Mt Webber Direct Shipping Ore: EPBC Compliance Report 2021 - Stage 1 and 2

EPBC 2012/6611

23/07/2021

132-LAH-EN-REP-0064 v [1]

Authorisation

Version	Reason for Issue	Prepared	Checked	Authorised	Date
1	Annual Report	A. Slabber	T. Sprenkels	H. Nielssen	01/07/2021

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1 Background

Atlas Iron Pty Ltd (Atlas Iron) operates the Mt Webber Direct Shipping Ore (DSO) Project (the Project) in the Pilbara region of Western Australia. The Project is located approximately 150 kilometres (km) southeast of Port Hedland.

Due to economic and opportunistic circumstances, the Project has been developed in stages with each assessed and approved individually. Stage 1 comprised the initial development of the mine (Ibanez and Fender pits), crushing infrastructure, contractor area, and permanent camp. Stage 2 comprised the development of the Dalton pit and associated mining infrastructure.

In accordance with the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), Atlas submitted a referral to the Department of Sustainability, Environment, Water, Population and Communities (SEWPaC), now the Department of Agriculture, Water and the Environment (DAWE) on 2 November 2012 to allow a determination of whether Stage 1 of the Project is a controlled action. On 3 December 2012, the DAWE advised the proposed action is 'controlled' and required to be assessed by preliminary documentation. Following the submission of additional documentation and public notification of the action, approval for Stage 1 was granted via EPBC 2012/6611 on 18 May 2013.

At the time of reporting, Stages 1 and 2 had progressed substantially with the completion of mining in the Ibanez and continuation of mining in the Dalton and Fender pits.

2 Objective

This report is intended to address Condition 9 of EPBC 2012/6611 whereby:

Within 3 months of every 12-month anniversary of the commencement of the action, the approval holder must publish a report on their website addressing compliance with each of the conditions of this approval, including implementation of the management plan as specified in the conditions. Documentary evidence providing proof of the date of publication and non-compliance with any of the conditions of this approval must be provided to the Department at the same time as the compliance report is published.

3 Scope

This report details the commitments outlined within the EPBC approval document and associated compliance with these commitments for the 1 July 2020 to 30 June 2021 period.

4 Compliance

EPBC 2012/6611		
Condition Number	**Description**	**Compliance Status**
1	Within 10 days after the commencement of the action, the approval holder must advise the Department in writing of the actual date of commencement.	Compliant: Atlas commenced the action on 11 July 2013. The Department were notified on 12 July 2013 (Appendix A).

EPBC 2012/6611		
2	For the purpose of the action, the approval holder must not clear outside of the approved application area as shown in Appendix 1 of this approval. Within the application area the approval holder must not clear more than 756 hectares of native vegetation.	Compliant: No clearing has occurred outside of the approved application area. To date, 304.99 hectares has been cleared.
3	The approval holder must not undertake drilling, blasting or excavation within 100 metres of the lateral extent of cave MW-AN-27.	Compliant: No drilling, blasting, or excavation has occurred within 100 metres of the lateral extent of cave MW-AN-27.
4	The approval holder must implement the Significant Species Management Plan.	Compliant: The Mt Webber Significant Species Management Plan (May 2013) is currently being implemented (Appendix B).

EPBC 2012/6611		
5	The approval holder must submit to the Minister for approval an Artificial Roost Research Plan for the Pilbara Leaf-nosed Bat. The plan must include: a) Provision for the construction of four artificial roosts; b) A summary of the research utilised to identify the required conditions and micro climate for suitable roosts for the species. This must include quantification of atmospheric conditions in cave MW-AN-27 and confirmation of its size and extent and whether it's a diurnal roost; c) The design details for the trial artificial roosts and how they will successfully recreate suitable micro climate for the Pilbara Leaf-nosed Bat; d) Discussion of alternative designs including a comparison of cost, longevity and justification for the preferred choice of design; e) A program to monitor the utilisation of the artificial roosts, including number of bats using the roost, timing of use (daily and seasonal), and how roost is used; and f) A requirement for an evaluation report to be prepared and made publically available on outcomes of the trial. The Artificial Roost Research Plan must be submitted to the Minister within 3 months of commencement of the action. The approved plan must be implemented.	Atlas submitted the Artificial Roost Research Plan (ARRP) for the Pilbara Leaf-nosed Bat to the Department on 11 October 2013. The Department provided comments on the plan to Atlas on 3 January 2014. Atlas submitted a response to the Department on 30 April 2014, with comments received from the Department to Atlas on 6 August 2014. After this time, the plan was in various stages of revision and review by MWH Pty Ltd (now Stantec Australia), with a final version provided to the Department on 3 August 2015. The final plan was approved on 3 February 2016 (Appendix C) and is being implemented accordingly. Atlas submitted quarterly ARRP progress report No. 1 to the Department on 19 March 2018 noting finalisation of artificial roost design, procurement of required materials to construct two roosts, and mobilisation of materials to site. Subsequent quarterly reports have been submitted to the Department, with the final ARRP progress report No. 6 being submitted on 28 June 2019 noting the completed construction of two additional artificial roosts within the Ibanez stage four backfill. The Draft Artificial Roost Monitoring Reports were submitted to the Department on 31 December 2019 and on 24 May 2020.

EPBC 2012/6611		
6	The approval holder must submit to the Minister a Regional Survey Plan for the Pilbara Leaf-nosed Bat to enable a better understanding of the habitat use and requirements for the species. The plan must include the aim, methodology and rationale for the survey, with a particular focus on: a) Location of roost sites and usage (transitory, day, colony and/or breeding roost) within 20km radius of the proposed action; b) The environmental attributes that influence roost selection and fidelity; c) The extent of movement between roosts; d) Foraging range for the species; e) Environmental attributes of foraging habitats; and f) Foraging energetics. The Regional Survey Plan must be submitted to the Minister within 3 months of the commencement of the action. The approved plan must be implemented.	Compliant: Atlas submitted the Regional Survey Plan for the Pilbara Leaf-nosed Bat to the Department on 11 October 2013. The Department provided comments on the plan to Atlas on 3 January 2014. Atlas submitted a response to the Department on 30 April 2014, with comments received from the Department to Atlas on 6 August 2014. After this time, the plan was in various stages of revision and review by MWH Pty Ltd (now Stantec Australia), with a final version provided to the Department on 3 August 2015. The final plan was approved on 3 February 2016 (Appendix C) and is being implemented accordingly. MWH Pty Ltd (now Stantec Australia) completed the regional Pilbara Leaf-nosed Bat survey in July 2016.
7	The approval holder must make a direct financial contribution of $70,000 (AUD) into an established fund administered by the WA DEC to implement actions for the management of those weeds identified as posing a risk to EPBC Act listed threatened species of the Chichester subregion of the Pilbara. Documentary evidence must be provided within 3 months of commencement showing that payment of $70,000 (AUD) to the established fund occurred.	Compliant: Atlas paid $70,000 (AUD) to the DEC (now Department of Biodiversity, Conservation and Attractions) on 20 September 2013 for the management of weeds. The Department was notified of the payment and provided with a receipt on 11 October 2013 (Appendix D).

EPBC 2012/6611		
8	The approval holder must maintain accurate records to substantiate all activities associated with or relevant to the conditions of approval, including measures taken to implement the plans, and make them available upon request to the Department. Such records may be subject to audit by the Department or an independent auditor in accordance with Section 458 of the EPBC Act, or used to verify compliance with the conditions of approval. Summaries of audits will be posted on the Department's website. The results of audits may also be published through the general media.	Compliant: Records of activities associated with or relevant to the conditions of approval are currently being maintained.
9	Within three months of every 12 month anniversary of the commencement of the action, the approval holder must publish a report on their website addressing compliance with each of the conditions of this approval, including implementation of the plans specified in the conditions. Documentary evidence providing proof of the date of publication and non-compliance with any conditions of this approval must be provided to the Department at the same time as the compliance report is published.	Noted: This compliance report shall be published and made available on Atlas' website (Appendix E).
10	If the approval holder wishes to carry out any activity otherwise than in accordance with the plans specified then the person undertaking the action must submit to the Department for the Minister's written approval a revised version of that plan. The varied activity shall not commence until the Minister has approved the varied plan in writing. The Minister will not approve the varied plan unless the revised plan would result in an equivalent or improved environmental outcome over time. If the Minister approves the revised plan, that plan must be implemented in place of the plan originally approved.	Compliant: All activities being carried out are in accordance with the approved management plan.

EPBC 2012/6611		
11	If the Minister believes that it is necessary or convenient for the better protection of listed threatened species and ecological communities to do so, the Minister may request that the approval holder make specified revisions to the plans specified in the conditions and submit the revised plan within a specified timeframe for the Minister's written approval. The approval holder must comply with any such request. The revised approved plan must be implemented. Unless the Minister has approved the revised plan, then the approval holder must continue to implement the plan originally approved, as specified in the conditions.	Compliant: No specified revisions of the approved plans have been requested to date.
12	If at any time after five years from the date of this approval, the approval holder has not substantially commenced the action, then the approval holder must not substantially commence the action without written agreement.	Compliant: The action has been substantially commenced.
13	Unless otherwise agreed in writing by the Minister, the approval holder must publish the plans referred to in these conditions of approval on their website. Each plan must be published on the website within 1 month of being approved.	Compliant: The Mt Webber Significant Species Management Plan (May 2013), Artificial Roost Research Plan (July 2015), and Regional Survey Plan (July 2015) have been published on the Atlas Iron website (Appendix E).

Appendix A. Notification of commencement of action

12 July 2013

Pablo Shopen
Pilbara Taskforce
Department of Sustainability, Environment, Water, Population and Communities
GPO Box 787
CANBERRA 2601

Dear Mr Shopen,

RE: Atlas Iron Limited Mt Webber Direct Shipping Ore Project (2012/6611) commencement

As specified in condition 1 of the approval decision for the Mt Webber Direct Shipping Ore Project (2012/6611), I am writing to advise you that on Thursday 11 July 2013, ground disturbance for the Mt Webber project commenced.

Please do not hesitate to contact me on (08) 6228 8284 if you require additional information or have any questions.

Yours sincerely

Michael Rovira
Senior Environmental Advisor
Atlas Iron Limited

Atlas Iron Limited ABN 63 110 396 168

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Appendix B. Mt Webber DSO Significant Species Management Plan

SIGNIFICANT SPECIES MANAGEMENT PLAN

Mt Webber DSO Project

May 2013

3292AC_04_SSMP_v4

Appendix C. Approval of Artificial Roost Research Plan and Regional Survey Plan

Australian Government
Department of the Environment

Our reference: 2012/6611

Ms Esme Wink
Senior Environmental Advisor – Compliance
Atlas Iron Limiter
Level 18, 300 Murray Street
PERTH WA 6000

Dear Ms Wink

Mt Webber Direct Shipping Ore Project, 150 km south of Port Hedland, Pilbara WA (EPBC 2012/6611)

Thank you for your email dated 3 August 2015 to the Department, seeking approval of the Artificial Roost Research Plan for the Pilbara Leaf-nosed Bat (July 2015) and the Regional Survey Plan for the Pilbara Leaf-nosed Bat (June 2015), in accordance with conditions 5 and 6 of the approval decision dated 18 May 2013.

Officers of this Department have considered the Artificial Roost Research Plan for the Pilbara Leaf-nosed Bat (July 2015) and the Regional Survey Plan for the Pilbara Leaf-nosed Bat (June 2015) and are satisfied that they meet the requirements of conditions 5 and 6 of the approval for this project. On this basis, and as a delegate of the Minister for the Environment, I have decided to approve the Artificial Roost Research Plan for the Pilbara Leaf-nosed Bat (July 2015) and the Regional Survey Plan for the Pilbara Leaf-nosed Bat (June 2015). These plans must now be implemented.

In accordance with EPBC 2012/6611 condition 10, if the approval holder wants to act other than in accordance with this approved plan, the approval holder must submit a revised plan for approval. Until the Minister (or his delegate) has approved the revised plan, the approved version of the plan must continue to be implemented.

Should you require any further information please contact Matthew Plunkett, Project Officer, Post Approvals Section, on 02 6275 9453 or by email: post.approvals@environment.gov.au.

