of traditionally constructed buildings on the Site, the underground railway station, the existing bat box and/or any trees identified by a Suitably Qualified Ecologist (SQE) as containing PRFs;
 - LED luminaires should be used where possible due to their sharp cut-off, lower intensity, good colour rendition and dimming capability (if relevant);
 - lights with blue components must not be used to light trees and/or key potential bat foraging or commuting features, using instead warm white sources (2700 Kelvin or lower) and peak wavelengths higher than 550nm. This is to avoid the component of light most disturbing to bats;
 - no direct sound at the location where the Event route crosses the railway tunnels;
 - no sound or lighting along the western boundary of the Site;
 - no sound or lighting at the pond in the east of the Site.

Event set up

- 4.40 During Event set-up, the above Design Phase actions will need to be implemented in full. In addition, the following measures will be required with respect to bats:



- where there is an intention to light trees contain PRFs or where the entirety of the tree cannot be viewed from ground level, PRFs should be inspected endoscopically at height by a Licensed Bat Worker (LBW) prior to the installation of the lighting. If evidence of bat occupancy is found during that inspection then it will not be possible to light that tree unless a licence is in place.

Event operation

- 4.41 If all measures described under the Design and Set-up stages are implemented in full, there should not be any additional measures required for bats during the actual operation of the Event.
- 4.42 However, any notable issues involving bats which occur during the Event should be noted in the Biodiversity Register (see above). The Register should include details regarding issue location, date and time, personnel involved, likely cause(s) and adopted solution.

Event close-out

- 4.43 There are no additional considerations for bats during the dismantling phase. However, any entries in the Biodiversity Register that relate to bats should be reviewed, to determine any actions needed in future years.

Hedgehog

Design phase

- 4.44 The majority of potential impacts on hedgehog can be designed out during the Design Phase of the event. This would include:
- planning of cable routes to avoid disturbing areas of scrub or brash;
 - no netting or other sources of entanglement to be placed within vegetation (trees or shrubs) which could be utilised by hedgehog for shelter.
- 4.45 It should be noted that these measures for hedgehog would also help to avoid impacts on **common amphibians**.

Event set up

- 4.46 During the setting out phase of the Event, the planned items described above from the Design Phase should be implemented in full.
- 4.47 If a hibernating hedgehog is discovered then the SSPCA should be contacted for advice.

Event operation

- 4.48 If all measures described under the Design and Set-up stages are implemented in full, there should not be any additional measures required for bats during the actual operation of the Event.
- 4.49 However, any notable issues involving hedgehogs which occur during the Event should be noted in the Biodiversity Register (see above). The Register should include details



regarding issue location, date and time, personnel involved, likely cause(s) and adopted solution.

Event close-out

- 4.50 There are no additional considerations for hedgehog during close-out. However, any entries in the Biodiversity Register that relate to birds should be reviewed, to determine any actions needed in future years.

Birds

Design phase

- 4.51 The majority of potential impacts on birds can be designed out during the Design Phase of the event. This would include:
- no sound or lighting along the western or northern boundaries of the Site;
 - use of mobile search beams (not static) and *potentially* the switching off of these for 10 min periods within each hour²²;
 - no netting or other sources of entanglement to be placed within vegetation (trees or shrubs) which could be utilised by birds for shelter.

Event set up

- 4.52 During the setting out phase of the Event, the planned items described above from the Design Phase should be implemented in full. In addition, locations where lighting will be installed within trees or shrubs will be checked in advance by a Suitable Qualified Ecologist to discount the presence of nesting woodpigeon.

Event operation

- 4.53 If all measures described under the Design and Set-up stages are implemented in full, there should not be any additional measures required for birds during the actual operation of the Event.
- 4.54 However, any notable issues involving birds which occur during the Event should be noted in the Biodiversity Register (see above). The Register should include details regarding issue location, date and time, personnel involved, likely cause(s) and adopted solution.

Event close-out

- 4.55 There are no additional considerations for birds during Event close-out. However, any entries in the Biodiversity Register that relate to birds should be reviewed, to determine any actions needed in future years.

²² A 20 min break technique is utilised at the September 11th monument in New York to “release” birds trapped by the light. It should be acknowledged however that the bird collision situation associated with the 9/11 monument is by no means transferable to the Event, and any such mitigation would be precautionary rather than essential.



Opportunities for biodiversity

- 4.56 The Site contains numerous opportunities for enhancing biodiversity despite its urban context. Such enhancements can be provided without creating new constraints for future users of the Site including event like GlasGLOW, through their careful siting and following consultation with other stakeholders. GCC has control of a wider area than that delimited by the Site boundary utilised for the Event, and therefore the potential area in which enhancement features could be deployed extends outwith the boundaries shown in this report.
- 4.57 Enhancement measures which may be appropriate could include:
- provision of dedicated hedgehog homes. These should be located along boundary features, in long grass and/or scrub²³;
 - provision of tree mounted bat boxes. These would need to be erected on trees where there is a low likelihood of arboricultural works being needed, in unlit areas and where there is clear flights accessed. A range of box types could be considered, including those suited to crevice roosting species such as pipistrelles²⁴, as well as cavity boxes suitable for *Myotis* species²⁵. The aim should be to erect boxes on a range of potential aspects to provide roosting options in all weathers/temperatures. There may be more suitable locations for such boxes outwith the Site boundary used for this report;
 - provision of bird boxes on trees²⁶ around the periphery of the Site and/or on appropriate features on the buildings²⁷ within the Site.
- 4.58 Consultation with stakeholders may reveal other activities which would assist with the conservation or management of biodiversity on the Site. This could include support for the formal monitoring of wildlife enhancement features, potentially in collaboration with personnel at the University of Glasgow.

²³ <https://www.hedgehoghighway.co.uk/shop/> Other similar products are available. Advice should be sought from an SQE.

²⁴ <https://www.greenwoodsecohabitats.co.uk/shop> Other similar products are available. Advice should be sought from an SQE.

²⁵ <https://www.nhbs.com/2f-schwegler-bat-box-with-double-front-panel> Other similar products are available. Advice should be sought from an SQE.

²⁶ <https://www.nhbs.com/1b-schwegler-nest-box> Other similar products are available. Advice should be sought from an SQE.

²⁷ <https://www.nhbs.com/vivara-pro-woodstone-house-martin-nest> Other similar products are available. Advice should be sought from an SQE.



5 Summary and Conclusions

- 5.1 In August 2023, a review was undertaken of the proposed content of a sound and light event to be held in the Glasgow Botanic Gardens, known as GlasGLOW. An appraisal was made of the likely ecological sensitivity in the context of the Event, and recommendations made for how these impacts and their resulting effects could first be avoided, and then mitigated or compensated. Measures to be implemented have been described for each of the design, set-up, operation and close-out phases of the Event, along with suggestions for opportunities for providing wildlife enhancements and biodiversity benefits within or close to the Gardens.
- 5.2 Although in the absence of complex before-and-after comparison studies it cannot be stated conclusively that these types of event will have zero effect on wildlife, adhering to the best practice measures outlined here will ensure compliance with both current best practice and legislation. A short review of the measures implemented will be carried out following the close-out of the 2023 Event, and this information will be used to inform approaches to be taken to similar events in future years.
- 5.3 The findings and recommendations made in this report will remain valid for a period of 18-24 months, after which time a review will be necessary.



Appendix A

List of Initialisms, Acronyms and Abbreviations Used in this Report



Short form	Full terminology
AEL	Applied Ecology Ltd
AWI	Ancient Woodland Inventory
BCT	Bat Conservation Trust
BoCC	Birds of Conservation Concern
BRS	Bat Roost Suitability
BRS	Biological Records Centre
CIEEM	Chartered Institute of Ecology and Environmental Management
DAFOR	Dominant, abundant, frequent, occasional or rare
EclA	Ecological Impact Assessment
EPS	European Protected Species
EUNIS	European Nature Information System
GIS	Geographical Information System
GMRC	Glasgow Museums Resource Centre
GPS	Global Positioning System
IEF	Important Ecological Feature
ILP	Institute of Lighting Professionals
INNS	Invasive Non-Native Species
LBAP	Local Biodiversity Action Plan
LDP	Local Development Plan
MMU	Minimum Mappable Unit
PEA	Preliminary Ecological Appraisal
PRF	Potential Roost Feature
RPZ	Root Protection Zone
SBL	Scottish Biodiversity List
SINC	Site of Importance for Nature Conservation
SQE	Suitable Qualified Ecologist
SSSI	Site of Special Scientific Interest
SWT	Scottish Wildlife Trust
WANE Act	Wildlife and Natural Environment (Scotland) Act (2011)



Appendix B

Habitat Survey Target Notes



Target note	Description
1	Toilet block. Red brick construction with slate roof and timber soffits. Soffits appear to be entire, and fairly cobwebby, but access around the rear of the building was impeded for clear view of the roof. Precautionarily allocated bat roosting suitability to this structure, although front façade appears to be well lit, and cluttered environment on other aspects for clear flight access.
2	Small pond feature. Could not be accessed directly as fenced off and personnel were actively working in this area. Surrounded by a variety of ornamental beds and rock features.
3	Lodges at main entrance to gardens. Both of red sandstone construction with traditional slate roofs, clay ridge tiles and chimneys. Slipped and missing tiles, and wasps entering nest location on western lodge. Both buildings considered to have bat roosting suitability.
4	Planted mature lime trees, with abundant rhododendron in the shrub layer. Occasional holly. Single plant of Japanese knotweed seen.
5	Former Botanic Gardens train station, with associated tunnels. Bat roosting suitability. Potential for hibernation suitability further into tunnel system.
6	Area of taller neutral grassland as a result of relaxation of mowing. Dominated by Yorkshire fog, but with abundant perennial rye-grass and common bent. A number of herbs were occasional throughout this area, including common hogweed, creeping buttercup, meadow buttercup, ribwort plantain, common ragwort, common bird's-foot-trefoil, common hawkweed, perfoliate St John's-wort and a few spikes of common spotted orchid.
7	Unmown neutral grassland, with saplings of <i>Populus</i> sp.. Dominated by Yorkshire fog, with abundant red fescue. Common cat's-ear was abundant and fox-and-cubs occasional, along with common ragwort, white clover, common bistort and creeping buttercup. Small rowan trees also in this area.
8	Scrubby undergrowth, with frequent broad-leaved helleborine.
9	Strip of native scrub forming part of the Site boundary. Dominated by alder, ash, a species of <i>Ribes</i> , birches, <i>Prunus</i> sp., horse chestnut and great willowherb.
10	Species-rich neutral grassland, seemingly managed for wildlife. Did not cross the fenceline, but from perimeter estimated Yorkshire fog to be abundant, cock's-foot, crested dog's-tail and Timothy occasional, and common bent frequent. Wide range of herbs were conspicuous, including fox-and-cubs, common knapweed, yellow rattle, tufted vetch, white clover, common bird's-foot-trefoil, red clover, common cat's-ear, curled dock, ribwort plantain, meadow buttercup and germander speedwell. Birch seedlings also noted.
11	Pile of turfs (potential hibernacula) and bird box.
12	Relatively species-poor area of taller grass where mowing regime has been relaxed.
13	Schwegler large colony bat box in Scots pine.
14	Large poplar with numerous good PRFs, although grey squirrel seem to be occupying a number of these. Lower level PRFs inspectable – no droppings seen.
15	Large ash tree in centre of fern garden. PRFs present in knotholes.
16	Garden Manager office – traditional construction with slate roof and lead flashing, with numerous PRFs visible. Existing security lighting affixed to first floor level.
17	Tea room buildings, also of traditional construction and likely to represent PRFs.



