TĪTOKI LANDCARE
Specialist Ecological Restoration

Hamilton City Wide Bat Survey 2023

June 2023

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PREPARED FOR	Project Echo			
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1 Introduction

1.1 Long-tailed bats

Long-tailed bats (*Chalinolobus tuberculatus*; pekapeka-tou-roa) are one of two extant native species of terrestrial mammals in New Zealand. Long-tailed bat populations have declined substantially since the arrival of humans and mammalian predators, and are now classified as Threatened - Nationally Critical, the highest threat classification given by the Department of Conservation (O'Donnell et al. 2022[1]). Deforestation, the introduction of predatory mammals, and increasing urbanisation have all been identified as the major threats to long-tailed bat survival (Pryde et al. 2005[2]; O'Donnell et al. 2022[1]).

1.2 Project background and objective

Hamilton City is one of three urban centres with confirmed populations of long-tailed bats. However, increasing urban expansion and roading development has resulted in the loss of potential roosting habitat and foraging areas (Dekrout et al. 2014[3]; Le Roux & Le Roux, 2012[4]).

Long-term monitoring of bat activity in the greater Hamilton City area will help identify long-term changes in spatial distribution of long-tailed bats and may potentially assist in identifying anthropogenic impacts on the population. Following the first city-wide bat survey in 2012 by Project Echo and Kessels Ecology (Le Roux & Le Roux, 2012[4]), interest was sparked in the presence and distribution of bats in Hamilton City. Since then, annual city-wide surveys have been conducted from 2016-2022 to monitor changes in the Hamilton long-tailed bat population (Mueller et al., 2017[5]; van der Zwan, 2018[6]; van der Zwan & Mueller, 2019[7]; Dumbleton & Montemezzani, 2020[8]; Aughton, 2021[9]; Caskey & Tempero, 2022[10]). These annual city-wide surveys are undertaken with assistance

[1] O'Donnell CFJ, Borkin KM, Christie J, Davidson-Watts I, Dennis G, Pryde M and Michel P. 2023: Conservation status of bats in Aotearoa New Zealand, 2022. New Zealand Threat Classification Series 41. Department of Conservation, Wellington. 18 p.
[2] Pryde MA, O'Donnell CFJ and Barker RJ. 2005. Factors influencing survival and long-term population viability of New Zealand long-tailed bats (Chalinolobus tuberculatus): Implications for conservation. Biological Conservation 126: 175-185.
[3] Dekrout AS, Clarkson BD and Parsons S. 2014. Temporal and spatial distribution and habitat associations of an urban population of New Zealand long-tailed bats (Chalinolobus tuberculatus). New Zealand Journal of Zoology 41: 285-295.
[4] Le Roux DS and Le Roux NN. 2012. Hamilton City Bat Survey 2011-2012. Kessels & Associates Limited 2012. Hamilton. pp 24.
[5] Mueller H, Ulrich C, Purcell A. 2017. Hamilton City Long-tailed Bat Survey 2016 – 2017. Client report prepared by for Project Echo. Kessels Ecology Ltd. Hamilton.
[6] van der Zwan W. 2018. Hamilton City Long-tailed Bat Survey, 2017 – 2018. Client report prepared for Project Echo by Tonkin & Taylor Ltd. Hamilton.
[7] van der Zwan W and Mueller H. 2019. Hamilton City Long-Tailed Bat Survey. Annual Monitoring Report 2018-2019 to Project Echo. Tonkin & Taylor Ltd. Hamilton.
[8] Dumbleton H and Montemezzani W. 2020. Hamilton City long-tailed bat survey. Annual Monitoring Report 2020 prepared for Project Echo. 4Sight Consulting. Hamilton.
[9] Aughton H. 2021. Project Echo 2021 Hamilton City wide bat survey. Go Eco. Hamilton.
[10] Caskey L and Tempero G. 2022. Hamilton City Long-tailed Bat Survey: Annual monitoring report, 2022. ERI report number 165. Prepared for Project Echo.

from DOC, Waikato Regional Council (WRC), Hamilton City Council (HCC) and community volunteers coordinated by GoEco Ltd.

The objective of the annual city-wide bat survey is to identify changes in spatial distribution of long-tailed bats within Hamilton City and the immediate surrounds over time.

1.3 Report objectives

This report details the findings of the 2023 annual acoustic monitoring survey, the seventh consecutive annual survey since 2016, and compares 2023 survey results with those of the 2022 and 2021 surveys.

2 Methods

2.1 Survey design

Between 2016 and 2020, all city-wide bat surveys had carried out survey that relied on expert opinion to select acoustic monitoring sites, resulting in acoustic monitors being primarily deployed in public parks and other low-density areas of the city where bats were more likely to be detected. Once gathered, data was summarised and described qualitatively, with no quantitative analysis carried out.