Yours sincerely

S. Gaddes

Shane Gaddes
Assistant Secretary
Compliance & Enforcement Branch
Environment Standards Division

3/2/2016

Appendix D. Payment of AUD $70 000 to DBCA (Weed Management)

Department of
Parks and Wildlife

TAX INVOICE
ABN: 38 052 249 024

Date 11-SEP-13
Page 1 of 1

Number 1885

Customer 38475
Site 85429

Enquiries To : KATHY SALONGA
Phone Number (08) 9405 5198

Attn: Accounts Payable
ATLAS IRON LIMITED
PO BOX 7071
CLOISTERS SQUARE PO
PERTH WA 6850

Terms 30 NET
Salesrep
Due Date 11-OCT-13

Item	Description	Qty Ordered	Unit Price	Amount
1	Mt Webber Direct Shipping Ore Project (EPBC 2012/6611) Offset: Condition 7 - Contribution to Weed Management in Chichester Subregion	1	70,000.00	70,000.00

Special Instructions

Item Amount	GST	Freight	Total
70,000.00	7,000.00	0.00	77,000.00

Currency: AUD

Department of
Parks and Wildlife

ABN: 38 052 249 024

Remittance Advice

PLEASE DETACH AND RETURN WITH YOUR PAYMENT

Remittance Advice to be faxed to:
Senior Finance Officer
Fax (08) 9219 8896
Email: revenue@dpaw.wa.gov.au

Pay By Direct Deposit:
BSB 066-040
A/C No 11300006
Account Name: Department of Parks and Wildlife
Reference: 38475 / 1885

Pay By Cheque:
Make cheque payable to: Department of Parks and Wildlife
Mail to: Department of Parks and Wildlife
Locked Bag 104, Bentley Delivery Centre WA 6983

Customer Number	Invoice Number	Invoice Date	Invoice Total
38475	1885	11-SEP-13	77,000.00

DEC 738A

DEPT OF ENVIRONMENT AND CONSERVATION

ABN 38 052 249 024

POSTAL ADDRESS: LOCKED BAG 104, BENTLEY DELIVERY CENTRE
BENTLEY 6983
TELEPHONE: (08) 9334 0555

CUSTOMER No.

20 SEP 2013

38425 981

ATLAS IRON LIMITED

OFFICIAL RECEIPT

NOT VALID UNLESS PAYMENT IS RECEIPTED BY CASH REGISTER

DATE	REF.	DETAILS	BALANCE
		1885	77000.00

INPUT
at
HEAD OFFICE
Date :- 24 SEP 2013
Operator

GST

TICK BOX IF RECEIPT REQUIRED

TOTAL INCLUDES GST 77000.00

DEPT OF ENVIRONMENT AND CONSERVATION
17 DICK PERRY AVE, KENSINGTON WA 6151

Appendix E. Proof of publication of compliance report and management plans

Mt Webber Direct Shipping Ore Project

MT WEBBER ARTIFICIAL ROOST RESEARCH PLAN	DOWNLOAD
MT WEBBER REGIONAL SURVEY PLAN	DOWNLOAD
MT WEBBER SIGNIFICANT SPECIES MANAGEMENT PLAN	DOWNLOAD
MT WEBBER COMPLIANCE REPORT 2017 (EPBC2012/6611)	DOWNLOAD
MT WEBBER COMPLIANCE REPORT 2018 (EPBC2012/6611)	DOWNLOAD
MT WEBBER COMPLIANCE REPORT 2019 (EPBC2012/6611)	DOWNLOAD
MT WEBBER COMPLIANCE REPORT 2020 (EPBC 2012/6611)	DOWNLOAD
MT WEBBER COMPLIANCE REPORT 2021 (EPBC 2012/6611)	DOWNLOAD

Appendix F. Mt Webber Artificial Bat Roost Monitoring Year 2: October 2019 to October 2020

Mt Webber Artificial Bat Roost Monitoring

Year 2: October 2019 to October 2020

Biologic Environmental Survey

Report to Atlas Iron Pty Ltd

February 2021

Document Status				
Revision No.	Author	Review / Approved for Issue	Approved for Issue to	
			Name	Date
1	A. Jenkins	B. Downing, C. Knuckey	T. Sprenkels, N. Bell	23/12/2020
2	A. Jenkins	C. Knuckey	T. Sprenkels, N. Bell	15/01/2021
3	A. Jenkins	C. Knuckey	T. Sprenkels, N. Bell	27/01/2021
4	A. Jenkins	C. Knuckey	T. Sprenkels, N. Bell	29/01/2021
5	A. Jenkins	C. Knuckey	T. Sprenkels, N. Bell	11/02/2021

"IMPORTANT NOTE"

We have prepared this report for the sole purposes of Atlas Iron Pty Ltd ("Client") for the specific purpose only for which it is supplied. This report is strictly limited to the Purpose and the facts and matters stated in it and does not apply directly or indirectly and will not be used for any other application, purpose, use or matter.

In preparing this report we have made certain assumptions. We have assumed that all information and documents provided to us by the Client or as a result of a specific request or enquiry were complete, accurate and up-to-date. Where we have obtained information from a government register or database, we have assumed that the information is accurate. Where an assumption has been made, we have not made any independent investigations with respect to the matters the subject of that assumption. We are not aware of any reason why any of the assumptions are incorrect.

This report is presented without the assumption of a duty of care to any other person (other than the Client) ("Third Party"). The report may not contain sufficient information for the purposes of a Third Party or for other uses. Without the prior written consent of Biologic:

a) This report may not be relied on by a Third Party; and

b) Biologic will not be liable to a Third Party for any loss, damage, liability or claim arising out of or incidental to a Third-Party publishing, using or relying on the facts, content, opinions or subject matter contained in this report.

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In this note, a reference to loss and damage includes past and prospective economic loss, loss of profits, damage to property, injury to any person (including death) costs and expenses incurred in taking measures to prevent, mitigate or rectify any harm, loss of opportunity, legal costs, compensation, interest and any other direct, indirect, consequential or financial or other loss.

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EXECUTIVE SUMMARY

Atlas Iron Pty Ltd (Atlas Iron) constructed four artificial bat roosts within waste rock dumps at their Mt Webber Direct Shipping Ore Project (the Project), located approximately 170 kilometres (km) south of Port Hedland in the Pilbara region of Western Australia (WA). The four artificial roosts were constructed to meet Condition 5 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) Approval Decision 2012/6611 for the Project. Specifications and key performance objectives for the roost were originally developed in the *Mt Webber Project: Artificial Roost Research Plan for the Pilbara leaf-nosed bat* (ARRP) and later revised by Bat Call (2018). The overall aim of the ARRP was to create four artificial roosts at Mt Webber to compensate for the removal of 17 nocturnal refuges utilised by the Pilbara leaf-nosed bat (*Rhinonicteris aurantia* Pilbara form). This experimental and adaptive management approach was developed to determine the feasibility of constructing artificial roost habitat as a viable management tool for the species, specifically within a post closure environment.

The first two roosts (MW-AR-01 and MW-AR-02) were installed in July 2018 within the Ibanez waste-rock landform. The second two roosts (MW-AR-03 and MW-AR-04) were installed within an area of backfill within the Ibanez pit in June 2019. All roosts are located approximately 3 km from the nearest permanent diurnal roost, MW-AN-27.

Biologic Environmental Survey (Biologic) was commissioned by Atlas Iron to undertake continuous monitoring of the four artificial roosts. The overarching objective of the monitoring was to identify and track the adoption of each artificial roost as a nocturnal refuge, particularly for the Pilbara leaf-nosed bat, in accordance with the ARRP and Bat Call (2018). Specifically, the report documents:

- when and by which bat species each roost was visited; and
- if the structures were being used by the Pilbara leaf-nosed bat and the extent to which the species were using the structures (night visitation, diurnal roosting etc.).

Microclimate data loggers were used to monitor temperature and relative humidity (RH) at all four artificial roosts as well as at two nocturnal refuges (MW-AN-17 and MW-AN-25) and one diurnal roost (MW-AN-27) known to occur in the area. Echolocation calls, recorded by SongMeter SM4BAT ultrasonic recorders (SongMeters), were used to record bat activity at the four artificial roosts as well as MW-AN-27 from 29th September 2019 to 18th September 2020. A SongMeter was placed internally throughout the monitoring period at MW-AR-01 and MW-AR-02. A SongMeter was placed outside the entrance at MW-AR-03 and MW-AR-04 and moved internally in January 2020. Due to interruptions in data, recording occurred over 311 nights at MW-AR-01, 303 nights at MW-AR-02, 33 nights at MW-AR-03 externally, 150 nights at MW-AR-03 internally, 83 nights at MW-AR-04 externally, 244 nights at MW-AR-04 internally and 328 nights at MW-AN-27.

Microclimate

Temperatures inside MW-AR-01, MW-AR-02, MW-AR-03 and MW-AR-04 remained relatively stable and within the target range stipulated by the key performance indicator (i.e. 25–32°C) for most of the monitoring period (74.59%, 92.17%, 70.18% and 93.38%, respectively). The temperatures recorded inside the nocturnal reference refuge were within the target range for 72.42% of the monitoring period

at MW-AN-17 and 14.33% at MW-AN-25. MW-AN-27 was within the temperature range of a diurnal roost (28-32ºC) for 57.19% of the monitoring period (microclimate logger may not be in the most representative location).

Relative humidity within the roosts was highly variable and within the target range stipulated by the key performance indicator (i.e. 25–100%) for approximately 72.25% at MW-AR-01, 78.48% at MW-AR-02, 65.61% at MW-AR-03 and 73.35% at MW-AR-04 of the monitoring period. Relative humidity in the naturally occurring roosts also fluctuated, whereby MW-AN-17 and MW-AN-25 were within the target range of a nocturnal refuge for 64.68% and 45.34% of the monitoring period respectively. MW-AN-27 was within the target RH of a diurnal roost (85%-100%) for 1.81% of the monitoring period only, together with the temperature results, suggesting that the logger was not in the most representative location.

Temperature and RH were within the target range (25 to 32 ºC and 25 to 100%) concurrently for 49.36% at MW-AR-01, 74.82% at MW-AR-02, 42.34% at MW-AR-03 and 52.24% at MW-AR-04. Temperature and RH were within the target range (25 to 32 ºC and 25 to 60%) concurrently for 48.08% at MW-AN-17, 6.43% at MW-AN-25 and 0.42% at MW-AN-27.

Roost Utilisation

Pilbara leaf-nosed bats were detected at the entrance of MW-AR-03 on 21 of the 33 recording nights (63.63%) and MW-AR-04 on 12 of the 83 recording nights (14.45%) between September 2019 and January 2020. The number of calls recorded at the artificial roosts was typically low throughout the monitoring period, suggesting calls were attributed to individuals or small numbers of individuals. Additionally, the timing of most calls indicated the species was present for the purposes of foraging. No Pilbara leaf-nosed bats were detected on the internal recorders at MW-AR-01 and MW-AR-02 between September 2019 and September 2020 as well as at MW-AR-03 and MW-AR-04 between January and September 2020. The species was detected in high numbers on all nights at MW-AN-27. Diurnal roosting was indicated for all nights during the monitoring period at MW-AN-27.

Conclusions

During the current monitoring period, the results indicate that Pilbara leaf-nosed bats were frequently present at the entrance of MW-AR-03 and MW-AR-04 between September 2019 and January 2020. However, the species was not recorded entering any of the four artificial roosts. The microclimate within the four artificial roosts was partially suitable for use as a nocturnal refuge, however, they are unable to hold this year-round under the current circumstances. Implementation of recommended roost alterations may increase the potential for a stable artificial roost microclimate and utilisation by Pilbara leaf-nosed bats. As such, none of the artificial roost, currently meet the criteria of a nocturnal refuge, as defined by Bat Call (2018). It is however important to recognise that it remains uncertain whether the criteria defined by Bat Call (2018) adequately represents conditions of a nocturnal refuge. Microclimate data obtained from other caves in the area (MW-AN-17 and MW-AN-25) would suggest that variation beyond the criteria occurs naturally.

Preliminary assessment of monitoring data against key performance indicators detailed in the ARRP, or subsequent revisions, indicated most key performance indicators are either being met or are on a positive trajectory towards being achieved.