Appendix C

Defining Important Ecological Features



Level of sensitivity or value	Examples (not exhaustive)
International (including European)	An internationally designated site or candidate site (SPA²⁸, proposed SPA (pSPA)²⁹, Special Area of Conservation (SAC)³⁰, candidate SAC (cSAC)³¹, pSAC³², Ramsar site³³, Biogenetic Reserve³⁴) or an area which NatureScot has determined meets the published selection criteria for such designations, irrespective of whether or not it has yet been notified. A viable area of a habitat type listed in Annex 1 of the Habitats Directive, or smaller areas of such habitat which are essential to maintain the viability of that ecological resource. A regularly occurring population representing >1 % of the European resource of a species listed in Schedules 2 or 4 of the Habitat Regulations (as amended post-Brexit).
National	A nationally designated site (Site of Special Scientific Interest (SSSI)³⁵, National Nature Reserve (NNR)³⁶, Marine Nature Reserve) or a discrete area which NatureScot has determined meets the published selection criteria for national designation irrespective of whether or not it has yet been notified. A viable area of a priority habitat identified in the former UK BAP or Scottish Biodiversity List, or smaller areas of such habitat which are essential to maintain the viability of that ecological resource. A regularly occurring population representing >1 % of the national population of a nationally important species, i.e., a priority species listed in the former UK BAP or Scottish Biodiversity List and/or Schedules 1, 5 (S9 (1, 4a, 4b)) or 8 of the Wildlife and Countryside Act, or Schedules 2 or 4 of the Habitat Regulations (as amended post-Brexit). A regularly occurring and viable population of a UK Red Data Book species.
Council/Regional	Viable areas of key habitat identified in Council LBAP or Scottish Biodiversity List, or smaller areas of such habitats that are essential to maintain the viability of that ecological resource. Any regularly occurring, locally significant population of a species listed as being nationally scarce (occurring in 16-100 10 km squares in the UK) or in a relevant Council LBAP or Natural Heritage Zone profile on account of its rarity or localisation. Non-statutory designated wildlife sites including semi-natural ancient woodland greater than 0.25 ha. Networks of species-rich hedgerows.
Local	Locally important habitats or species such as: - semi-natural ancient woodland smaller than 0.25 ha; - features that are scarce within the local area or which appreciably enrich the local habitat resource e.g. networks of hedgerow/ditches not considered to be species-rich; - small populations of notable species (e.g., SBL or LBAP species) regularly resident on or using the site.
Site	Commonplace and widespread habitats or species which contribute to the functioning or value of the wider ecological landscape, such as: - scrub, poor semi-improved grassland, coniferous plantation woodland, intensive arable farmland etc.; - common and widespread faunal species, or occasional individuals of more notable species such as SBL or LBAP species, either resident on or using the site.

²⁸ Special Protection Area classified under the EU Birds Directive for importance to birds.

²⁹ Potential Special Protection Area.

³⁰ Special Area of Conservation Area classified under the EU Habitats Directive for important habitat or non-bird species.

³¹ Candidate Special Area of Conservation.

³² Potential Special Area of Conservation.

³³ Wetland of international importance designated under the Ramsar Convention.

³⁴ Sites deemed representative examples of particular habitats in Europe.

³⁵ Site of Special Scientific Interest.

³⁶ National Nature Reserve.



Appendix D

Biodiversity Checklist for GlasGLOW



Checklist for biodiversity actions relevant to the Event

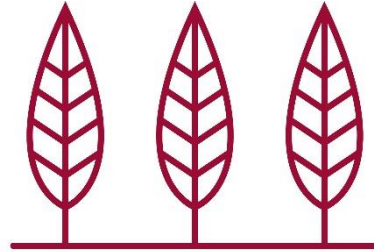
Feature to be considered	Design phase	Set-up	Operation	Close-out
Habitats				
Brief all personnel regarding biodiversity protection	●	●	●	●
Footfall in hard standing areas; provision of artificial surfaces	●	●	●	●
Provision of barriers	●	●	●	●
Exclusion of SINC/northern boundary	●	●	●	●
Exclusion of species-rich grassland areas	●	●	●	●
Exclusion of native scrub habitats	●	●	●	●
Plan/mark/use defined routes through taller grassland	●	●	●	●
Strategic placement of pyrotechnics	●	●		
Adhere to RPZs	●	●	●	●
Planning for/execution of habitat restoration				
Cabling must not disturb brash, compost heaps or undergrowth	●	●		●
Bats (and other nocturnal considerations)				
No new lighting of PRFs (structures and trees)	●	●		
Preferential use of LEDs	●			
No “white blue” lights in trees; < 2700 Kelvin; peak wavelengths > 500 nm	●			
No direct sound at railway tunnels	●	●	●	
No sound or new lighting along western and northern boundaries	●	●	●	
No sound or lighting at the pond	●	●	●	
LBW pre-check of PRFs in trees to be lit		●		
Hedgehog				
Cabling must not disturb brash, compost heaps or undergrowth	●	●		●
No netting or sources of entanglement	●			
Birds				
No sound or new lighting along western and northern boundaries	●	●	●	
Mobile search beams / 10 min rest breaks	●	●		
No netting or sources of entanglement	●			
Pre-checks for nesting woodpigeon		●		
General				
Biodiversity Register	●	●	●	●



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APPLIED ECOLOGY

GlasGLOW 2023

Bat Monitoring Surveys

Produced for itison

By Applied Ecology Ltd

February 2024

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1 Introduction

Background

- 1.1 In August 2023, Applied Ecology Ltd (AEL) was commissioned by itison to provide ecological support for their autumn sound and light event known as GlasGLOW ("the Event"), to be held in October and November 2023 within the Glasgow Botanic Gardens ("the Site"), in the West End of the City of Glasgow. A plan showing the location of the Site is provided in **Figure 1.1**.
- 1.2 GlasGLOW has run annually within the Botanic Gardens since 2018. Although sustainability has always been a consideration in the design and planning of the Event, in 2023 itison took this further with the appointment of a dedicated sustainability specialist to advise on all stages of their event planning and delivery. In parallel with this, and as part of recognising that the Event takes place within public greenspace with its own intrinsic sensitivities, Glasgow City Council (GCC) has required itison to engage with an independent ecological consultant, to provide objective advice regarding how the 2023 GlasGLOW event could be designed and run so as to minimise its biodiversity impact.
- 1.3 AEL provided ecological support to itison throughout the late summer and autumn of 2023, during which a knowledge gap was identified regarding the quantity, location and type of bat activity within the parts of the Botanic Gardens in which the Event was to take place. A proposal was therefore put together for a bat monitoring study covering the late summer and pre-hibernation periods, including the nights which would be covered by the Event.

Purpose of this report

- 1.4 This report provides details relating to a small-scale bat monitoring study undertaken within the Glasgow Botanic Gardens between September and November 2023. It includes an outline of the methodology and sampling strategy adopted, a description of the findings, and an evaluation of the implications of these, both in the context of the Event, and the Botanic Gardens more generally.

Report qualification

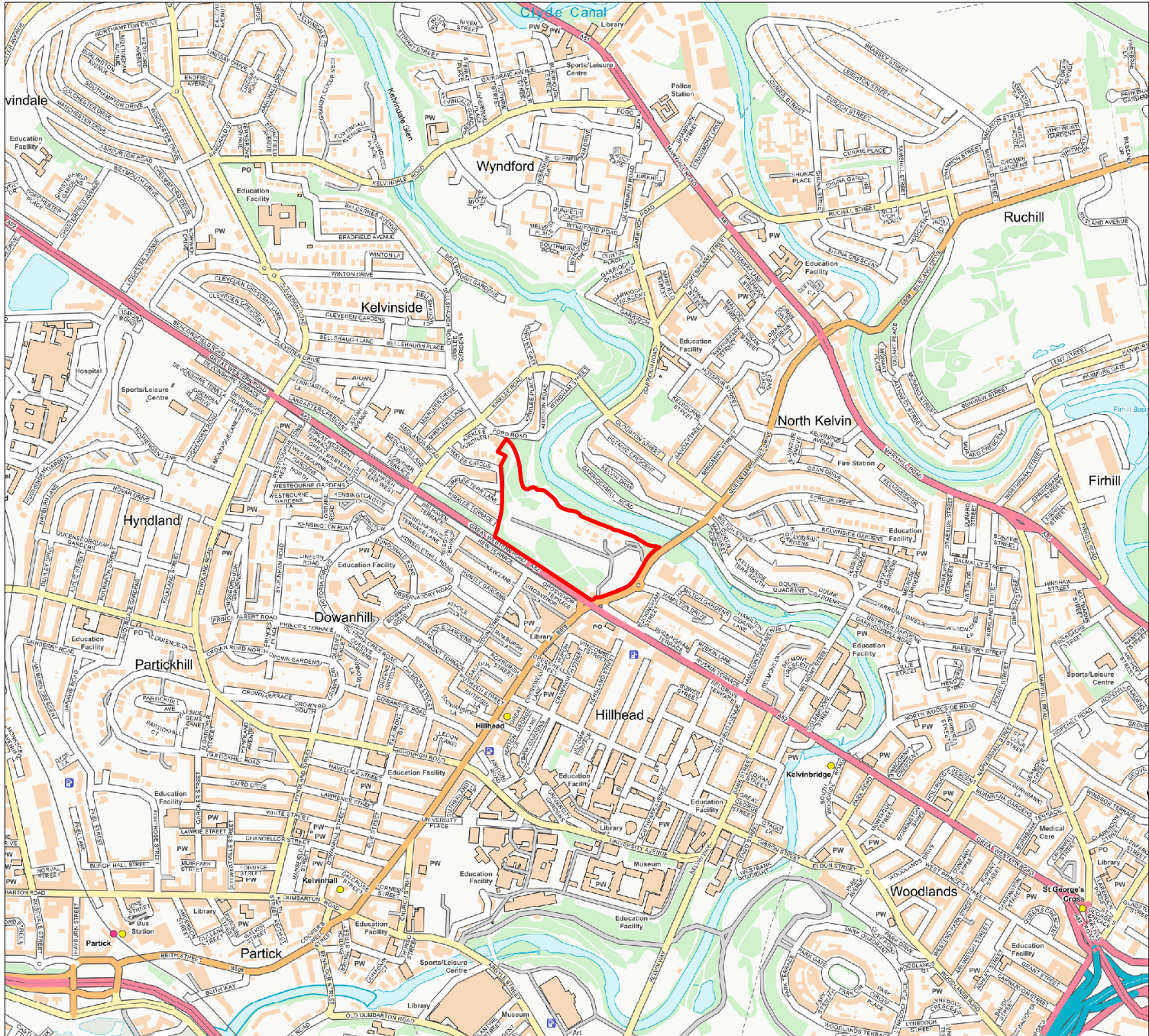
- 1.5 The survey described here was undertaken in accordance with the best practice methodologies current at the time of commissioning. Site circumstances, scientific knowledge or methodological requirements can change during the course of a project, and these external factors may impact on the scope of subsequent work requirements.
- 1.6 All survey work and reporting were undertaken by experienced and qualified ecologists in accordance with the Code of Professional Conduct of the Chartered Institute of Ecology and Environmental Management (CIEEM), as well as guidance produced by the Bat Conservation Trust (BCT) and that contained in BS 42020:2013 (Biodiversity).
- 1.7 All ecological surveys have an expected validity period, owing to the tendency of the natural environment to change over time. This validity period varies from feature to