In 2021, following advice from DOC scientists, a new survey method was adopted. This method aims to detect trends in spatial distribution of long-tailed bats across Hamilton City, using Generalised Linear Mixed Modelling (GLMM) to analyse data. Monitoring sites are selected using a 'balance acceptance sampling' (BAS) method (proposed by van Dam-Bates et al. (2018[11])) to generate a master sample. This is a more spatially balanced method of survey site selection and minimises bias, providing the ability to conduct environmental surveys with good spatial balance and at a wide range of spatial scales. A power analysis is undertaken according to the method of Green & MacLeod (2016[12]) to determine whether enough sites and days are used to allow detection of trends over time. Power analysis indicated that a minimum of 25-30 ABMs deployed for 10-12 days annually for 5-10 years would be sufficient to show a trend (Pryde, 2023a[13]).

A total of 113 potential survey locations were generated by DOC scientists using 'R' statistical software (Appendix 4), incorporating 20 historical sites used in previous surveys to allow for continuity with surveys done prior to 2021. This method allows for a portion of sites not to be monitored in a given survey year, if there is good reason (e.g. the site is located in the middle of a paddock with no means of deploying an ABM). All sites are numbered, and sites are monitored sequentially.

[11] van Dam-Bates P, Gansell O and Robertson B. 2018. Using balanced acceptance sampling as a master sample for environmental surveys. Methods in Ecology and Evolution, 9(7), 1718-1726.
[12] Green P. and MacLeod C. 2015. SIMR: An R package for power analysis of generalized linear mixed models by simulation. Methods in Ecology and Evolution. 7. n/a-n/a. 10.1111/2041-210X.12504.
[13] Pryde MA. 2023a. Presentation at the national Bat Hui. May 2023. Presentation title: Progress and update on testing the use of ABMs to monitor trends.

After a minimum of five years survey following this method, a GLMM model will be used to analyse data using 'sites' and 'days' as fixed effects to detect trends in spatial distribution over time. A negative binomial distribution will be used and code for 'R' statistical software is currently being written by DOC statisticians to allow this analysis (Pryde, 2023b[14]).

The 2023 survey represents the third year of survey carried out using this methodology. At least two further surveys (2024 and 2025) will need to be completed before GLMM analysis can be undertaken. In the meantime, analysis of data will continue to be limited to a summary and qualitative description only.

2.2 Bioacoustic monitoring

A total of 59 ABMs were available for this year's survey, resulting in 59 omnidirectional frequency compression Automated Bat Monitors (ABMs, model AR4 developed by DOC) being deployed in across the city (Figure 1). All 59 ABMs were deployed on 6 and 7 March and retrieved on 27 and 28 March 2023. The ABMs were left recording for 22 consecutive nights (unless batteries ran out or other issues occurred - see Appendix 1).

All monitors were pre-set to start 1 hour before official sunset and left recording until 1 hour after official sunrise. The data was downloaded and analysed using BatSearch 3.12 software (developed by DOC) in accordance with protocols described by Lloyd (2017[15]). The data was then tabulated using Microsoft Excel and mapped as a graphical representation of activity over the city using ArcGIS Pro 3.0.0.

Nightly weather conditions were monitored for the survey period to gain an understanding on the suitability for bat emergence. Air temperature (°C) and precipitation (mm) for the monitoring period were sourced from the NIWA Cliflo database, Ruakura EWS weather station, network number C75734. Refer to Appendix 2 for nightly averages for weather parameters during the survey period.

3 Results

Weather conditions during the survey period were optimal for bat emergence during most of the survey period, although average minimum night temperatures were below 10 °C on three consecutive nights (22 – 24 March). Rainfall was zero or very minimal during the entire survey period. A complete overview of weather data for the survey period is provided in Appendix 2.

Of the 59 deployed ABMs, one (site 37) was taken down by a member of the public after seven days of recording and six stopped recording prematurely (between 6-18 days after deployment). One ABM (site 4) had issues halfway through one night of recording, but no other issues were noticed; this site had the highest count of bat passes during the duration of this survey. The remaining 51 ABMs functioned well for the duration of the survey.

[14] Pryde MA. 2023b. Email from M. Pryde to A. Styche dated 27 June 2023.
[15] Lloyd B. 2017. Bat call identification manual for DOC's spectral bat detectors. (Ed. by The Department of Conservation). Wellington, New Zealand.

A total of 7,674 echolocation passes were recorded at 16 of 59 monitored sites, with a mean of 1.39 passes/night/site (Figure 1 and Table 1).

The highest number of bat passes were recorded at site 4, located in Hammond Park, followed by site 10 in Sandford Park. Both of these sites are near known roost sites.