1 INTRODUCTION

1.1 Project Background

Atlas Iron Pty Ltd (Atlas Iron) have developed the Mt Webber Direct Shipping Ore Project (the Project), located approximately 170 kilometres (km) south of Port Hedland, in the Pilbara region of Western Australia (WA) (Figure 1.1). In order to meet Condition 5 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) Approval Decision 2012/6611 for the Project, Atlas Iron was required to develop and implement the *Mt Webber Project: Artificial Roost Research Plan for the Pilbara leaf-nosed bat (*ARRP*)* (MWH, 2015b). The overall aim of the ARRP was to create four artificial roosts at Mt Webber to compensate for the removal of 17 nocturnal refuges utilised by the Pilbara leaf-nosed bat (*Rhinonicteris aurantia* Pilbara form). The ARRP stipulates Atlas Iron must design and install four artificial roosts and, once the species' presence has been established within the roosts, bi-annual (six monthly) monitoring be undertaken over a period of five years.

This experimental and adaptive management approach was developed to determine the feasibility of constructing artificial roost habitat as a viable management tool for the species, specifically within a post closure landform. Exclusive to this project, the development of suitable artificial roosts has been highlighted as a research priority to assist in offsetting impacts to naturally occurring roosts of threatened bat species, including the Pilbara leaf-nosed bat (*Rhinonicteris aurantia* Pilbara form) and ghost bat (*Macroderma gigas*) (Cramer *et al.*, 2016) . It has been recommended that artificial roosts be constructed in areas of suitable substrate that permit regular monitoring of microclimates, bat utilisation and bat populations (Cramer *et al.*, 2016).

Accordingly, four artificial roosts have been installed at Mt Webber between 2018 and 2019 as detailed in Table 1.1 and illustrated in Figure 1.1.

Table 1.1 Artificial roost locations

Artificial Roost	MW-AR-01	MW-AR-02	MW-AR-03	MW-AR-04
Installation Date	July 2018	July 2018	June 2019	June 2019
Location	Ibanez waste rock landform	Ibanez waste rock landform	Ibanez pit within area backfill	Ibanez pit within area backfill
Latitude and Longitude	-21.5377, 119.2849	-21.5386, 119.2846	-21.5354, 119.2936	-21.5379, 119.2919
Distance from MW-AN-27	~3.6 km	~3.6 km	~2.75km	~3.05km

*Note: MW-AN-27 is a natural Pilbara leaf-nosed roost.

Each roost comprises a large main chamber approximately 4.8 metres (m) in length by 2.4 m in height and width, with a single passage tunnel approximately 1.5 m in diameter and 8 m in length with a 90-degree elbow half-way along its length. The main chambers were constructed from solid concrete pillars originally designed and used as culverts for rail water crossings, and the entrance tunnel from cylindrical corrugated metal sheeting also used for culverts. Stainless steel chicken wire was applied to the internal upper surface of the main chamber at MW-AR-01, MW-AR-02 and MW-AR-03 to provide a surface to which bats can

attach. At MW-AR-04, purpose-built tiles designed from the roof of natural caves, were utilised to provide attachment points. A metal gate covering the roost's entrance tunnel was designed to prohibit entry by other animals, including the ghost bat which are known to prey on Pilbara leaf-nosed bats (Churchill, 1994). The entire roost structure was buried at a depth of approximately 3 m within a waste rock dump. Internal access to the main chamber for monitoring was facilitated by a vertical monitoring conduit accessible from above the roost.

1.1 Survey Scope and Objectives

To evaluate the effectiveness of the artificial roosts and inform future management measures for the species, both at the Project and more broadly across the species' distribution, continuous monitoring with bi-annual reporting of the roosts is required in accordance with the ARRP. The ARRP prescribed five performance objectives which would need to be met for the artificial roosts to be deemed successful. To meet these performance objectives, key performance indicators (KPI) have been determined to assess success against each performance objective. The AARP performance objectives (MWH, 2015b) are based on documented performance indicators for a diurnal/maternal roost and includes a range of features not applicable, or not applicable at the stated levels for a nocturnal refuge, which is the desired outcome of the artificial roosts. Bat Call (2018) provided an update to the artificial roost specifications and indicators applicable to a nocturnal refuge based on information acquired after development of the ARRP; such specifications are applied herein. The performance objectives, corresponding key performance indicators and their justification as detailed in the ARRP and revised by Bat Call (2018) are detailed in Table 1.2.

Biologic Environmental Survey (Biologic) was commissioned by Atlas Iron to undertake monitoring of the four artificial roosts to determine if the structures were being utilised by Pilbara leaf-nosed bats or any other bat species. This is the second annual monitoring report for the project from October 2019 to September 2020. For all information between the artificial roost installation date to October 2019 refer to Mt Webber artificial bat roost monitoring Year 1: October 2018 to October 2019 (Biologic, 2020b). The overarching objective of the monitoring was to identify and track the adoption of each artificial roost as a nocturnal refuge, particularly for the Pilbara leaf-nosed bat in accordance with the ARRP and Bat Call (2018). Specifically, the report documents:

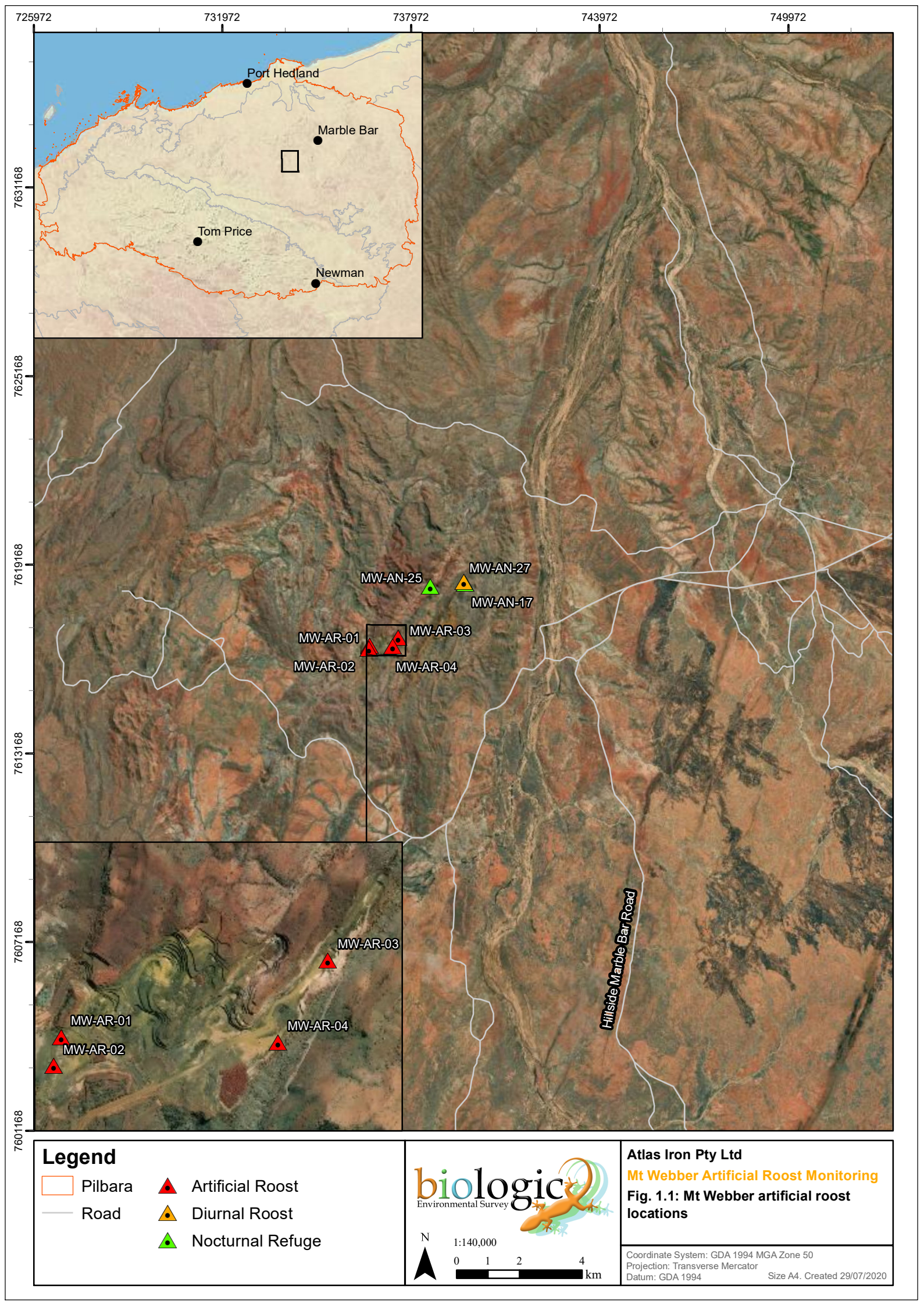
- when and by which bat species each roost was visited; and
- if the structures were being used by the Pilbara leaf-nosed bat, and the extent to which the species is using the structures (night visitation, diurnal roosting etc.).

Table 1.2: Key performance objectives for the evaluation of artificial roost success[1]

Performance objective	Key performance indicator (for diurnal/breeding roost)	Justification	Revised KPI for nocturnal refuge (following Bat Call (2018))
Design artificial roosts	Completed design for artificial roosts for Pilbara leaf-nosed bat complete with technical specifications (i.e. materials, dimensions, location, in cooperation with bat specialists and engineers)	The design component, which should be based on sound ecological and engineering knowledge, is critical to the success of the trial and ensuring the effectiveness of the artificial roosts.	No change
Construct four artificial roosts	Four roosts constructed according to design specifications	It is important to ensure that the roosts constructed are faithful to the original design specifications.	No change
Create and maintain a microclimate deemed suitable for supporting Pilbara leaf-nosed bat within the artificial roosts	Microclimate at different seasons characterised by: • temperature of 28–32°C • RH of 85–100%	These microclimatic attributes are deemed necessary in supporting populations of Pilbara leaf-nosed bat within roost caves.	Microclimate for nocturnal refuge characterised as: • temperature of 25–32°C • RH of 25–60%
Pilbara leaf-nosed bat utilising artificial roosts	Presence of Pilbara leaf-nosed bat detected at the entrance or within the chambers of the artificial roosts (i.e. pattern of activity indicating transitory visitation or greater)	Nocturnal refuges removed by the Project represented important habitat for the species and it is the intent of the trial to determine whether this habitat can be recreated and equivalent usage by the species restored.	No change
PLNB colonising artificial roost(s)	Status of roost(s) established as diurnal roost (i.e. bats residing within main chamber during daytime hours and exhibiting an activity profile of exiting at dusk and entering prior to dawn)	This objective represents an aspirational goal for the roosts; should this objective be satisfied, the trial would have resulted in a net positive gain for PLNB in the local area.	No change (Note this is an additional aspirational target and does not affect the success of the ARRP).

[1]Terminology describing the types of underground habitat used by Pilbara leaf-nosed bats has been aligned with (TSSC, 2016). Consequently, 'maternal roosts' are here referred to as 'breeding roosts', and 'nocturnal refuges/transitory roosts' are here referred to as 'nocturnal refuges'..

[2] Relative humidity has been interpreted as 25-100%, as a higher RH is likely to be preferred by the species (Baudinette *et al.*, 2000).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Port Hedland
Marble Bar
Tom Price
Newman
MW-AN-25
MW-AN-27
MW-AN-17
MW-AR-01
MW-AR-03
MW-AR-02
MW-AR-04
Hillside Marble Bar Road
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km
Atlas Iron Pty Ltd
Mt Webber Artificial Roost Monitoring
Fig. 1.1: Mt Webber artificial roost locations
Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994
Size A4. Created 29/07/2020

2 SPECIES OF INTEREST

Seventeen species of microbat occur within the Pilbara bioregion (McKenzie & Bullen, 2009; van Dyck & Strahan, 2008), of which five are obligate cave roosting bat species that are expected to make use of an artificial bat roost structure. These include two species listed as Vulnerable under the federal EPBC Act and WA *Biodiversity Conservation Act 2016* (BC Act); Pilbara leaf-nosed bat and ghost bat. Both species of conservation significance, the Pilbara leaf-nosed bat and ghost bat, are endemic to northern Australia and have historically been recorded roosting in the vicinity of the artificial roosts (MWH, 2015a, 2015b, 2016; Stantec, 2017). The three remaining species are the common sheath-tailed bat (*Taphozous georgianus*), Hill's sheath-tailed bat (*Taphozous hilli*) and Finlayson's cave bat (*Vespadelus finlaysoni*).