feature, and is also dependent on the degree of change in a site's management and overall landscape ecology. Where the potential for change is considered to be relevant to the Site, this is highlighted in the appropriate section.

- 1.8 This report does not purport to provide detailed, specialist legal advice. Where legislation is referenced, the reader should consult the original legal text, and/or the advice of a qualified environmental lawyer.





GlasGLOW

Site Location

 Site boundary

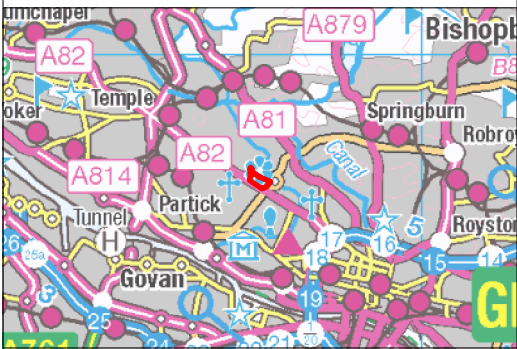


Figure 1.1

Map Scale @ A4: 1:15,000



Surveyed by: -

Survey date: -

Drawn by: RAH

Checked by: DS

Status: Final



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2 Methodology

Site context and pre-existing data

- 2.1 During a Daytime Bat Walkover (DBW) of the Site undertaken in August 2023, it was noted that both structures and trees considered to have suitability for roosting bats were present within the Gardens. A large maternity-style bat box was recorded in the north-east of the Site, although no information could be provided by GCC regarding whether or not roosting bats were known to be using it. The exposed sections of the underground station within the Site were considered unlikely to support bat roosts, being well lit in daylight hours. However, the darker recesses, and the covered tunnel system would have high suitability for both summer roosts, and hibernation. Both Daubenton's bat and common pipistrelle have been recorded in flight in or close to the Site, and it was thought likely that soprano pipistrelle would also be present.

Sampling strategy

- 2.2 Potential locations for the deployment of static bat detectors were searched for within the parts of the Site to be utilised for the Event. Sufficient budget was available for the use of up to five detectors, and deployment locations were selected based on:
- a need to sample a representative range of habitats within the Site;
 - availability of secure fixing points to reduce the risk of theft;
 - the presence of sufficient cover habitats to ensure concealment and reduce the probability of interference.
- 2.3 The final selected locations are shown in **Figure 2.1**, and summarised in **Table 2.1** below.

Table 2.1: Description of detector deployment locations

Location	Easting	Northing	Habitat
1	256795	667404	Above exposed section of the old Botanic Gardens railway station.
2	256719	667512	Within rhododendron bush in area of mown lawn. ¹
3	256615	667682	On unlit edge of Gardens, under mature tree canopies.
4	256689	667636	Opposite the colony bat box, within wooded unlit edge of Gardens.
5	256894	667506	Adjacent to tea rooms, and other buildings with bat roosting suitability.

- 2.4 A Permit to Use the Botanic Gardens for the study was provided by GCC for the time period between 04 September 2023 and 30 November 2023. Five Song Meter Mini Bat full spectrum detectors were used, and these were left *in situ* from the night of 04 September 2023 until they were collected in on the morning of 30 November 2023. All of the

¹ This location was more in the open than aerial imagery implies.



detectors were programmed to record from 30 mins before sunset each night, continuing until 30 mins after sunrise. They were deployed with the following settings:

- minimum frequency of 12 kHz;
- sampling rate of 256 kHz;
- trigger window of 2 secs.

2.5 In addition to the initial deployment date and final collection, there was sufficient budget for four other visits during the deployment to change over data cards and replace the batteries in the units². Within the periods of time between these maintenance visits, not all of the detectors ran continuously, either because the batteries ran out, the data cards became full, or for both of these reasons. A summary of the active deployment nights for each unit is provided in **Table 2.2** below; a total of 390 recording nights was achieved.

Table 2.2: Summary of deployment and recording periods

Deployment period	Sampling location and recording nights				
	1	2	3	4	5
Period 1: 04 – 16 September 2023 (12 nights)	7/12 (Card full)	12/12	12/12	12/12	12/12
Period 2: 16 September 2023 – 06 October 2023 (20 nights)	16/20 (Card full)	20/20	8/20 (Card full)	8/20 (Card full)	20/20
Period 3: 06 – 19 October 2023 (13 nights)	13/13	13/13	13/13	13/13	13/13
Period 4a: 19 October 2023 – 02 November 2023 (14 nights)	14/14	14/14	14/14	14/14	-
Period 4b: 19– 30 October 2023 (11 nights)	-	-	-	-	11/11
Period 5a: 02– 23 November 2023 (21 nights)	21/21	17/21	18/21 (Batteries empty)	19/21 (Batteries empty)	-
Period 5b: 30 October 2023 – 14 November 2023 (15 nights)	-	-	-	-	12/15
Period 6a: 23 – 30 November 2023 (7 nights)	7/7	7/7	7/7	7/7	-
Period 6b: 14 – 30 November 2023 (16 nights)	-	-	-	-	16/16
Total number of nights recorded	78	83	72	73	84

Weather data

2.6 Summary weather data were also collated during the deployment period, to provide environmental context for the recorded bat activity. The parameters used were:

- the maximum and minimum temperature at midnight during each recording night³;
- the total rainfall recorded for the 24 hour period preceding each recording night⁴.

² SM Mini Bat detectors are marketed as having the capacity to run for 3-4 weeks without a battery change, depending on ambient temperatures and the volume of recorded activity.

³ As taken from: <https://www.timeanddate.com/weather/uk/glasgow/historic?month=9&year=2023>

⁴ As taken from: <https://www2.sepa.org.uk/rainfall/data/index/341380> Killermont is the closest SEPA rain gauge to the Site.



Data analysis

- 2.7 All sound files recorded by the static detectors were downloaded after retrieval and processed using Kaleidoscope software. An experienced bat ecologist then reviewed data in AnalookW, to classify and tag each call to species level wherever possible. This method of analysis is in line with current guidelines (Collins, 2023⁵) for data analysis, which recommends the manual checking of all non-*Pipistrellus* calls when using automated methods. Sound files labelled as noise were not reviewed. Subsequent statistical analysis was carried out using Excel and/or Minitab. For the purposes of this report, a single bat pass was defined as an echolocation call separated from other calls by a minimum of 2 secs.

Potential limitations associated with the study

Breaks in recording

- 2.8 As shown in **Table 2.2** and described earlier, not all of the detectors recorded continuously. This meant that for some locations there was not a continuous timeline of data. Particular issues were experienced at Location 5 once the GlasGLOW event was up and running, when it was noticed that the data card in that detector had become full of noise files relatively early into the first during-event deployment period. It was thought likely that this was as a result of ultrasonic pulses emitting from the specific Event installation close to this location. A decision was taken to check this detector more frequently, meaning its changeover dates from that point onwards did not correspond with those at the other locations. However, there was only one night for which no data were collected (15 September 2023), and overall the longevity of the data set (ranging between 72 and 84 nights at each location) more than compensated for any gaps. It should be recognised that the standard approach to the sampling of bat activity, as per current guidelines (Collins, 2023), is based on six sampling periods each of 5 nights, within a 6 month period between May and September. The data collected far exceeded those requirements, albeit it outwith the traditional “bat active” period.

Subjectivity of deployment locations

- 2.9 The locations chosen for the deployment of detectors was by definition subjective, and it is possible that detectors placed in other locations may have generated a data set with different characteristics. However, the overall patterns observed (see **Chapter 3**) were relatively consistent, and it is therefore likely that the data were reasonable representative within the logistical constraints presented by the Site and budget.