Of note are the recorded bat passes along the eastern city boundary (sites 96, 72, 88, and 73) where bats had not previously been recorded.

Also notable are sites 52 and 67 in Frankton as these sites are located in busy industrial/commercial areas with very few trees present. Bats were also detected at site 67 during the 2022 study.

Table 1. Summary of bat passes detected across Hamilton City in the 2023 survey.

Site Name	Location	Habitat type	Number of bat passes	Mean number of passes/night
4	Riverlea	Park or gully	3939	179.0
7	Forest Lake	Park or gully	1	0.0
10	Melville	Park or gully	2397	114.1
14	Hamilton Central	Park or gully	18	0.9
16	Riverlea	Park or gully	280	12.7
20	Hillcrest	Park or gully	286	13.0
22	Glenview	Park or gully	77	3.7
31	Hillcrest	Park or gully	16	0.7
39	Peacocke	Agricultural or lifestyle	606	28.9
52	Frankton	Industrial and commercial	8	0.4
67	Hamilton Central	Industrial and commercial	1	0.0
72	Chedworth	Agricultural or lifestyle	1	0.0
73	Horsham Downs	Agricultural or lifestyle	2	0.1
79	Peacocke	Agricultural or lifestyle	37	1.8
88	Rototuna	Residential	4	0.2
96	Fairview Downs	Residential	1	0.1