2.1 Pilbara leaf-nosed bat (*Rhinonicteris aurantia* Pilbara form)

The Pilbara leaf-nosed bat is listed as Vulnerable under the EPBC Act and the BC Act. The Pilbara leaf-nosed bat is recognised as a geographically isolated population of the orange leaf-nosed bat, distributed across northern Australia and separated from the Pilbara populations by approximately 400 km of the Great Sandy Desert (Armstrong, 2001). The Pilbara population is regarded as representing a single interbreeding population comprising multiple colonies (TSSC, 2016). The most updated conservation advice (TSSC, 2016) stated that there were at least 10 confirmed day roosts (including maternity roosts) and a further 23 unconfirmed roosts throughout the Pilbara region, although this is likely to be an underestimate based on unpublished data.

Pilbara leaf-nosed bats typically roost in undisturbed caves, deep fissures or abandoned mine shafts (Armstrong, 2000, 2001). The species' limited ability to conserve heat and water (Baudinette *et al.*, 2000) means they require warm (28-32ºC) and very humid (85-100%) roost sites to persist in arid and semi-arid climates (Armstrong, 2001; Churchill, 1991). Roost sites with such attributes are relatively uncommon in the Pilbara and the limiting factor of the species' distribution (Armstrong, 2001). During the dry season (June to November), individuals are believed to aggregate in roosts that provide a suitably warm, humid microclimate (Armstrong, 2000, 2001; Bullen & McKenzie, 2011). While in the wet season (December to May), when conditions are generally wetter and more humid, individuals typically disperse roosting in seasonally suitable features (Armstrong, 2000, 2001; Bullen & McKenzie, 2011). TSSC (2016) categorised underground refuges used by the species into four categories:

- **Permanent Diurnal Roosts** (Priority 1 – critical habitat for daily survival): are occupied year-round and are likely to be the focus for some part of the 9-month breeding cycle.
- **Non-Permanent Breeding Roosts** (Priority 2 - critical habitat for daily and long-term survival): are used during some part of the 9-month breeding cycle but not year-round.
- **Transitory Diurnal Roosts** (Priority 3 – critical habitat for daily and long-term survival): are occupied outside the breeding season and could facilitate long distance dispersal.
- **Nocturnal Refuge** (Priority 4 – not considered critical but important for persistence in a local area): are occupied or entered at night for resting, feeding or other purposes (excluding overhangs).

The species forages within and in the vicinity of roost caves and more broadly along waterbodies with suitable fringing vegetation supporting prey species (TSSC, 2016). Foraging sites surrounding known or

suspected roosts can be critical to the survival of the species. TSSC (2016) categorised foraging habitat into five categories: gorges with pools (Priority 1); gullies (Priority 2); rocky outcrops (Priority 3); major watercourses (Priority 4); and open grassland and woodland (Priority 5) (TSSC, 2016). The species is predicted to travel up to 20 km from roost caves during nightly foraging (Cramer *et al.*, 2016); however, seasonal variation is known to occur, with foraging occurring up to 20 km in the dry season and up to 50 km during the wet season (Bullen, 2013). Long-distance movements by the species have also been recorded, with a single monitored individual recorded from two roost caves located 170 km distant approximately 12 months apart (Bullen & Reiffer, 2019).

3 METHODS

3.1 Licensing and personnel

The survey was conducted under the Department of Biodiversity Conservation and Attraction's (DBCA) Regulation 27 license BA27000153-3 issued to C. Knuckey. Microclimate and SongMeter data was collected on approximately a 3-monthly basis by Atlas or Biologic personnel. Biologic and Atlas personnel conducted maintenance on monitoring equipment when required.

3.2 Timing and weather

Monitoring of the artificial roosts, reference nocturnal refuges and reference diurnal roost occurred between 29th September 2019 and 18th September 2020 (hereafter referred to as the monitoring period).

The Pilbara bioregion has a semi-desert to tropical climate, with rainfall occurring sporadically throughout the year, although mostly during summer (Thackway & Cresswell, 1995). Summer rainfall is usually the result of tropical storms in the north or tropical cyclones that impact upon the coast and move inland (Leighton, 2004). The winter rainfall is generally lighter and is the result of cold fronts moving north easterly across the state (Leighton, 2004). The average annual rainfall ranges from 200-350 mm, although there are significant fluctuations between years, with some locations receiving up to 1,200 mm in some years (McKenzie *et al.*, 2009). From October 2019 to September 2020, Marble Bar Station (weather station 004106) recorded 409 millimetres (mm) of rainfall, which is higher than the long-term annual average for the same period (393 mm, Figure 3.1). A substantial amount of rainfall was received in January 2020 (312 mm was received comparted to the long-term average of 115 mm) on account of Cyclone Blake.

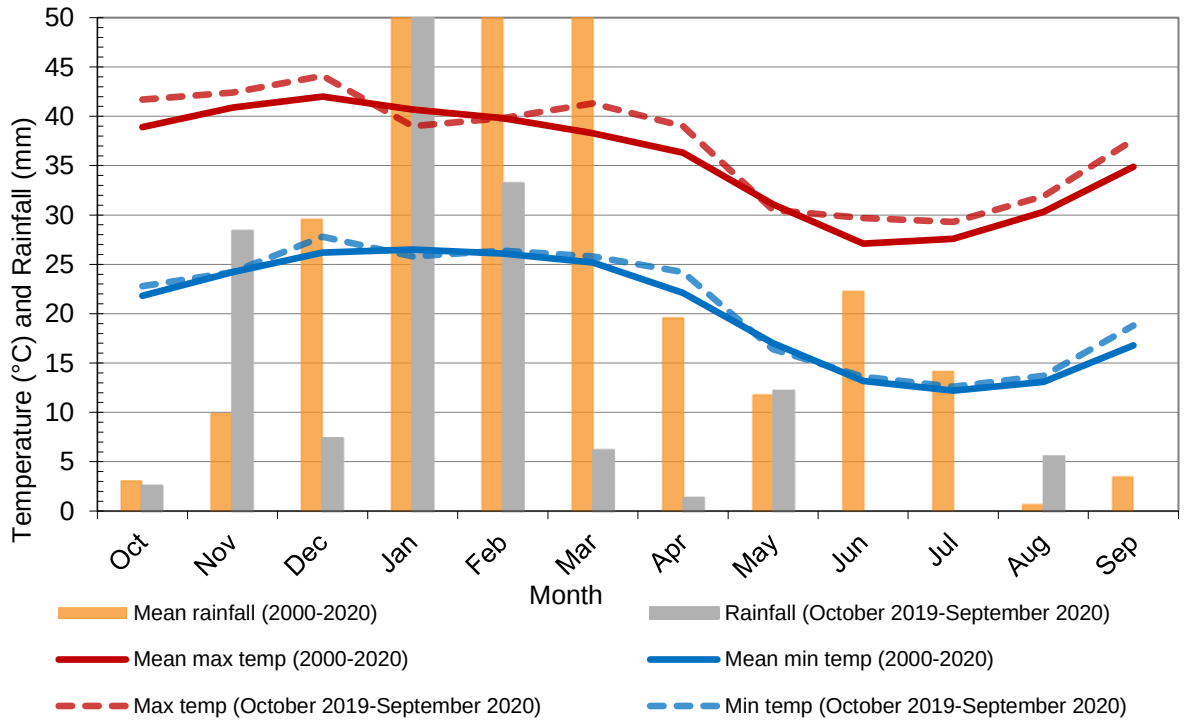


Figure 3.1: Climate data for the monitoring period, taken from Marble Bar (004106) (BoM, 2020)

3.3 Monitoring Locations

Seven roosts (Table 3.1), including four artificial roosts (MW-AR-01, MW-AR-02, MW-AR-03 and MW-AR-04), two reference nocturnal refuges (MW-AN-17 and MW-AN-25) and one permanent diurnal roost (MW-AN-27), were monitored broadly following methods specified in the ARRP.

Table 3.1: Summary of monitoring caves

Artificial Roost	Installation Date	Pilbara leaf-nosed bat importance	Location	Latitude and longitude	Distance from MW-AN-27	Microclimate Type
MW-AR-01	July 2018	Artificial Roost	Ibanez waste rock landform	-21.5377, 119.2849	~3.6 km	iButton at all locations
MW-AR-02	July 2018	Artificial Roost	Ibanez waste rock landform	-21.5386, 119.2846	~3.6 km	1 HOBO, 2 iButtons
MW-AR-03	June 2019	Artificial Roost	Ibanez pit within area backfill	-21.5354, 119.2936	~2.75 km	1 HOBO, 2 iButtons
MW-AR-04	June 2019	Artificial Roost	Ibanez pit within area backfill	-21.5379, 119.2919	~3.05 km	1 HOBO, 2 iButtons
MW-AN-17	-	Nocturnal Refuge	-	-21.5196, 119.3140	~0.09 km	1 iButton
MW-AN-15	-	Nocturnal Refuge	-	-21.5205, 119.3032	~1.07 km	1 iButton
MW-AN-27	-	Permanent Diurnal Roost	-	-21.5190, 119.3134	-	2 iButtons

3.4 Microclimate Analysis

Microclimate loggers (Hydrochron iButton temperature and RH loggers (iButtons) or HOBO (MX2301A) temperature/RH Bluetooth data loggers) were deployed to assess the interior microclimate (temperate and RH) within the artificial roosts (MW-AR-01, MW-AR-02, MW-AR-03 and MW-AR-04), reference nocturnal refuges (MW-AN-17, MW-AN-25) and MW-AN-27. At all artificial roosts a total of three microclimate loggers were deployed, one outside the entrance tunnel (outside/external), one ~1 m inside the roost entrance (entrance), and one down the monitoring tube that leads into the main chamber (inside/internal). One microclimate logger was deployed inside MW-AN-17 and MW-AN-25, and two microclimate loggers was deployed inside MW-AN-27. The microclimate loggers were deployed from the 30th September 2019 to 18th September 2020 (Table 3.1).

All microclimate loggers recorded at 3-hour intervals. At each of the artificial roosts, the range of temperature and RH recorded (daily minimum and maximum parameters records) was plotted against target ranges of a nocturnal refuge (as a minimum) and diurnal roost (as a maximum) as defined by Bat Call (2018), providing a range of 25–32°C for temperature and 25–100% for RH. A higher maximum RH was used as it is likely to be preferred by the species (Baudinette *et al.*, 2000). The reference diurnal roost was plotted against the target ranges of a diurnal roost (28–32°C for temperature and 85-100% for RH) (Armstrong, 2000).

Due to technical difficulties (see Table 3.2 for details) data was not recorded at MW-AR-01 (entrance to roost - 30th September to 16th December 2019), MW-AR-02 (monitoring tube - 18th December 2019 to 12th March 2019, entrance to roost - 30th September to 15th December 2019) and MW-AR-03 (outside the roost - 18th December 2019 to 14th April 2020) and MW-AN-17 (inside refuge - 18th December 2019 to 15th March 2020).

Table 3.2: Location and deployment information of the microclimate loggers

Roost	Number of loggers	Microclimate logger location	Oct 19	Nov 19	Dec 19	Jan 20	Feb 20	Mar 20	Apr 20	May 20	Jun 20	Jul 20	Aug 20	Sep 20
MW-AR-01	3	~1m inside roost entrance.	No data											
		Outside entrance tunnel.												
		Monitoring tube.												
MW-AR-02	3	~1m inside roost entrance.	No data											
		Outside entrance tunnel.												
		Monitoring tube.			No data									
MW-AR-03	3	~1m inside roost entrance												
		Outside entrance tunnel			No data									
		Monitoring tube												
MW-AR-04	3	~1m inside roost entrance			No data									
		Outside entrance tunnel												
		Monitoring tube												
MW-AN-17	1	Inside roost			No data									
MW-AN-25	1	Inside roost												
MW-AN-27	2	Inside roost												

Note: The orange box illustrates the period microclimate loggers were deployed, the grey box illustrates the period during which no data was recorded on account of technical issues

3.5 Ultrasonic Analysis

To record bat echolocation calls, a single SongMeter SM4BAT-FS (SM4; Wildlife Acoustics, USA) powered by an external solar power supply was installed at each artificial roost (Appendix BAppendix B – Location of monitoring equipment at artificial roost). These more recently developed SM4 echolocation recording devices replaced the SM2BAT recorders (as specified in the ARRP), due to their greater accuracy and efficiency in relation to the monitoring requirements. External SM4 units were fitted with a directional SMX-U2 ultrasonic microphone when deployed at the entrance of the roosts and an omnidirectional SMX-U1 ultrasonic microphone when deployed internally. Recorders were preconfigured to activate at astronomical sunset each day and deactivate at astronomical sunrise the following morning. Settings were adjusted to record calls for both the Pilbara leaf-nosed bat as well as any other cave dwelling bat species occurring in the region, with a frequency recording range of 12–160 kilohertz (kHz). Data was analysed on all recorded nights at the four artificial roosts and MW-AN-27 for all species of bats, including Pilbara leaf-nosed bats, ghost bats. All recordings were analysed by Robert Bullen of Bat Call WA using standardised bat call detection techniques. Raw files were first scanned for Pilbara leaf-nosed bat calls using Kaleidoscope software (Wildlife Acoustics, USA), then reviewed for significant times and call numbers using Cool Edit software (Adobe, USA). During analysis, a recording night was from sunset to sunrise the following day.