Interpretation of calls

- 2.10 Caution is always required when interpreting bat calls recorded by static bat detectors. Each recorded call represents a pass of a bat within the range of the microphone. These data do not provide information about the actual number of bats present (a high number of passes could be a single bat repeatedly foraging for an extended period of time). However,

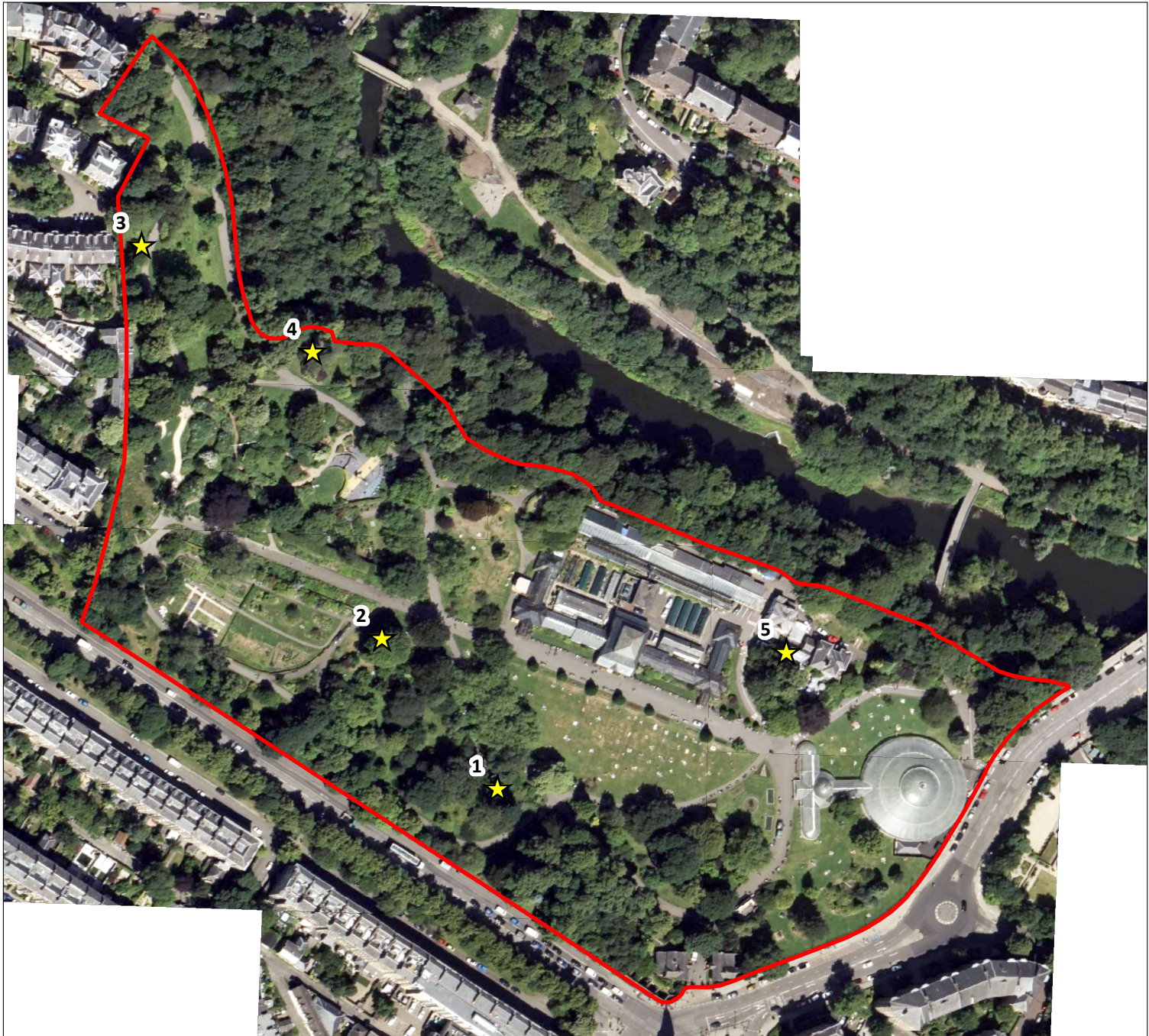
⁵ Collins, J. (2023) *Bat Surveys for Professional Ecologists: Good Practice Guidelines, 4th Edition*. Bat Conservation Trust, September 2023.



static detector data provide invaluable information regarding relative levels of activity, and times of bat passes. Experienced operators of this equipment can use the data comparatively.

- 2.11 Similarly, it was not always possible to identify recorded bat calls to species level, and *Myotis* and *Nyctalus* bats were only classified to genus. However, all pipistrelle bats recorded were classified to species level.





GlasGLOW

Sampling Strategy

-  Site boundary
-  Static detector location

Figure 2.1

Map Scale @ A4: 1:2,500



Surveyed by: AEL

Survey date: Sept - Nov 2023

Drawn by: RAH

Checked by: DS

Status: Final



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3 Results

- 3.1 A summary of the pass data recorded by the detectors on a night-by-night basis is provided in **Appendix B**.

Total passes and species composition

- 3.2 A grand total of 31,416 bat passes were recorded during the study, as summarised in **Table 3.1**. The vast majority of these (over 80 %) were at Location 1, above the disused railway station and tunnel entrances. Of these, soprano pipistrelles were the most frequently recorded species, as was the case at all locations except Location 3 where common pipistrelle was more frequently present.
- 3.3 Overall, at least five species of bat were recorded during the monitoring, although nearly two-thirds of passes were made by soprano pipistrelles, and just under two-fifths by common pipistrelles. A very small number of brown long-eared (BLE) bat passes were picked up at Location 1, along with a low number of *Myotis* calls, which were also detected at Location 5. The pattern of the *Myotis* calls was indicative of these being Daubenton's bats *M. daubentonii*. Low numbers of *Nyctalus* bats were picked up at all locations except Location 2. The sonograms from these were suggestive of Leisler's bats *N. leisleri*.

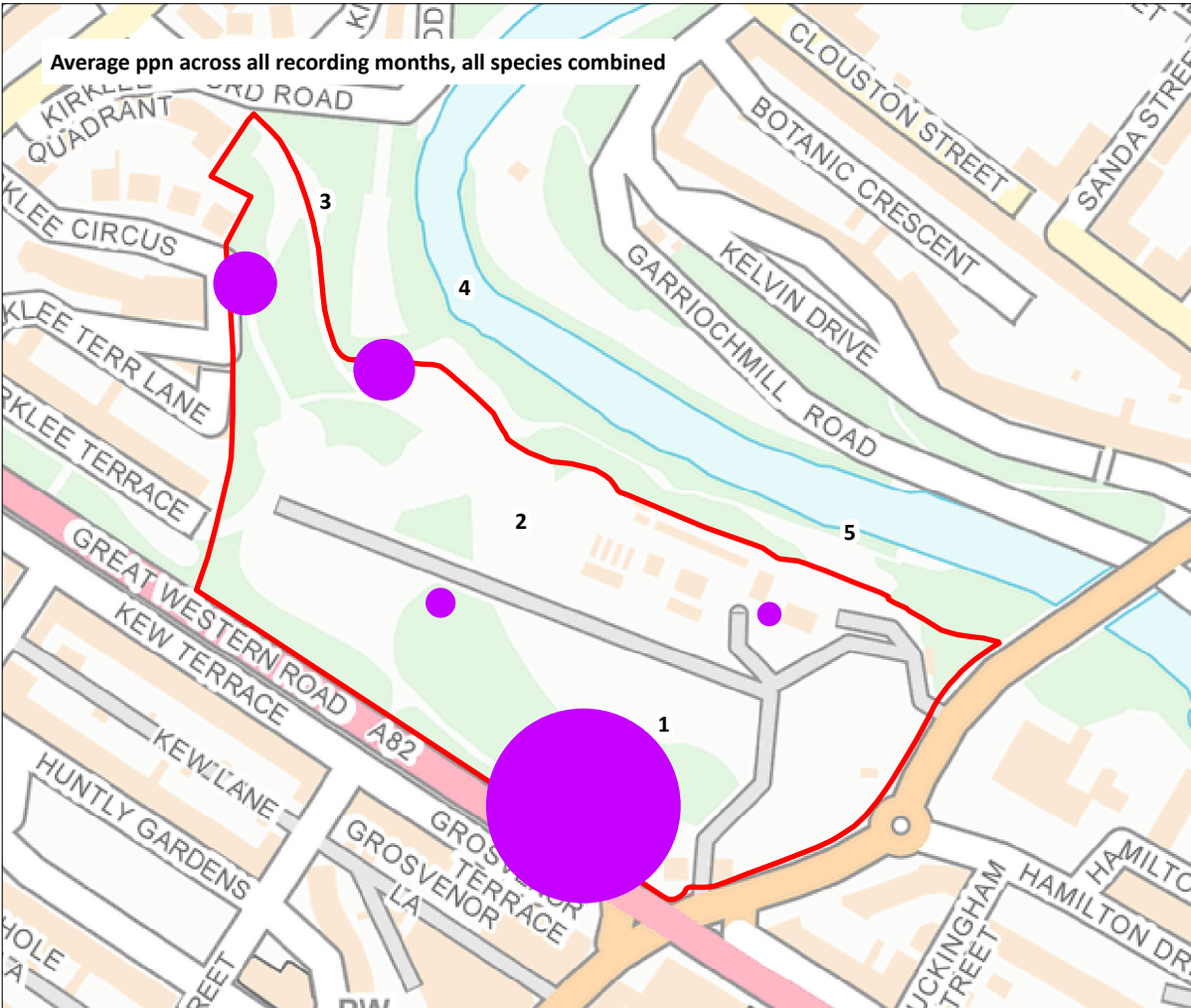
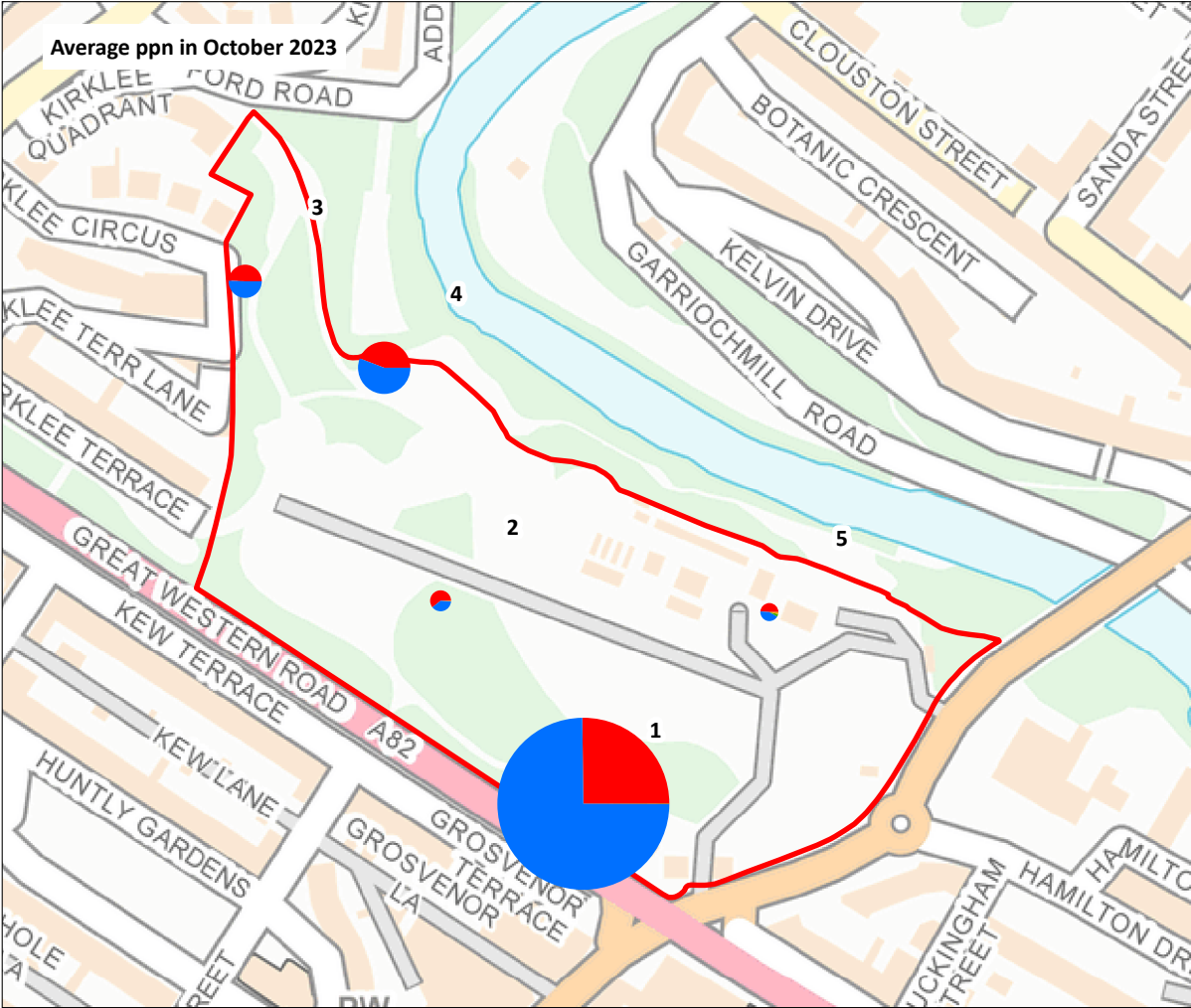
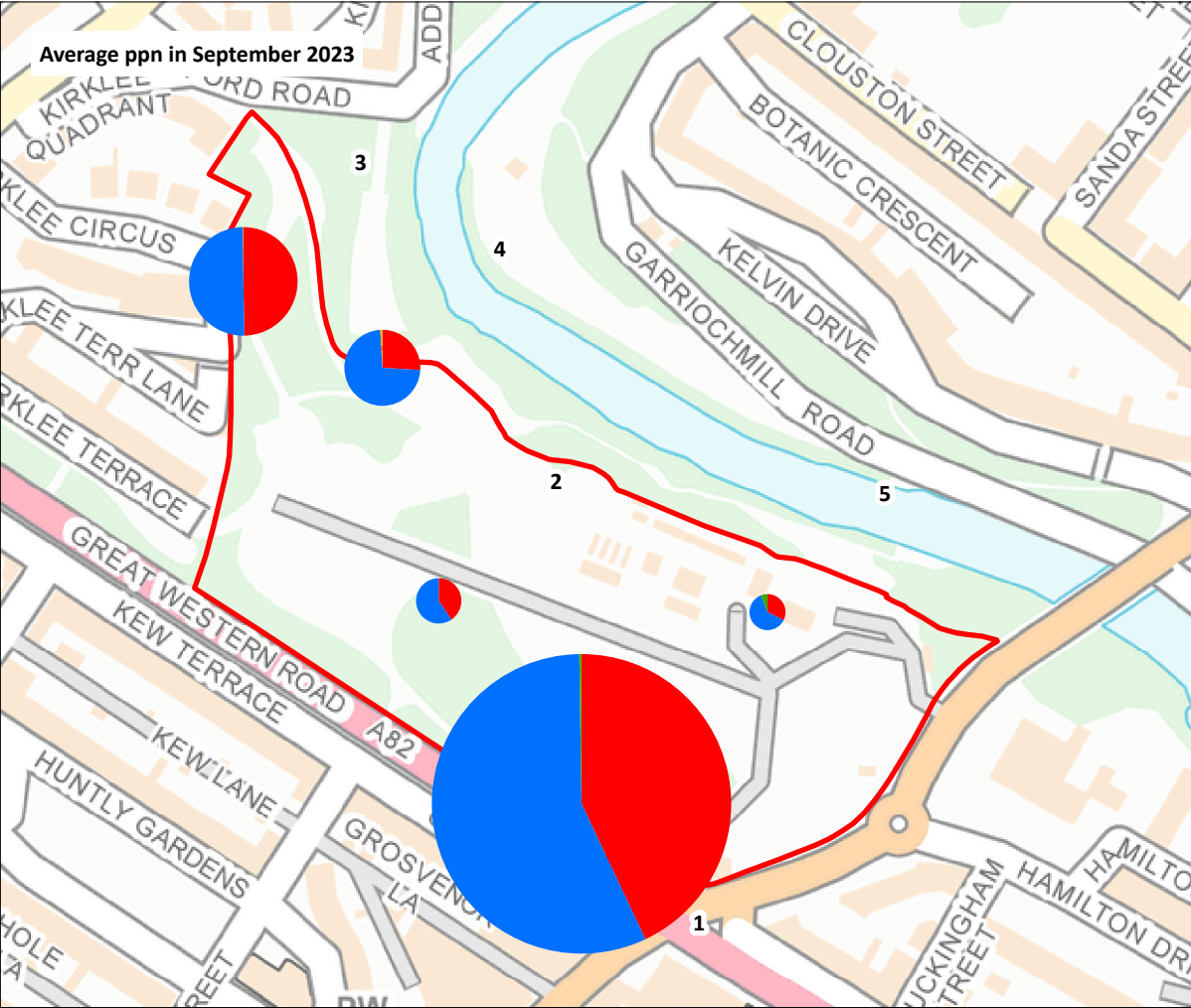
Table 3.1: Summary of species composition of all recorded passes by location