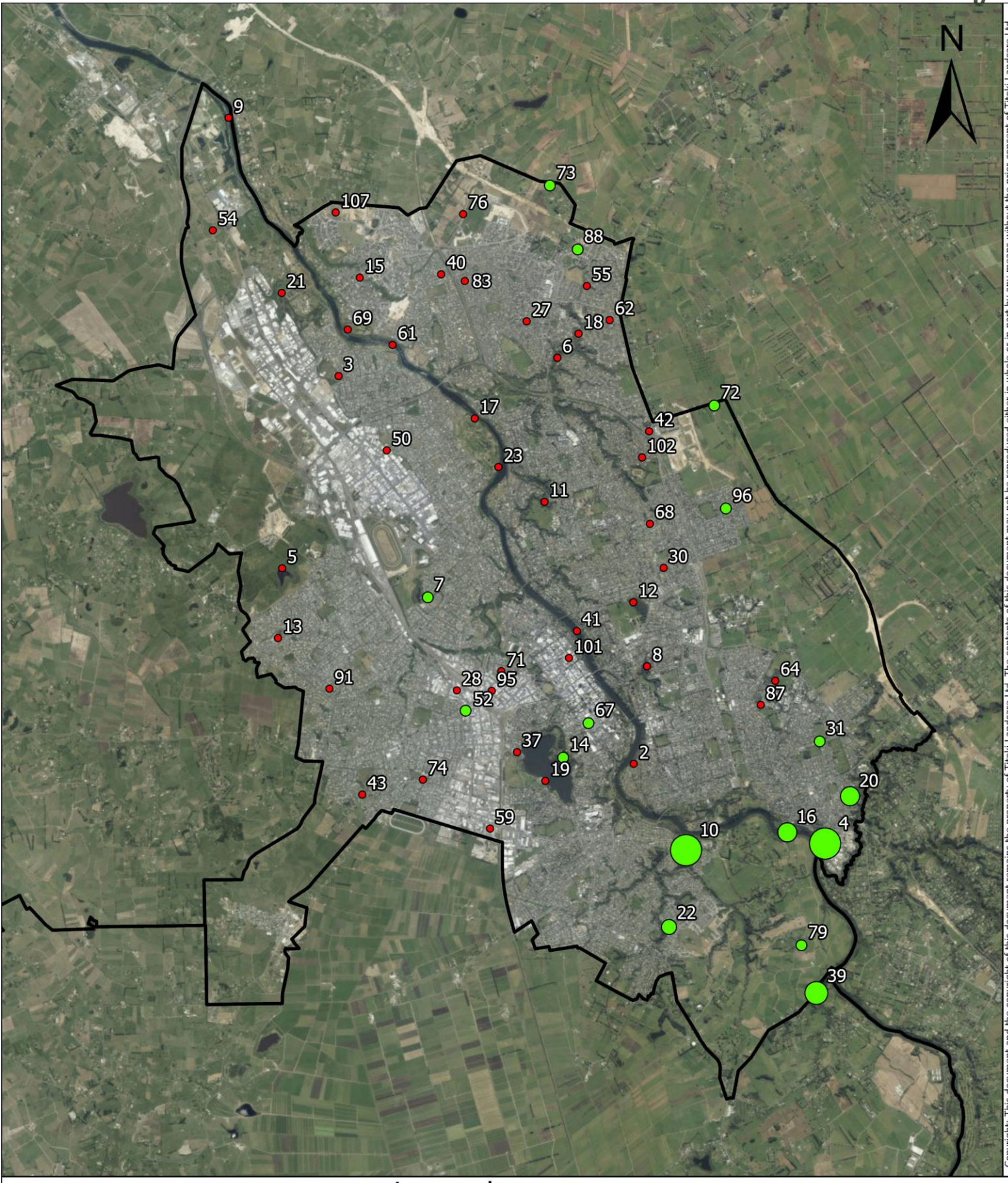

Figure 1
Monitoring results 2023

Drawn by: WM Approved: NS

Date Saved: 16/05/2023 2:00 pm

Folder: C:\OneDrive\Mapping\0129 Hamilton bat survey\

0 2,000 4,000 m

Legend

2023 results

- No bat passes
- 0.02 - 1.88
- 1.89 - 3.67
- 3.68 - 13.00
- 13.01 - 28.86
- 28.87 - 179.05

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4 Comparison to previous surveys

The following observations can be made regarding the 2021, 2022 and 2023 survey results (Table 2):

- A total of 83 sites have been surveyed at least once in the past three years;
- Five sites detected bat passes in all three years of survey (sites 4, 10, 16, 31, and 39). These sites are all located in the southern part of Hamilton City (Figure 1), in parks or gully habitats (with the exception of site 39 which is classed as agricultural land);
- 27 sites detected bats in one or two survey seasons in the past three years; and
- 51 sites did not detect any bat passes in the past three years.

On a city-wide level, the highest levels of bat activity were detected in the southern parts of Hamilton City on the outskirts of dense urban areas. This is in line with the results from previous surveys, dating back to 2011 (Appendix 3) (Le Roux & Le Roux, 2012[4]; Mueller et al., 2017[5]; van der Zwan, 2018[6]; van der Zwan & Mueller, 2019[7]; Dumbleton & Montemezzani, 2020[8]; Aughton, 2021[9]; Caskey & Tempero, 2022[10]). Bats are known to roost in those areas (Davidson-Watts, 2019[16]).

Bat activity across the remainder of the city is sporadic and is less consistent than activity in the southern parts of the city. However, bats do utilise all habitat types found in the city, likely for foraging and to commute across to other sites.

Table 2. Survey results presented of the past three years. (N/D = not deployed; N/A = no data)

Site Name	Location	2023 Mean number of passes/night	2022 Mean number of passes/night	2021 Mean number of passes/night
1	Dinsdale	N/D	N/A	0
2	Hamilton East	0.0	90.3	0.5
3	Pukete	0.0	0	0
4	Riverlea	179.1	258.4	166.3
5	Baverstock	0.0	0.4	0
6	Rototuna	0.0	0	0
7	Forest Lake	0.05	0	0
8	Hamilton East	0.0	0	0
9	Horotiu	0.0	0.3	0
10	Melville	114.1	2	75.3
11	Fairfield	0.0	0	0
12	Claudelands	0.0	0.0	0
13	Grandview Heights	0.0	0	0
14	Hamilton Central	0.9	0	4.2
15	Flagstaff	0.0	0	0
16	Riverlea	12.7	16.3	11.6

[16] Davidson-Watts I. 2019. Long-tailed bat trapping and radio tracking, baseline report 2018 and 2019 Southern Links, Hamilton. Report prepared for AECOM by Davidson-Watts Ecology (Pacific) Ltd.

Site Name	Location	2023 Mean number of passes/night	2022 Mean number of passes/night	2021 Mean number of passes/night
17	St Andrews	0.0	0	0
18	Rototuna	0.0	0	0
19	Hamilton Central	0.0	0	1.7
20	Hillcrest	13.0	8	0
21	Pukete	0.0	0	0
22	Glenview	3.7	0	1.5
23	St Andrews	0.0	0	0
24	Dinsdale	N/D	0	0
25	Ruakura	N/D	0	N/D
27	Rototuna	0.0	0	0
28	Frankton	0.0	0	0
29	Te Rapa	N/D	0	N/D
30	Enderley	0.0	0	0
31	Hillcrest	0.7	0.2	0.1
32	Beerescout	N/D	N/D	0
33	Rototuna	N/D	0	0
35	Nawton	N/D	N/D	0
36	Te Rapa	N/D	N/D	0
37	Hamilton Central	0.0	12.3	N/D
39	Peacocke	28.9	30	10.4
40	Rototuna	0.0	0	0
41	Claudelands	0.0	0	0
42	Chedworth	0.0	0.1	0.05
43	Dinsdale	0.0	0	N/D
45	Rotokauri	N/D	0	N/D
46	Hillcrest	N/D	0	N/D
47	Te Rapa	N/D	N/D	0
49	Melville	N/D	0.2	0.05
50	Te Rapa	0.0	0	0
51	Burbush	N/D	N/D	0
52	Frankton	0.4	0	0
53	Peacocke	N/D	1.3	N/D
54	Horotu	0.0	0	N/D
55	Rototuna	0.0	0	0
57	Dinsdale	N/D	N/D	0.3
58	Burbush	N/D	N/D	0
59	Frankton	0.0	0	N/D
61	Pukete	0.0	0	N/D
62	Huntington	0.0	0	0
63	Rototuna North	N/D	0	N/D