At MW-AR-01 and MW-AR-02, microphones were deployed inside the monitoring tube that leads into the main roosting chamber of the artificial roost, to determine if Pilbara leaf-nosed bats were entering the roosts and if any diurnal roosting was occurring. A total of 311 and 303 nights of recording were obtained between the 29th September 2019 and 18th October 2020, respectively. Due to technical difficulties with the recording devices and power supply, there was gaps in the data recorded at MW-AR-01 (4th to 16th December 2019, 23rd February to 24th April 2020) and MW-AR-02 (4th December to 16th December 2019, 15th February to 24th April 2020; Table 3.3).

Initially, recorders were placed outside the entrance of roosts MW-AR-03 and MW-AR-04 with the microphone facing away from the roosts entrance to maximise detection of any passing bats. A total of 33 and 83 recording nights were obtained from these locations between the 29th September 2019 and 17th January 2020, respectively. The recorders were moved into the monitoring tubes once Pilbara leaf-nosed bats were recorded at the entrance of the artificial roost to determine if the bats were foraging or roosting. Recordings occurred internally for 150 and 244 nights between the 18th January and 18th September 2020, respectively. Due to technical difficulties with the recording devices and power supply, there were gaps in the data at MW-AR-03 (1st November 2019 to 17th January 2020, 21st January to 24th April 2020) and MW-AR-04 (19th November to 16th December 2019 and 2nd July to 12th August 2020).

The reference diurnal roost (MW-AN-27) was monitoring for 327 nights from the 29th September 2019 to 18th September 2020 (technical difficulties occurring between 23rd May to 19th June 2020).

Table 3.3: Location and deployment dates of SongMeters at monitoring roosts

Roost	Oct 19	Nov 19	Dec 19	Jan 20	Feb 20	Mar 20	Apr 20	May 20	Jun 20	Jul 20	Aug 20	Sep 20
MW-AR-01 Internal			No data			No data						
MW-AR-02 Internal			No data		No data							
MW-AR-03 Entrance		No data										
MW-AR-03 Internal					No data							
MW-AR-04 Entrance		No data										
MW-AR-04 Internal										No data		
MW-AN-27									No data			

Note: The orange box illustrate the period SongMeters were deployed, the white illustrates the period where SongMeters were decommissioned, the grey box illustrates the period during which no data was recorded on account of technical issues.

4 RESULTS

4.1 Microclimate Analysis

4.1.1 MW-AR-01

Temperature

The microclimate logger recorded temperatures ranging from 27.6ºC to 33.6 ºC (5.99 ºC difference) inside the roost (Figure 4.1, Table 4.1) and averaging 30.65 ºC (± 0.03). Temperatures inside the roost remained within the target range (25 to 32 ºC) for 74.59% of the monitoring period. During the monitoring period, temperatures inside MW-AR-01 were relatively stable with minimal daily fluctuation overall. However, there was a gradual increase in temperature from September 2019 to April 2020, before decreasing between May to September 2020. (Figure 4.1). Outside temperatures recorded greater daily fluctuation. However, a similar decrease in temperatures was recorded between May and September 2020 corresponding with the Pilbara winter months.

Table 4.1: Summary of temperature data recorded inside MW-AR-01

Summary Statistics - Temperature	
Mean (± standard deviation)	30.65 ºC (± 0.03)
Minimum	27.61ºC
Maximum	33.60ºC
Difference between Minimum and Maximum	5.99ºC
Number of recordings within target range	2,105 / 2,822
Percentage of recordings within target range	74.59%

Relative Humidity

Relative humidity was variable within MW-AR-01, ranging from 9.79% to 73.57% (63.78% difference) and averaging 34.50% (± 0.25) (Table 4.2, Figure 4.2). The RH recorded at MW-AR-01 was within the target range (25 to 100%) for 72.25% of the monitoring period. Overall, RH was highest between January and March 2020. Although more stable, RH cyclic pattern broadly mirrored cycles in ambient RH. Outside temperatures recorded greater daily fluctuation, however, internal temperatures followed similar trends to those recorded externally.

Table 4.2: Summary of relative humidity data recorded inside MW-AR-01

Summary Statistics – Relative Humidity	
Mean (± standard deviation)	34.50% (± 0.25)
Minimum	9.79%
Maximum	73.57%
Difference between minimum and maximum	63.78%
Number of recordings within target range	2,039 / 2,822
Percentage of recordings within target range	72.25%

Combined Microclimate

Temperature and RH were within the target range (25 to 32 ºC and 25 to 100%) concurrently for 49.36% of the monitoring period.

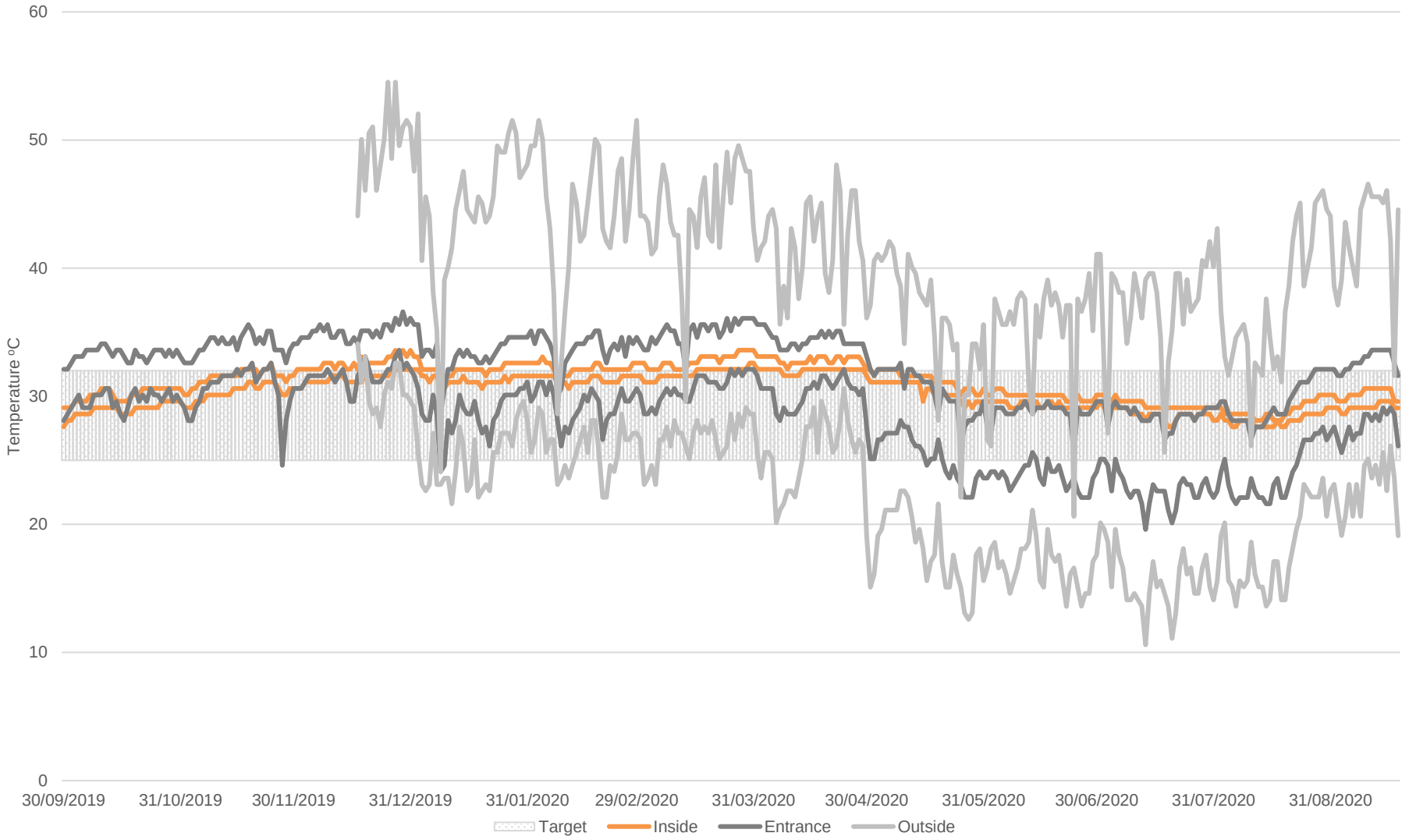


Figure 4.1: Daily temperature range recorded inside MW-AR-01 during the monitoring period

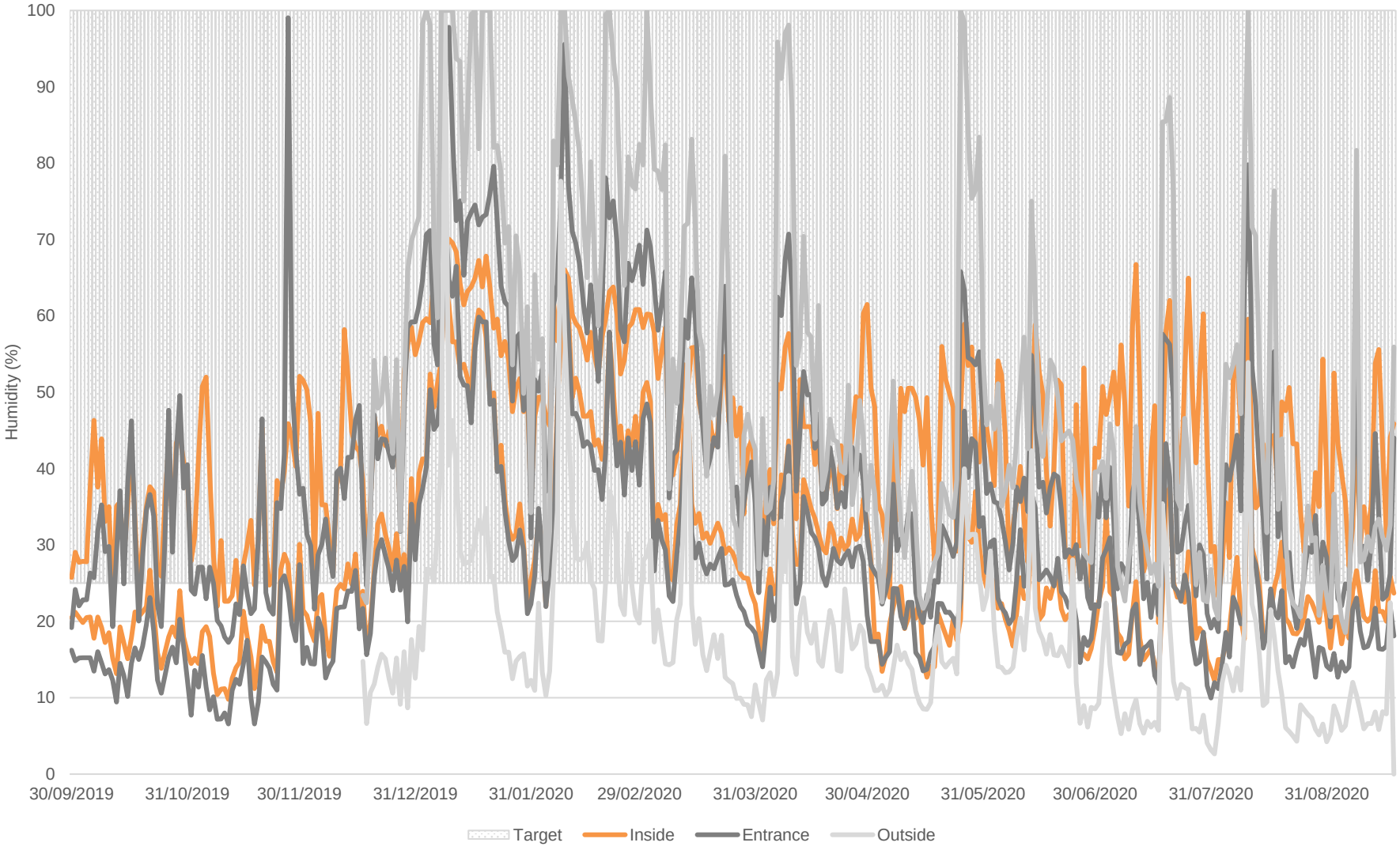


Figure 4.2: Daily relative humidity range recorded inside MW-AR-01 during the monitoring period