Detector location	Common pipistrelle	Soprano pipistrelle	Brown long-eared bat	<i>Myotis</i> sp.	<i>Nyctalus</i> sp.	Total	% of all passes
1	9238	16146	4	40	2	25430	80.9
2	283	359	0	0	0	642	2.0
3	1341	1184	0	0	2	2527	8.0
4	831	1552	0	0	7	2390	7.6
5	165	239	0	22	1	427	1.4
Total	11858	19480	4	62	12	31416	100.0
% of all passes	37.7	62.0	< 0.1	0.2	< 0.1	100.0	-

Seasonal patterns

- 3.4 A summary of the species abundance and distribution for each month in which sampling occurred is presented in **Figure 3.1**, with activity levels standardised across the locations through the use of passes per night (ppn). These maps show how bat activity declined over the autumn months included in the sampling, but proportionally this was generally consistent across all of the sampling locations.



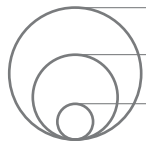


GlasGLOW

Passes per Night (ppn) Recorded Sept-Nov 2023

Site boundary

Average recorded ppn:



The radius of each disc shown on the maps is proportional to the total number of ppn in the displayed recording period. The radii of the discs shown here in the legend represents the given number of ppn.

- Common pipistrelle
- Soprano pipistrelle
- BLE
- Myotis sp.
- Nyctalus sp.

Figure 3.1

Map Scale @ A3: 1:4,000

Surveyed by: AEL
Survey date: Sept-Nov 2023
Drawn by: RAH
Checked by: DS
Status: Final



- 3.5 More detail regarding the activity recorded at each location is provided in **Figures 3.2-3.7**. These plots show the total number of passes recorded at each location on each recording night, with a smoothed LOWESS plot (**L**ocally **W**eighted **S**catter-plot **S**moothing) to highlight the trends shown in each plot. LOWESS plots can be particularly useful for exploring patterns in time series data. The different vertical axis scales used for these plots should also be noted.
- 3.6 These figures also show that bat activity decreased over the sampling period. However, they also show that at all locations, the main period of decrease was prior to a point in time between 04 October 2023 and 14 October 2023, and after this time, activity was generally very low.

Weather data

- 3.7 The summary weather data used in the study has been included in **Appendix C**.
- 3.8 A plot of maximum and minimum temperatures at midnight over the sampling period is provided in **Figure 3.8**, and rainfall totals in **Figure 3.9**. A summary of correlation coefficients between these parameters and the number of recorded bat passes is provided in **Table 3.2**. These data show that prevailing weather conditions were relatively wet and mild up to the second week in October, after which time temperatures started to fluctuate more noticeably, with more frequent dry or relatively low rainfall periods.
- 3.9 There were significant correlations between the recorded number of passes of all species and both maximum and minimum recorded temperatures with the exception of BLE, because there were too few BLE passes to generate a significant result. There was no relationship however between number of bat passes and recorded rainfall for the 24 hour period preceding midnight on the recording night. The analysis was repeated for the rainfall recorded for the 24 hr period commencing at midnight of the recording night, and no significant correlations were obtained in this way, either.

Table 3.2: Correlation coefficients between number of bat passes and weather data

Species/ genus	Maximum midnight temp		Minimum midnight temp		Rainfall	
	<i>r</i>	<i>P</i>	<i>r</i>	<i>P</i>	<i>r</i>	<i>P</i>
Common pipistrelle	0.386	< 0.001	0.338	0.001	-0.176	NS
Soprano pipistrelle	0.385	< 0.001	0.359	0.001	-0.154	NS
BLE	0.036	NS	-0.042	NS	-0.090	NS
<i>Myotis</i> sp.	0.375	< 0.001	0.334	0.001	0.125	NS
<i>Nyctalus</i> sp.	0.216	< 0.05	0.216	< 0.05	-0.110	NS
All passes	0.409	< 0.001	0.372	< 0.001	-0.173	NS