Site Name	Location	2023 Mean number of passes/night	2022 Mean number of passes/night	2021 Mean number of passes/night
64	Hillcrest	0.0	0	0.05
65	Hamilton East	N/D	0	0
66	Forest Lake	N/D	N/D	0
67	Hamilton Central	0.05	0.3	N/D
68	Fairfield	0.0	0.1	N/D
69	Flagstaff	0.0	0	0
71	Frankton	0.0	0	0.8
72	Chedworth	0.05	0	0.1
73	Horsham Downs	0.1	0	N/D
74	Frankton	0.0	0	0
76	Rototuna	0.0	0	0
79	Peacocke	1.8	0	N/D
81	Fairfield	N/D	0.1	0
82	Baverstock	N/D	N/D	0
83	Rototuna	0.0	0	0
87	Hillcrest	0.0	0	0
88	Rototuna	0.2	0	0
91	Western Heights	0.0	0	0
93	Nawton	0.0	N/D	N/D
95	Frankton	0.0	0	0.1
96	Fairview Downs	0.1	N/D	0
97	Peacocke	N/D	N/D	1
101	Hamilton Central	0.0	0	N/D
102	Chedworth	0.0	0	N/D
105	Hillcrest	N/D	0	N/D
107	Rototuna North	0.0	0	N/D
108	Melville	N/D	1	0.19

5 Conclusion

Long-tailed bat passes were recorded at 16 of 59 monitored sites, with a mean of 1.39 passes/night/site. The majority of the bat passes were detected in the southern parts of Hamilton City, while several sites along the eastern boundary also recorded bats. Bat passes were detected at two sites within busy industrial/commercial areas near the city centre, which are of note as very few trees are present in these localities.

On a city-wide level, the highest levels of bat activity were detected in the southern parts of Hamilton City on the outskirts of dense urban areas. This is in line with the results from previous surveys, dating back to 2011. Bat roosts are known in these southern gullies.

Bat activity across the remainder of the city is sporadic and is less consistent than activity in the southern parts of the city.