4.1.2 MW-AR-02

Temperature

Fluctuations were recorded inside the roost, particularly between May to July 2020, ranging from 25.87ºC to 33.59ºC (7.72ºC difference) and averaging 29.28ºC (± 0.04). Temperature within the roost was inside the target range (25 to 32ºC) for majority of the monitoring period (92.17%) (Figure 4.3, Table 4.3). Temperatures gradually increased over the monitoring period, whereby temperatures exceeded the upper limit inside the roost in November 2019 and December 2019 as well as between March 2020 and April 2020 (insufficient data in January and February 2020) before remaining inside the target range for the rest of the monitoring period (Figure 4.3). Outside temperatures were more variable and fluctuated on a daily basis throughout the monitoring period.

Table 4.3: Summary of temperature data recorded inside MW-AR-02.

Summary Statistics – Temperature	
Mean (± standard deviation)	29.28ºC (± 0.04)
Minimum	25.87ºC
Maximum	33.59ºC
Difference between Minimum and Maximum	7.72ºC
Number of recordings within target range	1,966 / 2,133
Percentage of recordings within target range	92.17%

Relative Humidity

Relative humidity inside the roost was variable, ranging from 7.39% to 62.83% (55.44% difference) and averaging 33.83% (± 0.21). RH was recorded within the target range (25 to 100%) for 78.48% of the monitoring period (Figure 4.4, Table 4.4)There was an increase in RH inside the roost recorded in March and April 2020 in comparison to November and December 2019 (insufficient data in January and February 2020). RH outside was higher and more variable than that recorded inside the artificial roost. Internal RH followed a less exaggerated trend than ambient RH, with sudden decreases in RH appearing concurrently both inside and outside the roost throughout the monitoring period. Towards the end of the monitoring period, internal RH appear to stabilise and did not follow the ambient climate.

Table 4.4: Summary of relative humidity data recorded inside MW-AR-02.

Summary Statistics – Relative Humidity	
Mean (± standard deviation)	33.83% (± 0.21)
Minimum	7.39%
Maximum	62.83%
Difference between minimum and maximum	55.44%
Number of recordings within target range	1,674 / 2,133
Percentage of recordings within target range	78.48%

Combined Microclimate

Temperature and RH were within the target range (25 to 32 ºC and 25 to 100%) concurrently for 74.82% of the monitoring period..

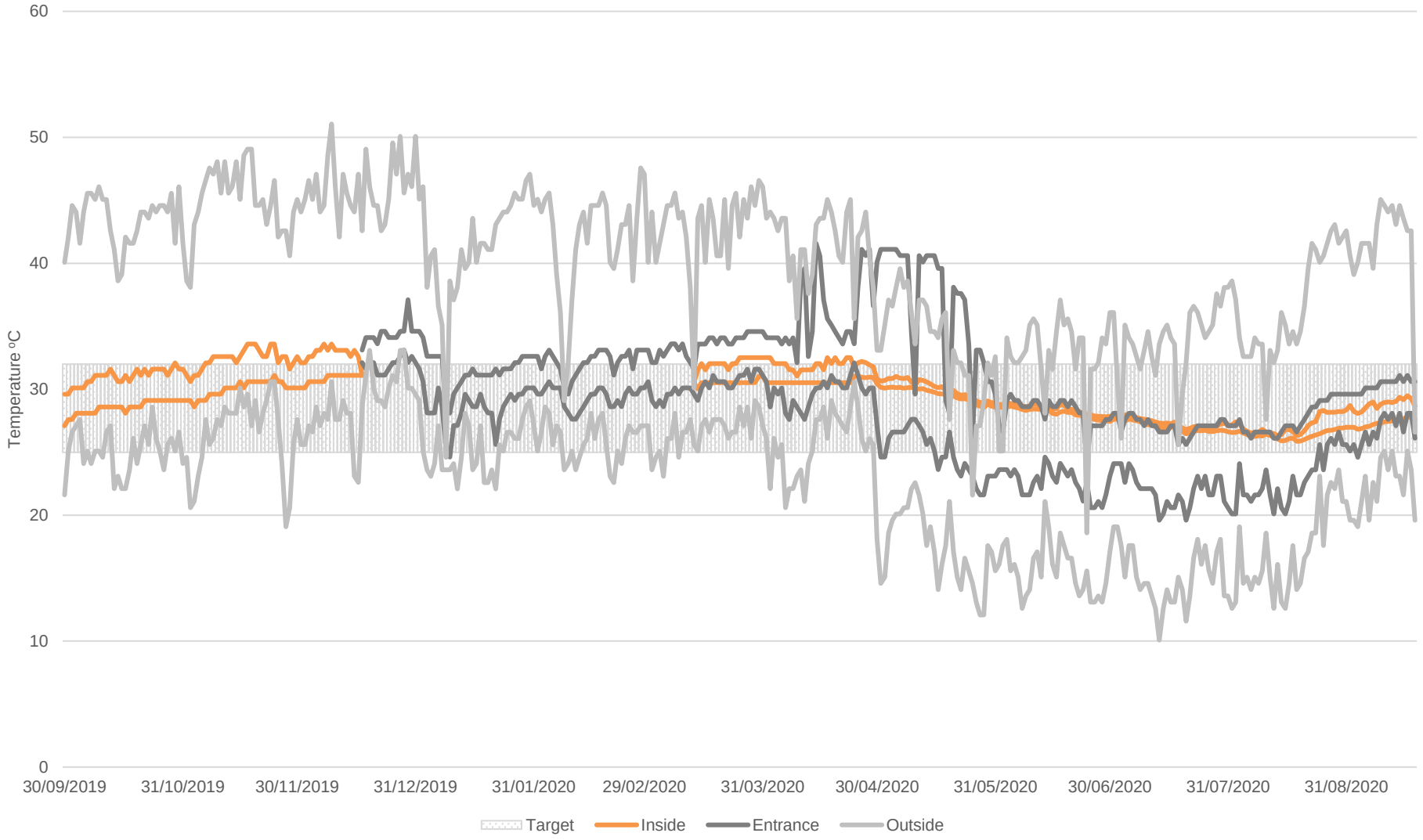


Figure 4.3: Daily temperature range recorded inside MW-AR-02 during the monitoring period

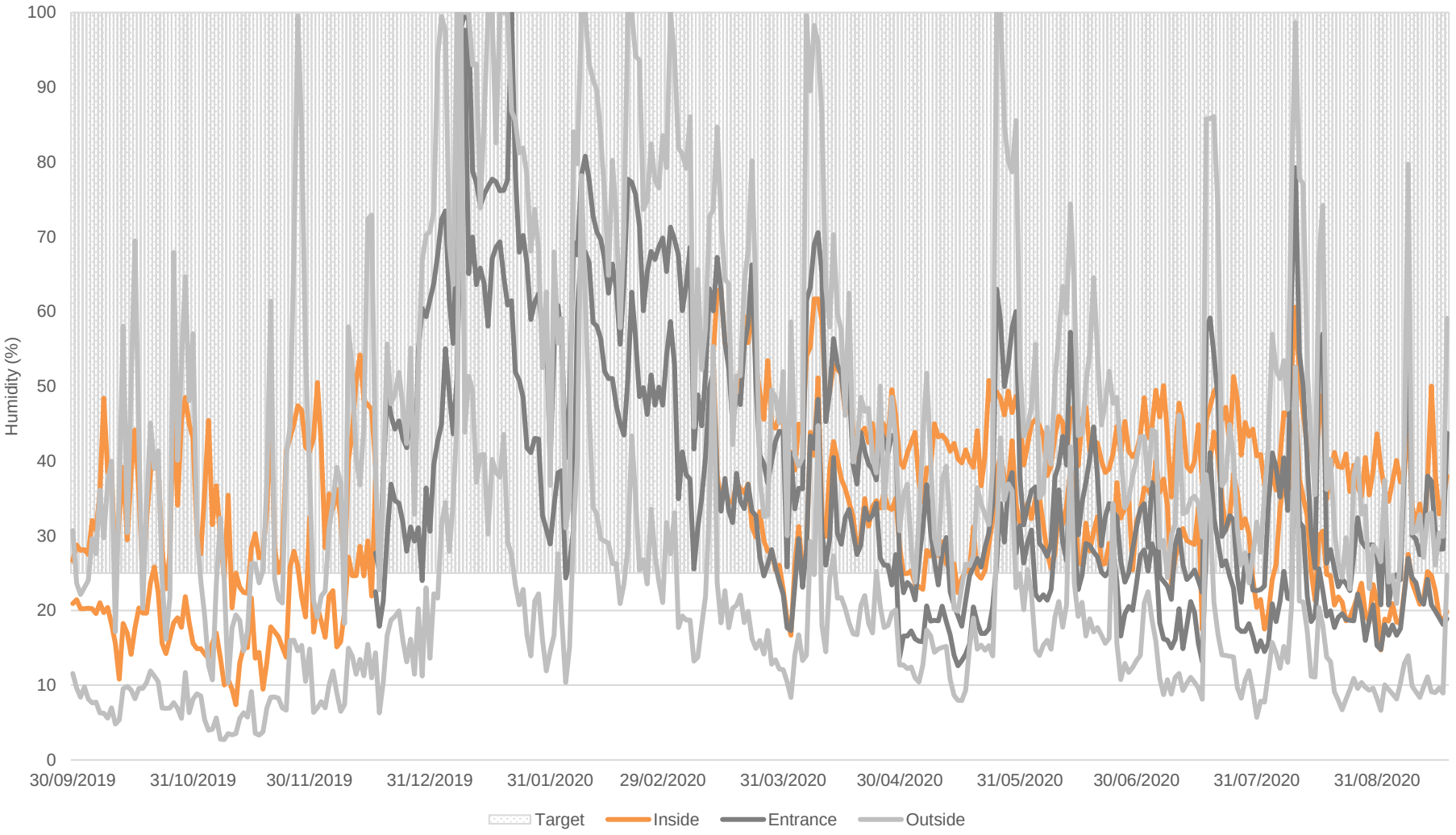


Figure 4.4: Daily relative humidity range recorded inside MW-AR-02 during the monitoring period

4.1.3 MW-AR-03

Temperature

Internal temperatures at MW-AR-03 were fluctuated, ranging between 23.49ºC to 34.09ºC (10.60ºC difference) and averaging 29.16ºC (± 0.05). The temperatures recorded were within the target range (25 to 32ºC) for 70.18% of the monitoring period. However, they increased over the monitoring period until May 2020, with temperature regularly exceeding the target range in between December 2019 and April 2020, the Pilbara's summer period. Maximum temperatures recorded outside the artificial roost were considerably higher than inside between October to early December 2019 (insufficient data from December to April 2020) (Figure 4.5; Table 4.5).