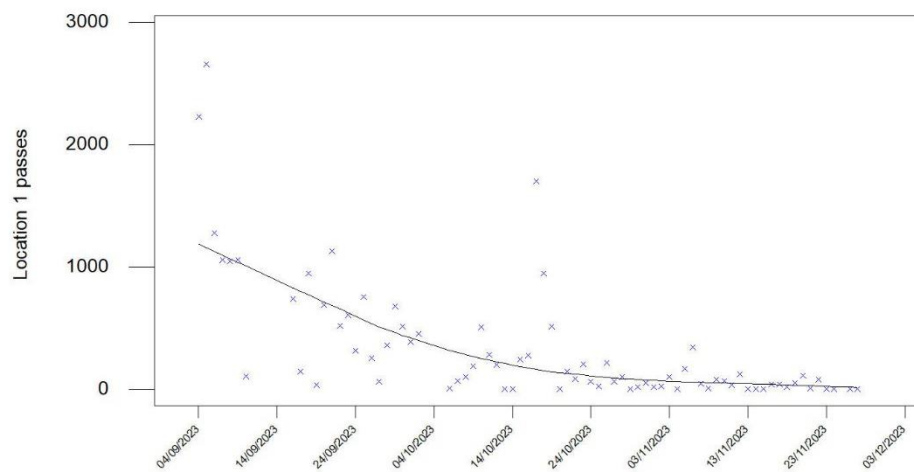
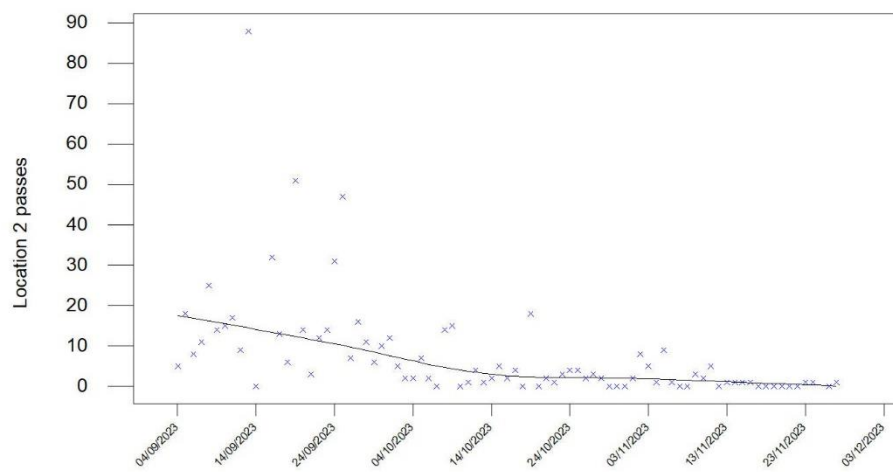
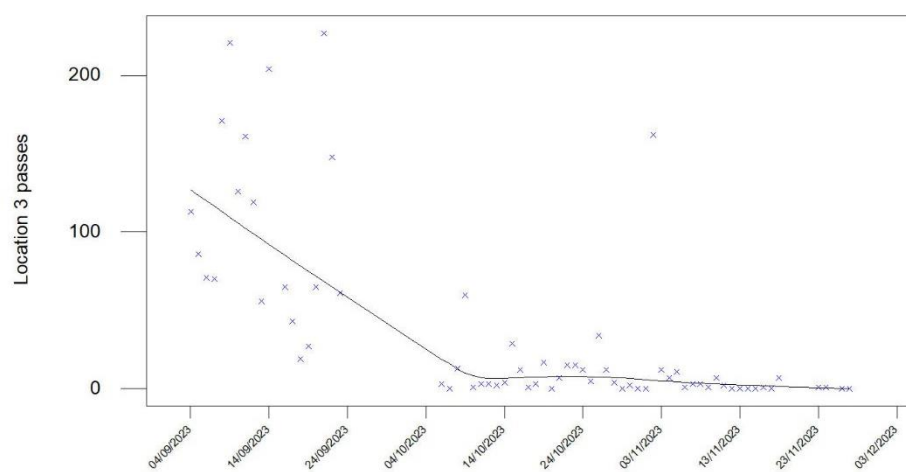
Figure 3.2: Number of passes per night recorded at Location 1, with associated LOWESS plot**Figure 3.3: Number of passes per night recorded at Location 2, with associated LOWESS plot****Figure 3.4: Number of passes per night recorded at Location 3, with associated LOWESS plot**

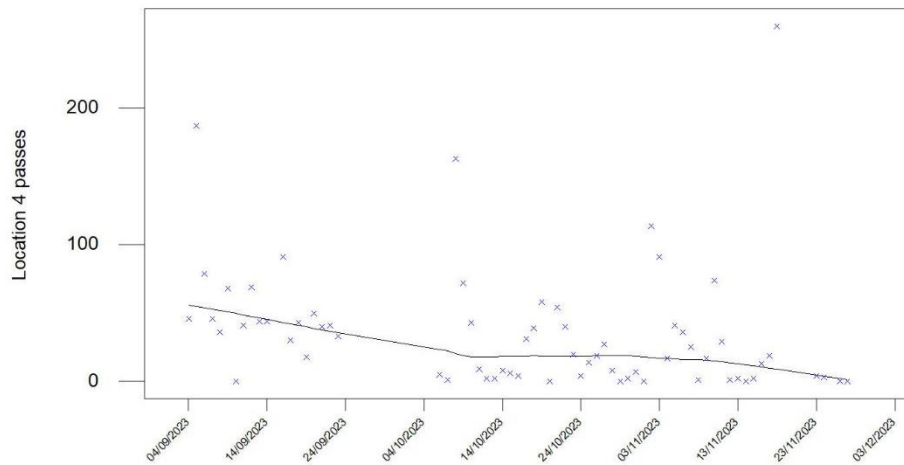
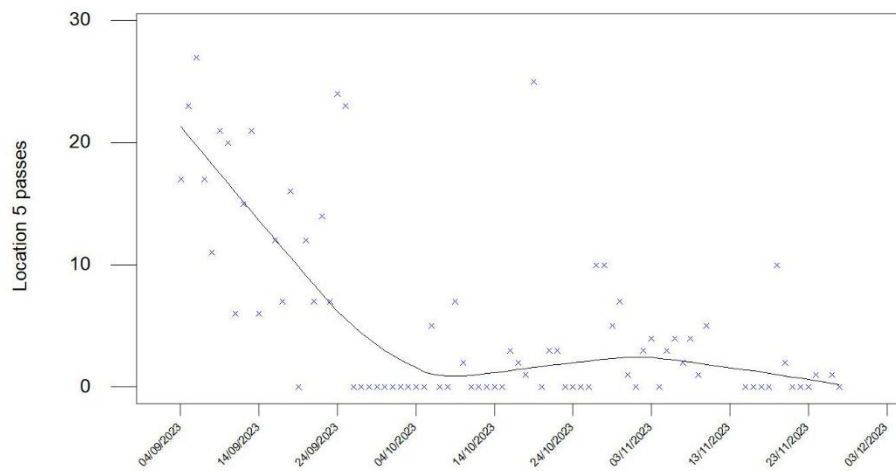
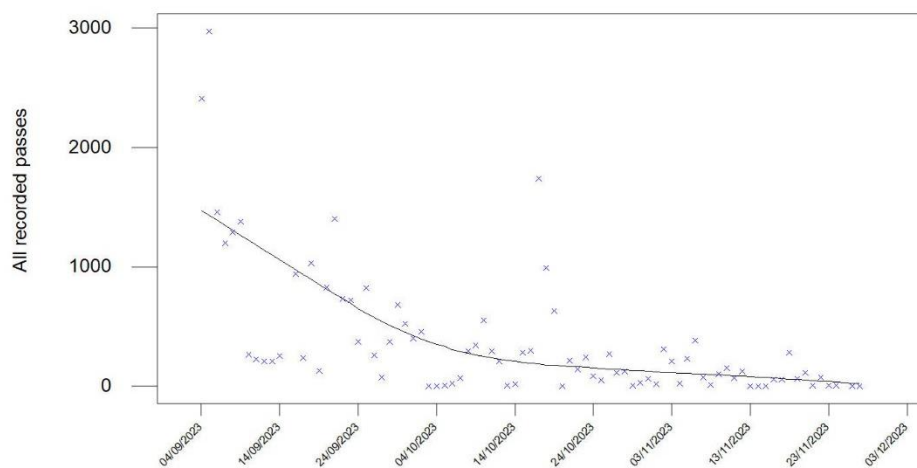
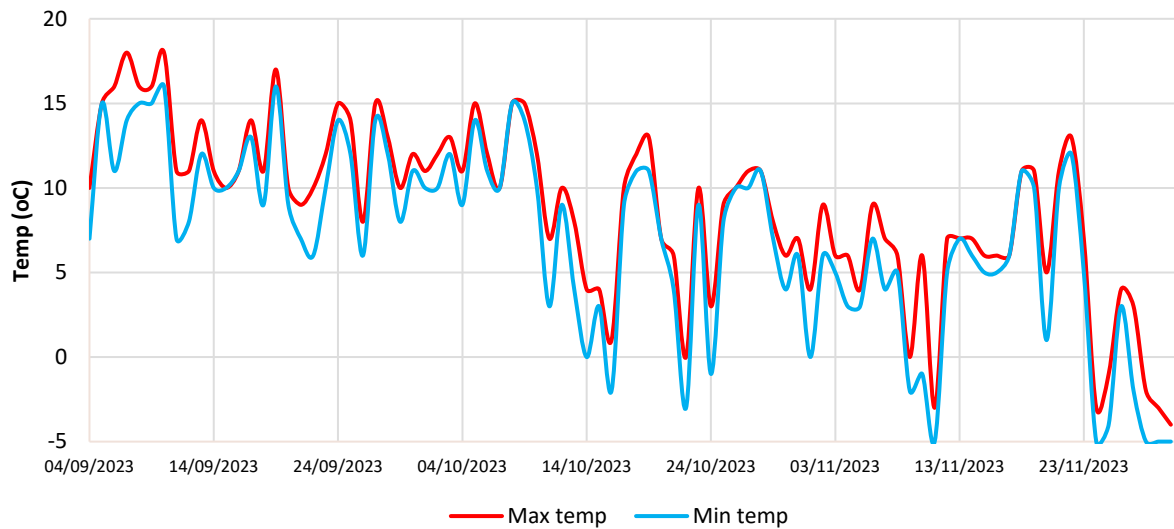
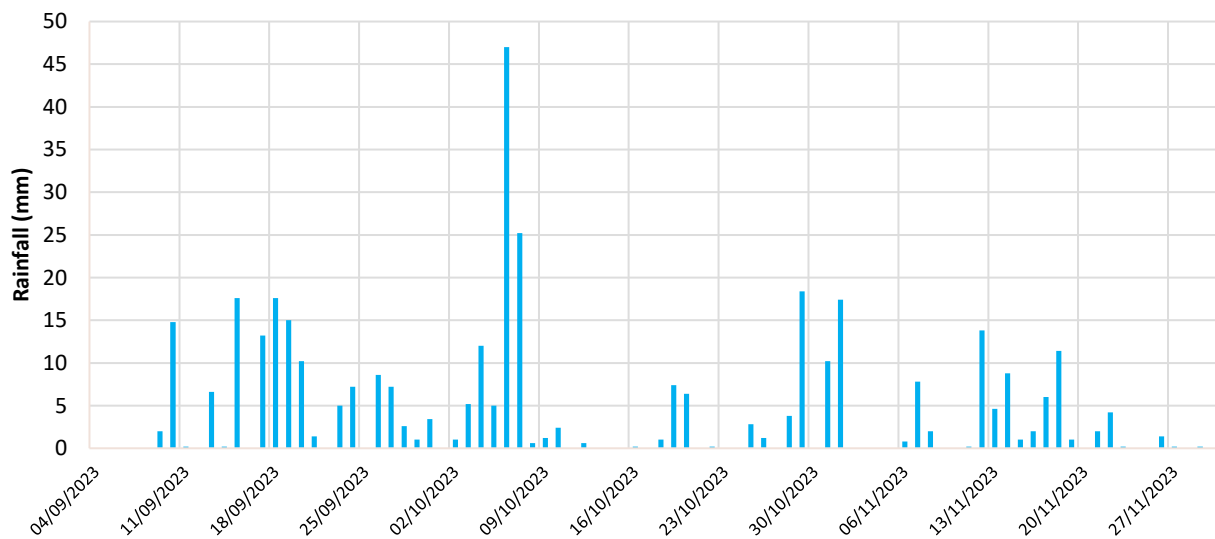
Figure 3.5: Number of passes per night recorded at Location 4, with associated LOWESS plot**Figure 3.6: Number of passes per night recorded at Location 5, with associated LOWESS plot****Figure 3.7: Total number of passes per night recorded at all locations, with associated LOWESS plot**