Appendices

Appendix 1 – Complete survey results 2023

Site Name	Location	Northing	Easting	Habitat type	1st night record	last night record	Number of Nights Deployed	Number of Nights Recorded	Number of bat passes	Mean Number of Passes/Night	Comments
2	Hamilton East	5814165	1801611	Park or gully	7-Mar	28-Mar	22	22	0	0.00	
3	Pukete	5820500	1797005	Park or gully	6-Mar	27-Mar	22	22	0	0.00	
4	Riverlea	5812814	1804658	Park or gully	6-Mar	27-Mar	22	22	3939	179.05	Recording error on 22 May, partial night data. No further errors after this
5	Baverstock	5817435	1796025	Park or gully	6-Mar	27-Mar	22	22	0	0.00	
6	Rototuna	5820703	1800537	Park or gully	6-Mar	19-Mar	14	14	0	0.00	
7	Forest Lake	5816913	1798356	Park or gully	6-Mar	27-Mar	22	22	1	0.05	
8	Hamilton East	5815726	1801863	Park or gully	5-Mar	27-Mar	23	23	0	0.00	
9	Horotiu	5824681	1795332	Park or gully	6-Mar	16-Mar	11	6	0	0.00	Errors in data recording, missing files
10	Melville	5812764	1802414	Park or gully	6-Mar	26-Mar	21	21	2397	114.14	
11	Fairfield	5818403	1800272	Park or gully	7-Mar	Mar-23	22	22	0	0.00	
12	Claudelands	5816756	1801665	Park or gully	6-Mar	27-Mar	22	22	0	0.00	
13	Grandview Heights	5816321	1795932	Park or gully	6-Mar	27-Mar	22	22	0	0.00	
14	Hamilton Central	5814296	1800476	Park or gully	6-Mar	26-Mar	21	21	18	0.86	
15	Flagstaff	5822067	1797387	Park or gully	6-Mar	27-Mar	22	22	0	0.00	
16	Riverlea	5813007	1804055	Park or gully	6-Mar	27-Mar	22	22	280	12.73	
17	St Andrews	5819769	1799182	Park or gully	6-Mar	27-Mar	22	22	0	0.00	
18	Rototuna	5821083	1800890	Park or gully	6-Mar	27-Mar	22	22	0	0.00	
19	Hamilton Central	5813930	1800181	Park or gully	6-Mar	14-Mar	9	9	0	0.00	Unit stopped recording after 9 days
20	Hillcrest	5813560	1805074	Park or gully	6-Mar	27-Mar	22	22	286	13.00	
21	Pukete	5821853	1796121	Park or gully	6-Mar	27-Mar	22	22	0	0.00	
22	Glenview	5811539	1802111	Park or gully	6-Mar	26-Mar	21	21	77	3.67	
23	St Andrews	5818975	1799548	Park or gully	6-Mar	27-Mar	22	22	0	0.00	
27	Rototuna	5821304	1800058	Residential	6-Mar	27-Mar	22	22	0	0.00	
28	Frankton	5815415	1798790	Industrial and commercial	6-Mar	26-Mar	21	21	0	0.00	
30	Enderley	5817295	1802164	Residential	6-Mar	27-Mar	22	22	0	0.00	
31	Hillcrest	5814454	1804610	Park or gully	6-Mar	27-Mar	22	22	16	0.73	
37	Hamilton Central	5814402	1799735	Park or gully	6-Mar	28-Mar	23	7	0	0.00	ABM taken down by member of the public after 7 days
39	Peacocke	5810424	1804455	Agricultural or lifestyle	6-Mar	26-Mar	21	21	606	28.86	
40	Rototuna	5822091	1798701	Residential	6-Mar	21-Mar	16	16	0	0.00	Fault with ABM after 16 days, power supply interrupted?
41	Claudelands	5816319	1800746	Park or gully	6-Mar	28-Mar	23	23	0	0.00	
42	Chedworth	5819492	1801990	Residential	6-Mar	27-Mar	22	22	0	0.00	
43	Dinsdale	5813780	1797226	Residential	6-Mar	27-Mar	22	22	0	0.00	
50	Te Rapa	5819289	1797755	Park or gully	6-Mar	27-Mar	22	22	0	0.00	
52	Frankton	5815085	1798926	Industrial and commercial	6-Mar	26-Mar	21	21	8	0.38	
54	Horotu	5822884	1795037	Agricultural or lifestyle	6-Mar	27-Mar	22	22	0	0.00	

55	Rototuna	5821846	1801041	Park or gully	6-Mar	27-Mar	22	21	0	0.00	
59	Frankton	5813185	1799269	Industrial and commercial	6-Mar	26-Mar	21	21	0	0.00	
61	Pukete	5820979	1797891	Park or gully	6-Mar	27-Mar	22	22	0	0.00	
62	Huntington	5821293	1801398	Industrial and commercial	6-Mar	27-Mar	22	22	0	0.00	
64	Hillcrest	5815442	1803921	Park or gully	6-Mar	27-Mar	22	22	0	0.00	
67	Hamilton Central	5814839	1800899	Industrial and commercial	6-Mar	26-Mar	21	21	1	0.05	
68	Fairfield	5818010	1801964	Residential	6-Mar	28-Mar	23	23	0	0.00	
69	Flagstaff	5821240	1797173	Park or gully	7-Mar	27-Mar	21	21	0	0.00	
71	Frankton	5815699	1799515	Residential	6-Mar	26-Mar	21	21	0	0.00	
72	Chedworth	5819881	1803046	Agricultural or lifestyle	6-Mar	27-Mar	22	22	1	0.05	
73	Horsham Downs	5823470	1800487	Agricultural or lifestyle	6-Mar	27-Mar	22	22	2	0.09	
74	Frankton	5813997	1798208	Park or gully	6-Mar	26-Mar	21	21	0	0.00	
76	Rototuna	5823048	1799077	Residential	6-Mar	27-Mar	22	22	0	0.00	
79	Peacocke	5811195	1804238	Agricultural or lifestyle	6-Mar	26-Mar	21	21	37	1.76	
83	Rototuna	5821971	1799078	Residential	6-Mar	26-Mar	21	21	0	0.00	
87	Hillcrest	5815062	1803674	Park or gully	6-Mar	27-Mar	22	22	0	0.00	
88	Rototuna	5822438	1800906	Residential	6-Mar	27-Mar	22	22	4	0.18	
91	Western Heights	5815490	1796738	Residential	6-Mar	27-Mar	22	22	0	0.00	
93	Nawton	1797308	5816724	Residential	6-Mar	27-Mar	22	22	0	0.00	
95	Frankton	5815392	1799354	Industrial and commercial	6-Mar	26-Mar	21	21	0	0.00	
96	Fairview Downs	5818222	1803195	Residential	12-Mar	29-Mar	18	18	1	0.06	Late deployment and retrieval?
101	Hamilton Central	5815886	1800608	Industrial and commercial	6-Mar	19-Mar	14	14	0	0.00	ABM failure after 14 days
102	Chedworth	5819075	1801861	Residential	6-Mar	27-Mar	22	22	0	0.00	
107	Rototuna North	5823123	1797024	Residential	6-Mar	27-Mar	22	22	0	0.00	