Table 4.5: Summary of temperature data recorded inside MW-AR-03

Summary Statistics - Temperature	
Mean (± standard deviation)	29.16ºC (± 0.05)
Minimum	23.49ºC
Maximum	34.09ºC
Difference between Minimum and Maximum	10.60ºC
Number of recordings within target range	1,984 / 2,827
Percentage of recordings within target range	70.18%

Relative Humidity

The RH inside MW-AR-03 ranged from 8.91% to 74.63% (52.32% difference) and averaged 33.12% (± 0.26). MW-AR-03 recorded RH within the target range (25 to 100%) for approximately 65.72%. RH was below the target range during October to November 2019 increasing to within the target range between December 2019 to April 2020 before decreasing between April to September 2020 (Figure 4.6). While RH within the roost was more stable than outside the roost, internal and external RH followed similar trends (Figure 4.6; Table 4.6).

Table 4.6: Summary of relative humidity data recorded inside MW-AR-03

Summary Statistics – Relative Humidity	
Mean (± standard deviation)	33.12% (± 0.26)
Minimum	8.91%
Maximum	74.63%
Difference between minimum and maximum	65.72%
Number of recordings within target range	1,855 / 2,827
Percentage of recordings within target range	65.61%

Combined Microclimate

Temperature and RH were within the target range (25 to 32 ºC and 25 to 100%) concurrently for 42.34% of the monitoring period.

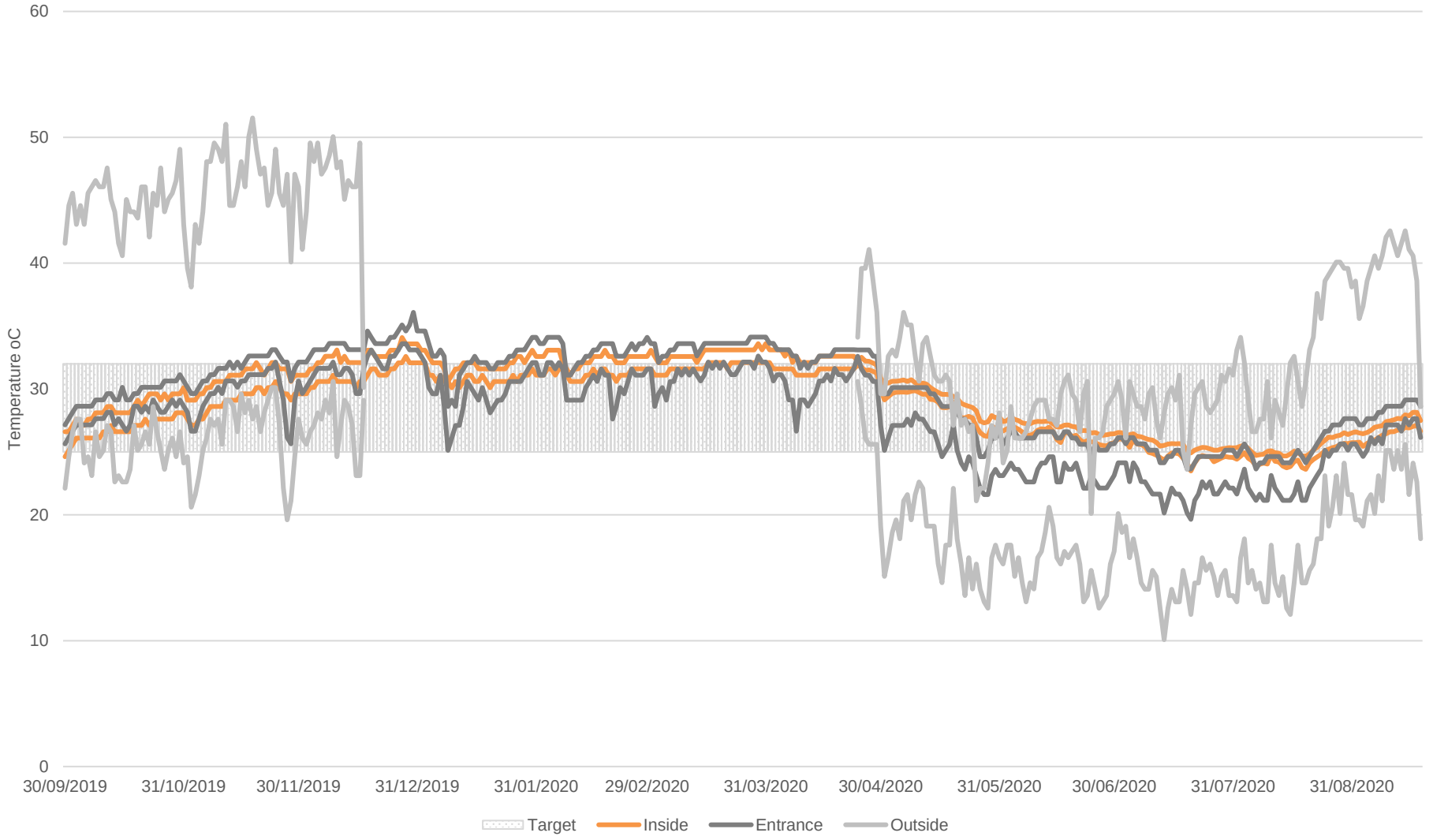


Figure 4.5: Daily temperature range recorded inside MW-AR-03 during the monitoring period

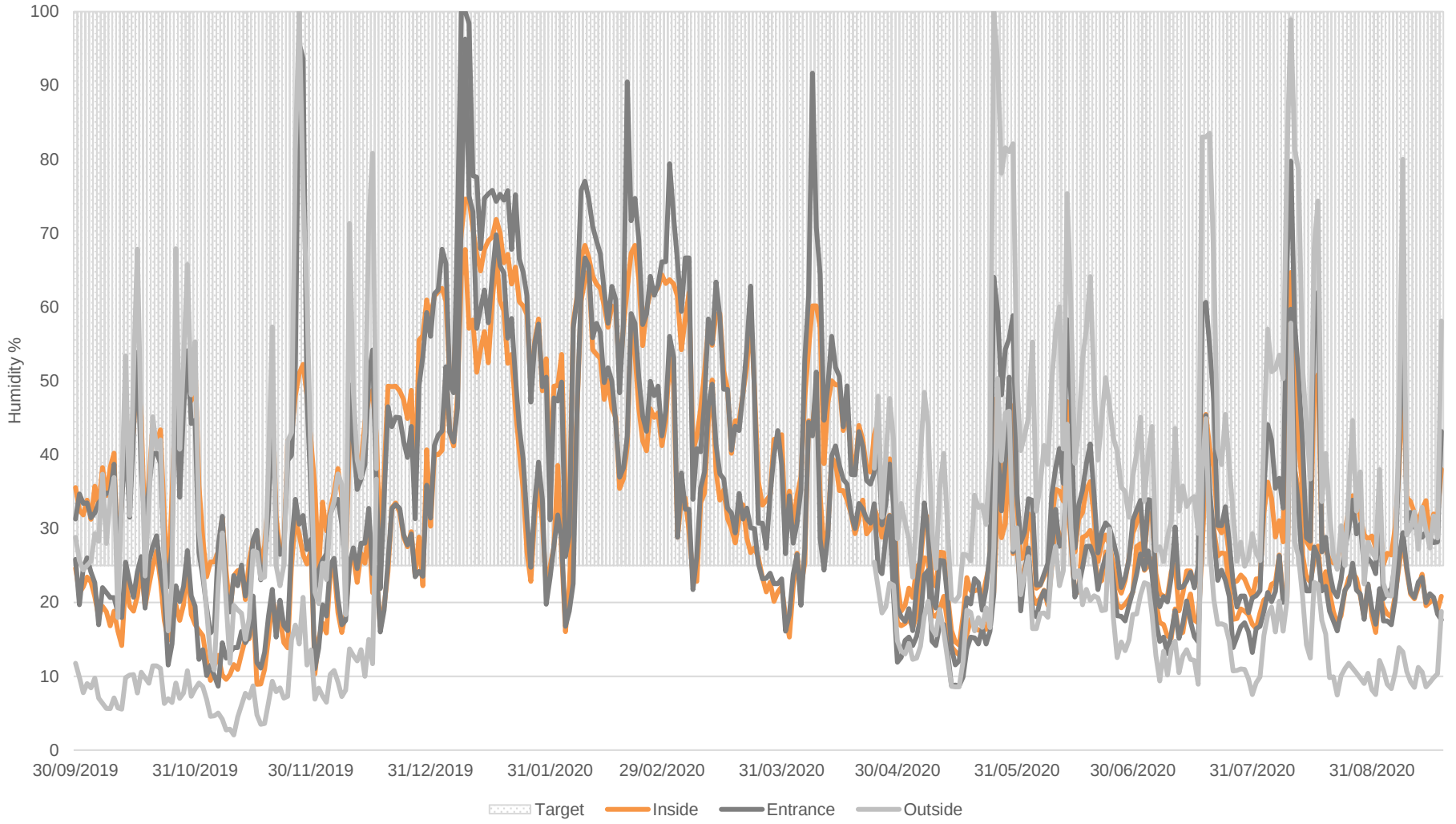


Figure 4.6: Daily relative humidity range recorded inside MW-AR-03 during the monitoring period

4.1.4 MW-AR-04

Temperature

The internal temperature ranged from 23.82ºC to 32.54ºC (8.66ºC difference) and averaged 28.63ºC (± 0.04). Temperatures inside MW-AR-04 were within the target range (25 to 32ºC) for 93.38% of the monitoring period (Table 4.7, Figure 4.7). MW-AR-04 recorded much lower daily fluctuations than experienced outside the roost. Temperatures appear to follow seasonal variations, both internally and externally, with temperatures increasing above 32 ºC over the Summer and Autumn months (December 2019 to April 2020) before decreasing to slightly below the target range during Winter (June to August 2020) (Figure 4.7).

Table 4.7: Summary of temperature data recorded inside MW-AR-04

Summary Statistics - Temperature	
Mean (± standard deviation)	28.63ºC (± 0.04)
Minimum	23.82ºC
Maximum	32.54ºC
Difference between Minimum and Maximum	8.72ºC
Number of recordings within target range	2,638 / 2,825
Percentage of recordings within target range	93.38%

Relative Humidity

The RH recorded within the roost was highly variable, ranging from 11.09% to 100% (88.91%) and averaging 41.90% (± 0.39). During the monitoring period, the RH inside MW-AR-04 was within the target range (25 to 100%) for 73.35% (Figure 4.8, Table 4.8). Internally, RH was considerably higher in December 2019 to March 2020, reaching 100% RH on multiple occasions. Internal RH mirrored external levels and coincided with the increased rainfall experienced during the wet season (December to April) - RH decreased from May 2020 until to end of the monitoring period (September 2020) when rainfall decreased.

Table 4.8: Summary of relative humidity data recorded inside MW-AR-04

Summary Statistics – Relative Humidity	
Mean (± standard deviation)	41.90% (± 0.39)
Minimum	11.09%
Maximum	100%
Difference between minimum and maximum	88.91%
Number of recordings within target range	2,072 / 2,25
Percentage of recordings within target range	73.35%

Combined Microclimate

Temperature and RH were within the target range (25 to 32 ºC and 25 to 100%) concurrently for 52.24% of the monitoring period.