Figure 3.8: Maximum and minimum recorded temperatures at midnight on each recording night**Figure 3.9: Total rainfall for 24 hr period preceding recording night**

4 Discussion

Species composition

- 4.1 The sampling reported here has confirmed that a wider range of bat species utilise the Site during autumn and early winter than previously known. The most active species appeared to be soprano pipistrelle, rather than the common pipistrelle recorded by other users of the Gardens.
- 4.2 Soprano pipistrelle bats tend to be more frequent in this part of Scotland than common pipistrelles, and therefore this finding is not unexpected. Both species are common and widespread, and they are classified as Not Threatened (Hutson 1993⁶). In 2013, population estimates in Scotland⁷ were 352,000 for common pipistrelle and 198,000 for soprano pipistrelle. It is accepted that this is likely significantly lower than the true figure. They are crevice roosters, and as such have adapted to finding roosting spaces in built features, and are potentially less affected by environmental constraints of urban areas, such as street-lighting. Pipistrelles are fast-flying species and there is some evidence to suggest that they congregate around artificial lighting to hawk insects attracted to the lights.
- 4.3 Of the three other species/genus of bats which were recorded in much lower numbers than the pipistrelles, *Myotis* bats were the most frequent. The sonograms recorded were suggestive of these being Daubenton's bats, and these have previously been recorded in the Gardens. They were only recorded at Location 5 in closest proximity to the River Kelvin, and at Location 1 at the railway tunnels. Daubenton's are well adapted to hunting over water surfaces and this is probably the reason why they are associated with the River Kelvin corridor. It is possible that the railway tunnels represent a roost location for this species, and further analysis of the first and last pass times could provide more information regarding this.
- 4.4 With regards to the BLE passes, it is useful to have it confirmed that this species is occasionally present in the general location of the Site, but as the Site and its environs do not represent preferred habitat for either roosting or foraging for this species, it is not unexpected that so few passes were recorded. BLE is typically a species which roosts in older buildings, barns, churches and trees, preferring cavities rather than crevices, and preferably a "warm up" space for use immediately prior to commencing and evening's hunting. Preferred foraging habitats are open deciduous and coniferous woodlands, parkland and gardens, and in combination these roosting and foraging habitats are not commonplace around the Site.
- 4.5 The *Nyctalus* passes recorded are interesting, as these species are thought to be at their northernmost limit in Scotland, although their distribution is becoming better known through the use of static detector studies such as this. In the UK, Leisler's bats are classed as Vulnerable: scarce (except in Ireland) and with a poorly known conservation status

⁶ Hutson, A.M. (1993). *Action plan for the conservation of bats in the United Kingdom*. Bat Conservation Trust, London

⁷ JNCC (2013). *Individual Species Reports - 3rd UK Habitats Directive Reporting 2013*.



(Hutson, 1993). However, a study in 2017⁸ stated that the population of Leisler's bat in Scotland may actually be in the region of many thousands. *Nyctalus* species are early emerging bats, typically leaving a roost 0-30 mins after sunset and sometimes even earlier. They are able to fly long distances (up to 20 km) quickly after emerging (Jones *et al.*, 2009)⁹. It is thought unlikely that a *Nyctalus* roost is present in close proximity to the Site, but closer analysis of first- and last-pass times may provide greater insight into this.

Frequency of bat activity

- 4.6 ECOBAT¹⁰ is a UK-wide database and analysis platform which enables temporal and spatial comparisons of bat activity recorded by static detectors, relative to reference datasets already entered into the platform. It is usually possible to enter new datasets into ECOBAT to generate an objective evaluation of a site's bat activity relative to the datasets already contained within the platform. At the time of writing, ECOBAT was in a prolonged period of outage to enable a rebuild, and therefore no comparisons via that platform were possible. Without ECOBAT, the general levels of activity recorded, when expressed as passes per night, are difficult to compare with activity recorded elsewhere, as the study here focussed on a time period which is not typically covered by longer running static bat detector surveys. The late autumn and early winter bat activity periods are much less well studied, and therefore direct comparisons cannot be easily made.
- 4.7 The closest pre-existing dataset to the Site held by AEL and for which ECOBAT analysis was undertaken was located c. 23 km to the north-west. This was however for a peri-urban location within the Loch Lomond and the Trossachs National Park; the environmental context is not at all comparable to the Site. However, a subjective comparison between the two datasets suggests that at least during some nights in September, bat activity within the Botanic Gardens may be classifiable as being "high", if the data were to be passed through ECOBAT. This would not be unexpected given that the Gardens represent a notable area of greenspace within a predominantly urban environment, and is well connected via the River Kelvin to potential roosting locations and other foraging habitats. It is possible that bats commute to forage here from roost locations at some distance away, as well as from roosts in close vicinity.
- 4.8 However, bat activity levels did vary greatly between locations and over time. Peaks and troughs were clearly identifiable, including as expected lower activity at times of lower temperatures, and higher activity on milder nights, and nights following sub-optimal foraging weather.

Trends in activity

- 4.9 The data collected during this study show clearly how bat activity tails off during the autumn, in the weeks leading up to hibernation. Activity was most notably reduced after

⁸ Newson, S.E., Evans, H.E., Gillings, S., Jarrett, D. & Wilson, M.W. (2017). *A survey of high risk bat species across southern Scotland*. Scottish Natural Heritage Commissioned Report No. 1008.

⁹ Jones, G., Cooper-Bohannon, R., Barlow, K. and Parsons, K. (2009). *Scoping and Method Development Report: Determining the potential ecological impact of wind turbines on bat populations in Britain*. University of Bristol and Bat Conservation Trust.

¹⁰ <https://www.mammal.org.uk/science-research/ecostat/ecobat/> Not currently available.



the first week in October, which corresponded with the first sub-zero air temperatures for this part of Glasgow. A lack of a relationship between bat activity and rainfall was interesting, as it may be that, to a certain extent, bats in the West of Scotland are habituated to some level of night time precipitation given the prevailing weather conditions in this part of the UK. However, it may also be because the rainfall data used here were not at a sufficiently fine resolution to allow within-night correlations.

- 4.10 The trend lines for the whole data set, and those derived for each individual recording location, all show the drop off in activity as plateauing in mid October 2023. The GlasGLOW event commenced on 27 October 2023, and lasted until 12 November 2023, and although the datasets are noisy (as is characteristically the case for sampling within real world natural environments where it is not possible to control all potential variables), none of the trend lines showed an accelerated decrease in activity within the time period of the Event.

Roosting bats

- 4.11 The high level of bat activity at Location 1 is likely to confirm the hypothesis that the railway tunnel system contains roosting locations, at least for common and soprano pipistrelles. Nearly 400 passes of bats recorded at this location were exceptionally early, and timed *before* sunrise; approximately a quarter of these were during the Event. It is not possible to determine from these data the size of these roosts, whether they are summer or hibernation roosts or both, and/or whether any of the activity recorded may represent an autumn swarming pre-hibernation location for pipistrelles. These could all be areas for further study.

Aspects for further investigation

- 4.12 The data presented here are interesting because they have focussed on a time period of bat activity which is less well studied. Due to budget (i.e. time) constraints, it has not been possible to undertake all of the potential analyses which the data offer, and further work, particularly on between-species comparisons of activity and first- and last-pass timings could be undertaken if the opportunity presented itself. Other routes to enquiry could include *inter alia*:
- liaison with the University of Glasgow regarding use of the existing dataset by a BSc, MSc or MRes student as part of a dissertation or thesis;
 - manual surveys with observers at the railway tunnels, to add qualitative data regarding bat behaviour to the quantitative data collected during this investigation;
 - completion of additional 3 month recording periods (e.g. Dec-Feb, May-July) for a fuller understanding of bat usage of the Gardens;
 - completion of similar studies for other events which take place in the Botanic Gardens, in particular those occurring in the summer months.
- 4.13 Following advice given by AEL to itison prior to the commencement of the 2023 GlasGLOW event, some changes to the sound and light installations were made, to take into consideration potential impacts on bats. There are no historical data which could be used to determine whether or not the bat activity recorded during the Event period differed to that seen in previous years, but the analyses presented here do not appear to indicate any



detectable effect on bat activity that might be attributable to anthropogenic sourced disturbance. However, it would be prudent for the biodiversity recommendations made for the 2023 event to be carried forward for future events.



5 Summary and Conclusions

- 5.1 Throughout late autumn and early winter 2023, bat activity monitoring was undertaken within the Glasgow Botanic Gardens. Within the study period, the GlasGLOW event took place in the gardens, comprising 17 nights of a sound and light installation.
- 5.2 The monitoring data revealed at least five species of bat were using the Gardens, and at least three of these had not previously been formally recorded there. Bat activity was concentrated in the area in the vicinity the former Botanics railway station and it was thought likely that this was the entry location to a well-used roost of common and soprano pipistrelle bats. The nature of this roost, and whether or not this included hibernaculae, could not be determined.
- 5.3 In general, the levels of recorded bat activity varied significantly between sampling locations and over time, and appeared to be determined by ambient temperatures rather than rainfall. Activity decreased throughout the autumn, levelling off in the first two weeks of October. No discernible effect of the Event could be detected in the data.
- 5.4 This was a snapshot study which has provided useful insights into a less well studied period of the bat annual cycle, despite a number of difficulties associated with sampling “real world” environments where a range of variables cannot be controlled. Potential further lines of enquiry have been highlighted, and recommendations made regarding best practice mitigation for biodiversity features that should be incorporated into strategies for events in the Gardens.