Appendix 2 – Weather conditions

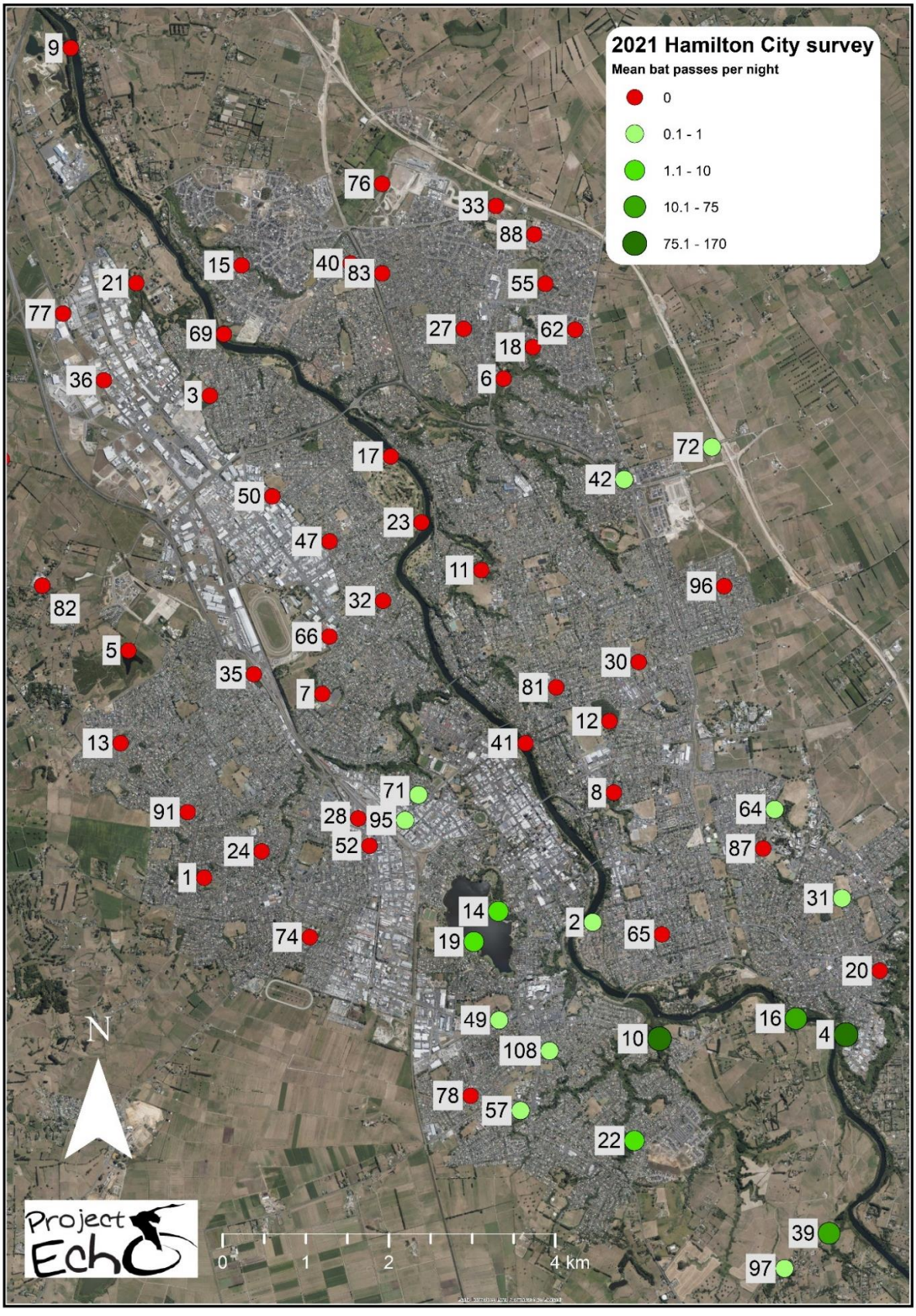
Weather conditions obtained from NIWA Cliflo. Station: Ruakura EWS weather station. network number C75734.

Average rainfall and minimum temperature data was calculated for each survey night. Values in red identify below-threshold values for bat emergence.