Appendix A

List of Initialisms, Acronyms and Abbreviations Used in this Report



Short form	Full terminology
AEL	Applied Ecology Ltd
BCT	Bat Conservation Trust
BLE	Brown long-eared bat
BRS	Bat Roost Suitability
CIEEM	Chartered Institute of Ecology and Environmental Management
DBW	Daytime Bat Walkover
EPS	European Protected Species
GCC	Glasgow City Council
LOWESS	Locally Weighted Scatter-plot Smoothing
PEA	Preliminary Ecological Appraisal



Appendix B

Summary Bat Activity Data (September – November 2023)



Night start date	Total number of passes recorded					
	Common pipistrelle	Soprano pipistrelle	Brown long-eared bat	<i>Myotis</i> sp.	<i>Nyctalus</i> sp.	Total
04/09/2023	1506	899	0	6	1	2412
05/09/2023	1305	1659	0	5	3	2973
06/09/2023	708	747	2	5	0	1462
07/09/2023	588	613	0	2	0	1203
08/09/2023	614	670	0	1	4	1289
09/09/2023	526	850	0	3	2	1381
10/09/2023	120	146	0	0	0	266
11/09/2023	92	132	0	0	0	224
12/09/2023	108	104	0	0	0	212
13/09/2023	51	157	0	1	0	209
14/09/2023	77	177	0	0	0	254
15/09/2023	*	*	*	*	*	*
16/09/2023	501	439	0	1	0	941
17/09/2023	134	105	0	2	0	241
18/09/2023	283	744	0	4	0	1031
19/09/2023	49	84	0	0	0	133
20/09/2023	322	501	0	6	0	829
21/09/2023	327	1077	0	1	0	1405
22/09/2023	266	466	0	2	0	734
23/09/2023	136	586	0	3	0	725
24/09/2023	104	265	0	2	0	371
25/09/2023	473	346	0	5	0	824
26/09/2023	121	139	0	2	0	262
27/09/2023	43	34	0	0	0	77
28/09/2023	173	198	0	1	0	372
29/09/2023	205	480	0	0	0	685
30/09/2023	132	388	0	3	0	523
01/10/2023	113	286	0	2	0	401
02/10/2023	144	312	0	0	0	456
03/10/2023	0	2	0	0	0	2
04/10/2023	0	2	0	0	0	2
05/10/2023	1	6	0	0	0	7
06/10/2023	5	16	0	3	0	24
07/10/2023	1	67	0	0	0	68
08/10/2023	187	104	0	1	0	292
09/10/2023	168	175	0	0	0	343
10/10/2023	226	329	0	1	0	556
11/10/2023	117	177	0	0	0	294
12/10/2023	51	160	0	0	0	211
13/10/2023	3	5	0	0	0	8
14/10/2023	7	8	2	0	0	17
15/10/2023	62	224	0	0	0	286



Night start date	Total number of passes recorded					
	Common pipistrelle	Soprano pipistrelle	Brown long-eared bat	<i>Myotis</i> sp.	<i>Nyctalus</i> sp.	Total
16/10/2023	30	268	0	0	0	298
17/10/2023	325	1415	0	0	0	1740
18/10/2023	172	821	0	0	0	993
19/10/2023	130	504	0	0	0	634
20/10/2023	0	1	0	0	0	1
21/10/2023	29	184	0	0	0	213
22/10/2023	52	92	0	0	0	144
23/10/2023	61	182	0	0	0	243
24/10/2023	31	53	0	0	0	84
25/10/2023	38	11	0	0	0	49
26/10/2023	144	127	0	0	0	271
27/10/2023	41	73	0	0	0	114
28/10/2023	38	85	0	0	0	123
29/10/2023	3	3	0	0	0	6
30/10/2023	23	5	0	0	1	29
31/10/2023	52	9	0	0	0	61
01/11/2023	3	16	0	0	0	19
02/11/2023	278	31	0	0	0	309
03/11/2023	85	126	0	0	0	211
04/11/2023	14	12	0	0	0	26
05/11/2023	41	190	0	0	0	231
06/11/2023	6	380	0	0	0	386
07/11/2023	32	43	0	0	0	75
08/11/2023	8	6	0	0	0	14
09/11/2023	11	90	0	0	0	101
10/11/2023	75	79	0	0	0	154
11/11/2023	17	54	0	0	0	71
12/11/2023	24	101	0	0	0	125
13/11/2023	0	3	0	0	0	3
14/11/2023	2	1	0	0	0	3
15/11/2023	1	2	0	0	0	3
16/11/2023	3	54	0	0	1	58
17/11/2023	0	59	0	0	0	59
18/11/2023	3	282	0	0	0	285
19/11/2023	14	48	0	0	0	62
20/11/2023	12	100	0	0	0	112
21/11/2023	0	9	0	0	0	9
22/11/2023	0	77	0	0	0	77
23/11/2023	5	1	0	0	0	6
24/11/2023	5	3	0	0	0	8
25/11/2023	0	0	0	0	0	0
26/11/2023	1	0	0	0	0	1



Night start date	Total number of passes recorded					
	Common pipistrelle	Soprano pipistrelle	Brown long-eared bat	<i>Myotis</i> sp.	<i>Nyctalus</i> sp.	Total
27/11/2023	0	1	0	0	0	1
28/11/2023	0	0	0	0	0	0
29/11/2023	0	0	0	0	0	0
30/11/2023	0	0	0	0	0	0



Appendix C

Collated Weather Data



Night start date	Max temperature at midnight (°C)	Min temperature at midnight (°C)	Rainfall (past 24 hrs)	Time of sunrise	Time of sunset
04/09/2023	10	7	0	06:26	20:04
05/09/2023	15	15	0	06:28	20:02
06/09/2023	16	11	0	06:30	19:59
07/09/2023	18	14	0	06:32	19:56
08/09/2023	16	15	0	06:34	19:54
09/09/2023	16	15	2	06:36	19:51
10/09/2023	18	16	14.8	06:38	19:49
11/09/2023	11	7	0.2	06:40	19:46
12/09/2023	11	8	0	06:42	19:44
13/09/2023	14	12	6.6	06:44	19:41
14/09/2023	11	10	0.2	06:46	19:38
15/09/2023	10	10	17.6	06:48	19:36
16/09/2023	11	11	0	06:49	19:32
17/09/2023	14	13	13.2	06:51	19:30
18/09/2023	11	9	17.6	06:53	19:27
19/09/2023	17	16	15	06:55	19:24
20/09/2023	10	9	10.2	06:57	19:22
21/09/2023	9	7	1.4	06:59	19:19
22/09/2023	10	6	0	07:01	19:16
23/09/2023	12	10	5	07:03	19:14
24/09/2023	15	14	7.2	07:05	19:11
25/09/2023	14	12	0	07:07	19:08
26/09/2023	8	6	8.6	07:09	19:06
27/09/2023	15	14	7.2	07:11	19:03
28/09/2023	13	12	2.6	07:13	19:01
29/09/2023	10	8	1	07:15	18:58
30/09/2023	12	11	3.4	07:17	18:55
01/10/2023	11	10	0	07:19	18:53
02/10/2023	12	10	1	07:21	18:50
03/10/2023	13	12	5.2	07:23	18:47
04/10/2023	11	9	12	07:25	18:45
05/10/2023	15	14	5	07:27	18:42
06/10/2023	12	11	47	07:29	18:40
07/10/2023	10	10	25.2	07:31	18:37
08/10/2023	15	15	0.6	07:33	18:35
09/10/2023	15	14	1.2	07:35	18:32
10/10/2023	12	10	2.4	07:37	18:29
11/10/2023	7	3	0	07:39	18:27
12/10/2023	10	9	0.6	07:41	18:24
13/10/2023	8	4	0	07:43	18:22
14/10/2023	4	0	0	07:45	18:19
15/10/2023	4	3	0	07:47	18:17



Night start date	Max temperature at midnight (°C)	Min temperature at midnight (°C)	Rainfall (past 24 hrs)	Time of sunrise	Time of sunset
16/10/2023	1	-2	0.2	07:49	18:14
17/10/2023	10	9	0	07:51	18:12
18/10/2023	12	11	1	07:53	18:09
19/10/2023	13	11	7.4	07:55	18:07
20/10/2023	7	7	6.4	07:57	18:05
21/10/2023	6	4	0	07:59	18:02
22/10/2023	0	-3	0.2	08:01	18:00
23/10/2023	10	9	0	08:03	17:57
24/10/2023	3	-1	0	08:05	17:55
25/10/2023	9	8	2.8	08:08	17:53
26/10/2023	10	10	1.2	08:10	17:50
27/10/2023	11	10	0	08:12	17:48
28/10/2023	11	11	3.8	08:14	17:46
29/10/2023	8	7	18.4	07:16	16:44
30/10/2023	6	4	0	07:18	16:41
31/10/2023	7	6	10.2	07:20	16:39
01/11/2023	4	0	17.4	07:22	16:37
02/11/2023	9	6	0	07:24	16:35
03/11/2023	6	5	0	07:27	16:33
04/11/2023	6	3	0	07:29	16:31
05/11/2023	4	3	0	07:31	16:29
06/11/2023	9	7	0.8	07:33	16:27
07/11/2023	7	4	7.8	07:35	16:25
08/11/2023	6	5	2	07:37	16:23
09/11/2023	0	-2	0	07:39	16:21
10/11/2023	6	-1	0	07:41	16:19
11/11/2023	-3	-5	0.2	07:43	16:17
12/11/2023	7	5	13.8	07:46	16:15
13/11/2023	7	7	4.6	07:48	16:13
14/11/2023	7	6	8.8	07:50	16:11
15/11/2023	6	5	1	07:52	16:10
16/11/2023	6	5	2	07:54	16:08
17/11/2023	6	6	6	07:56	16:06
18/11/2023	11	11	11.4	07:58	16:05
19/11/2023	11	10	1	08:00	16:03
20/11/2023	5	1	0	08:02	16:02
21/11/2023	11	10	2	08:04	16:00
22/11/2023	13	12	4.2	08:06	15:59
23/11/2023	7	5	0.2	08:08	15:57
24/11/2023	-3	-5	0	08:10	15:56
25/11/2023	-1	-4	0	08:11	15:55
26/11/2023	4	3	1.4	08:13	15:54



Night start date	Max temperature at midnight (°C)	Min temperature at midnight (°C)	Rainfall (past 24 hrs)	Time of sunrise	Time of sunset
27/11/2023	3	-2	0.2	08:15	15:53
28/11/2023	-2	-5	0	08:17	15:51
29/11/2023	-3	-5	0.2	08:19	15:50
30/11/2023	-4	-5	0	08:20	15:49