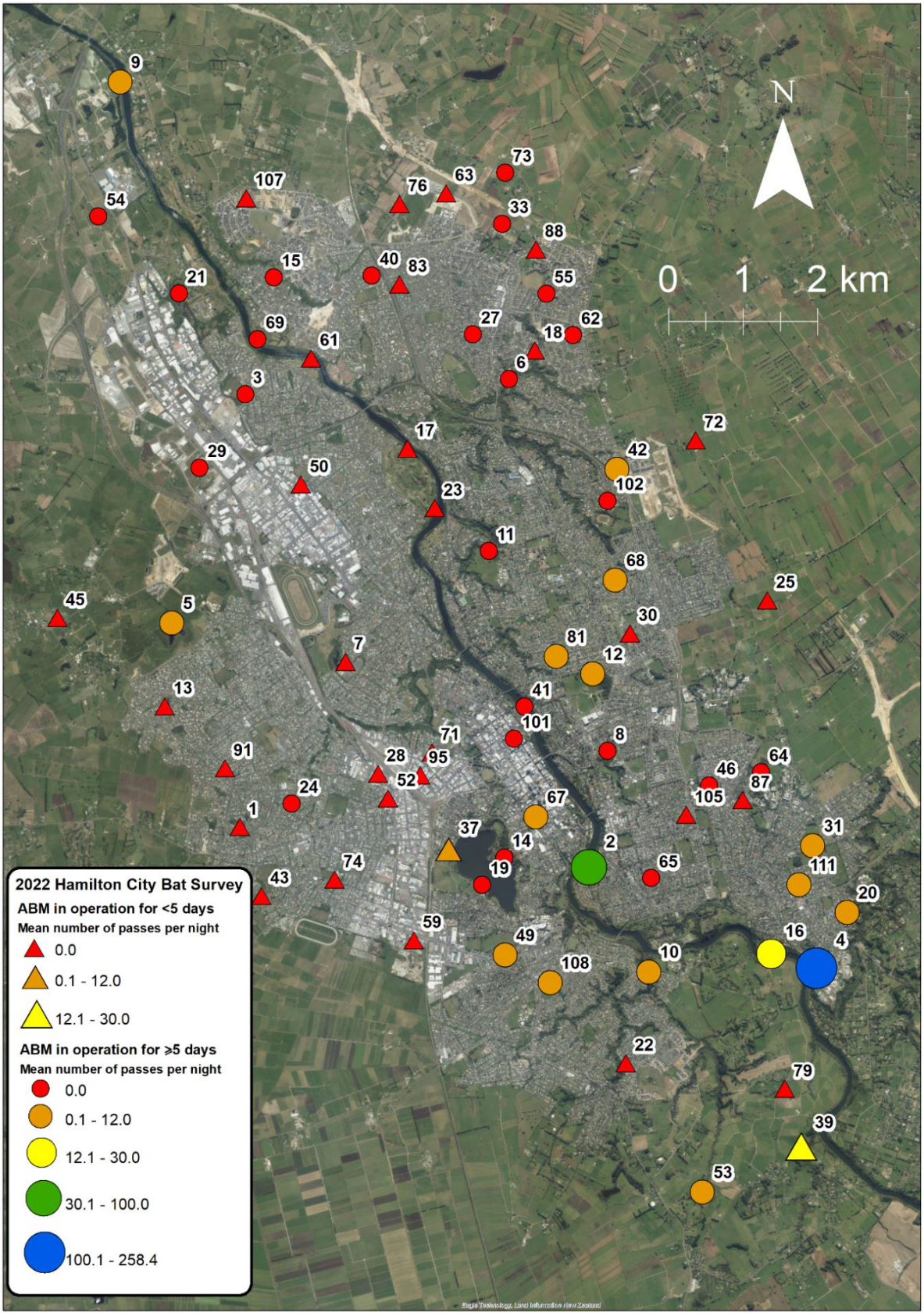
Date	AVG rainfall (mm)	AVG MIN temp (°C)
6/03/2023	0.0	14.8
7/03/2023	0.0	10.4
8/03/2023	0.0	14.6
9/03/2023	0.0	17.7
10/03/2023	0.0	16.8
11/03/2023	0.0	13.0
12/03/2023	0.0	14.3
13/03/2023	0.0	12.7
14/03/2023	0.0	10.3
15/03/2023	0.0	11.7
16/03/2023	0.9	16.8
17/03/2023	1.3	18.6
18/03/2023	0.0	11.3
19/03/2023	0.0	12.2
20/03/2023	0.0	13.5
21/03/2023	0.2	11.4
22/03/2023	0.0	7.8
23/03/2023	0.0	9.2
24/03/2023	0.0	9.4
25/03/2023	0.0	11.4
26/03/2023	0.0	16.9
27/03/2023	0.0	13.9
28/03/2023	0.1	12.7

Appendix 3 – Previous surveys

2021 City Wide Survey



2022 City Wide Survey



Appendix 4 – Master Sample Design

Master Sample locations (van Dam-Bates et al., 2018)