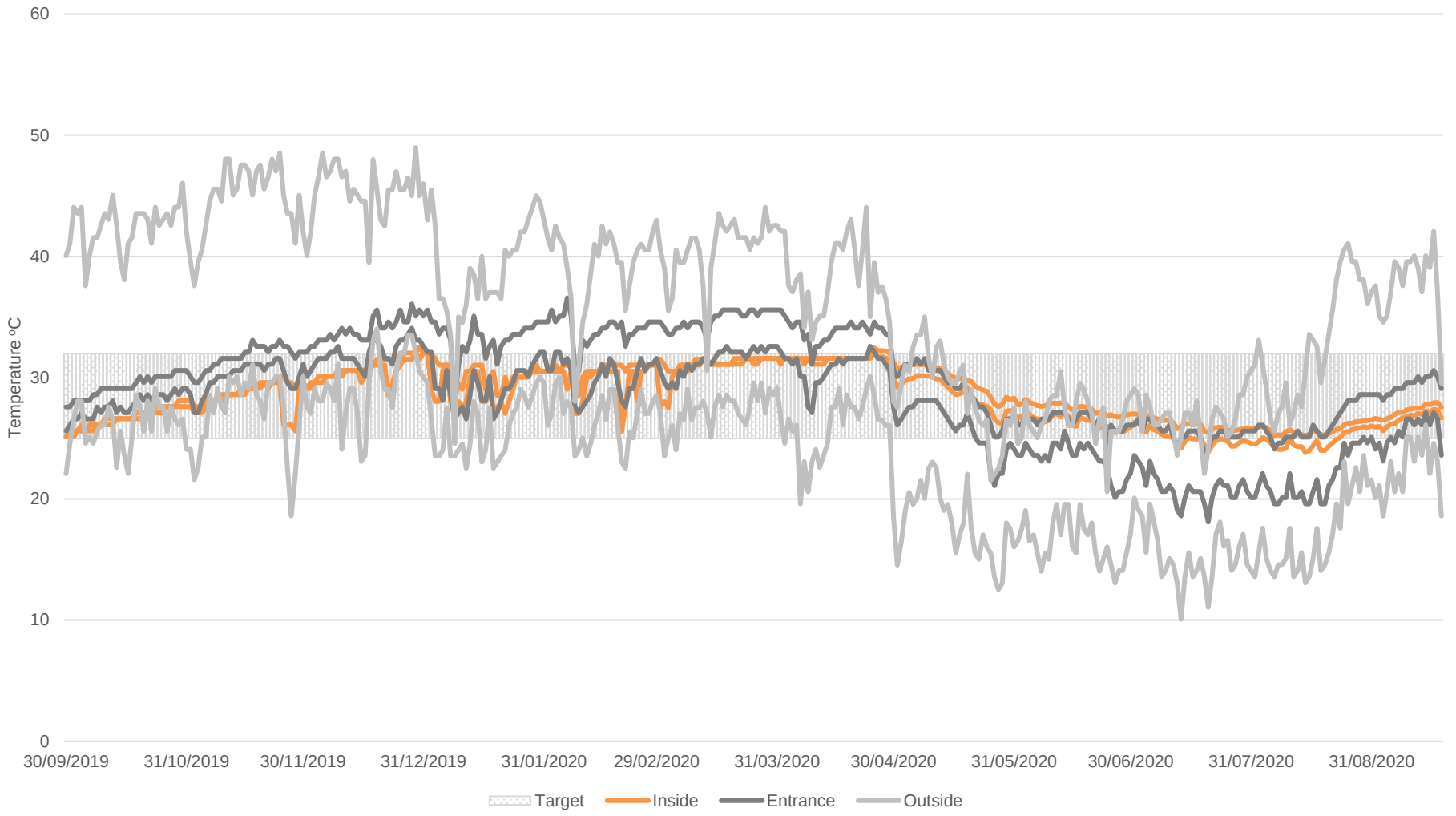


Figure 4.7: Daily temperature range recorded inside MW-AR-04 during the monitoring period

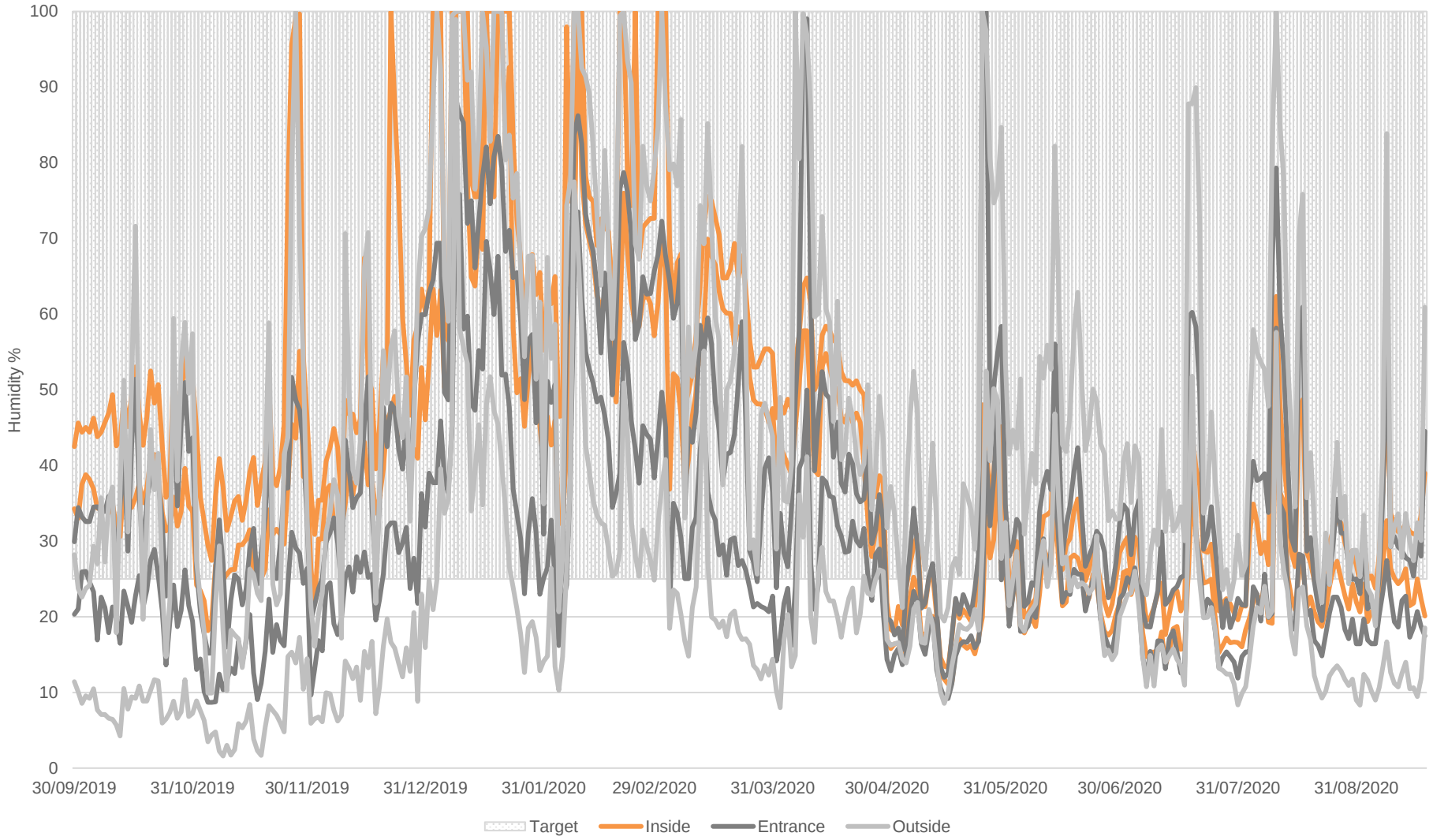


Figure 4.8: Daily relative humidity range recorded inside MW-AR-04 during the monitoring period

4.1.5 MW-AN-27

Temperature

Temperature inside MW-AN-27 was variable, ranging from 29.03ºC to 34.53ºC (5.50ºC difference) and averaging 31.53ºC (± 0.02). MW-AN-27 was within the target range for a diurnal roost (28ºC to 32ºC) for 57.19% of the monitoring period (Figure 4.9, Table 4.9). Temperatures were above the target range of 32ºC between November 2019 to January 2020 and mid-March to May 2020. Temperatures then stabilised within the roost and remained within the temperature range from May 2020 until the end of the monitoring period.

Table 4.9: Summary of temperature data recorded inside MW-AN-27

Summary Statistics – Temperature	
Mean (± standard deviation)	31.53ºC (± 0.02)
Minimum	29.03ºC
Maximum	34.53ºC
Difference between Minimum and Maximum	5.50ºC
Number of recordings within target range	1,615 / 2,824
Percentage of recordings within target range	57.19%

Relative Humidity

RH fluctuated significantly, ranging from 6.00% to 100% (94% difference) and averaging 41.66% (± 0.34). RH inside MW-AN-27 was within the target range for 1.81% of the monitoring period (Figure 4.10, Table 4.10). The RH was consistently below the target range (25 to 100%) from September 2019 to September 2020. Levels increased for a period between December 2019 to January 2020, reaching the target range between 8th January and 21st January 2020. This increase coincided with a cyclone event in the area (Cyclone Blake).

Table 4.10: Summary of relative humidity data recorded inside MW-AN-27

Summary Statistics – Relative Humidity	
Mean (± standard deviation)	41.66% (± 0.34)
Minimum	6%
Maximum	100%
Difference between minimum and maximum	94%
Number of recordings within target range	51 / 2,824
Percentage of recordings within target range	1.81%

Combined Microclimate

Temperature and RH were within the target range (25 to 32 ºC and 25 to 100%) concurrently for 0.42% of the monitoring period.

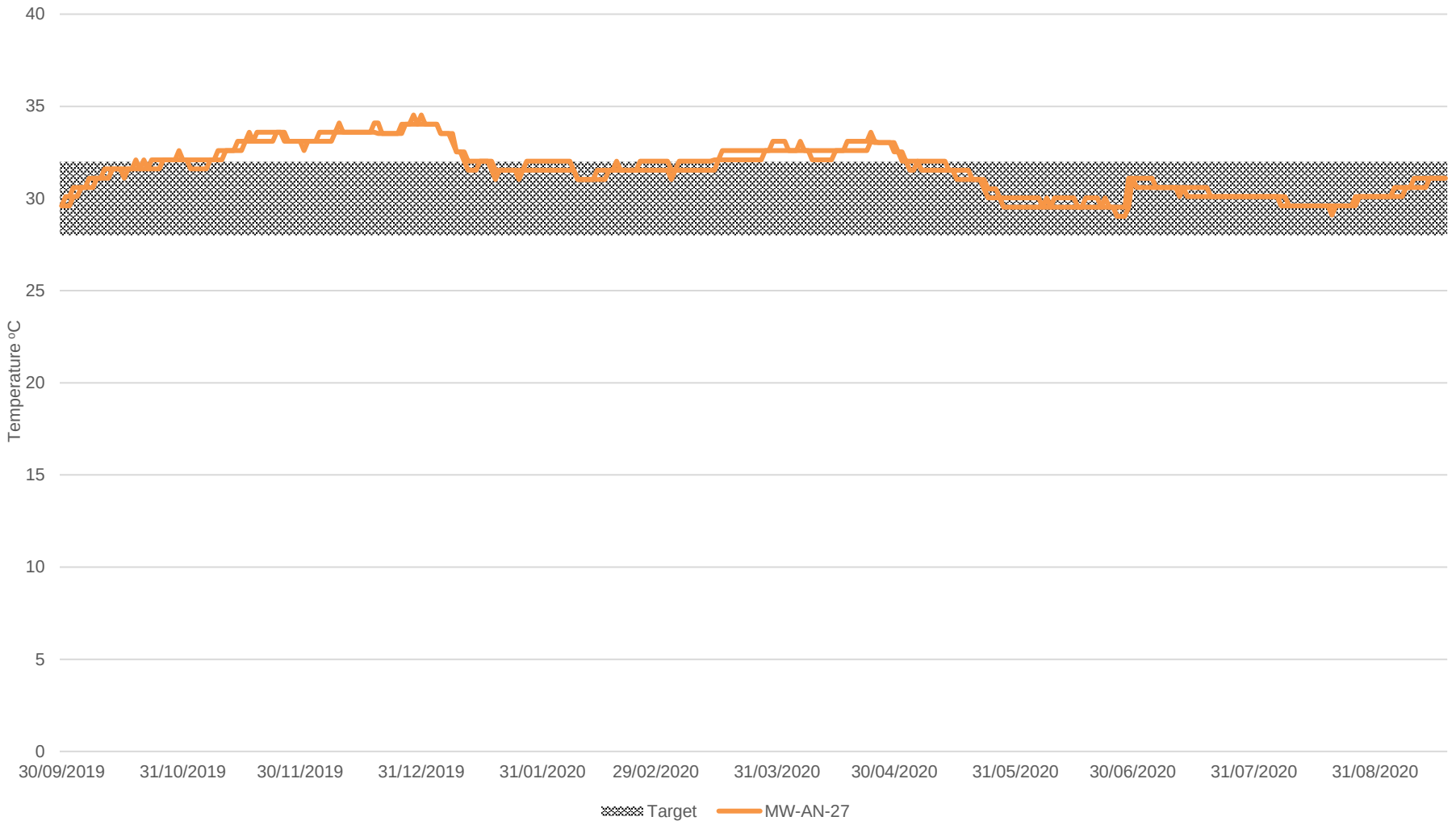


Figure 4.9: Daily temperature range recorded inside MW-AN-27 during the monitoring period

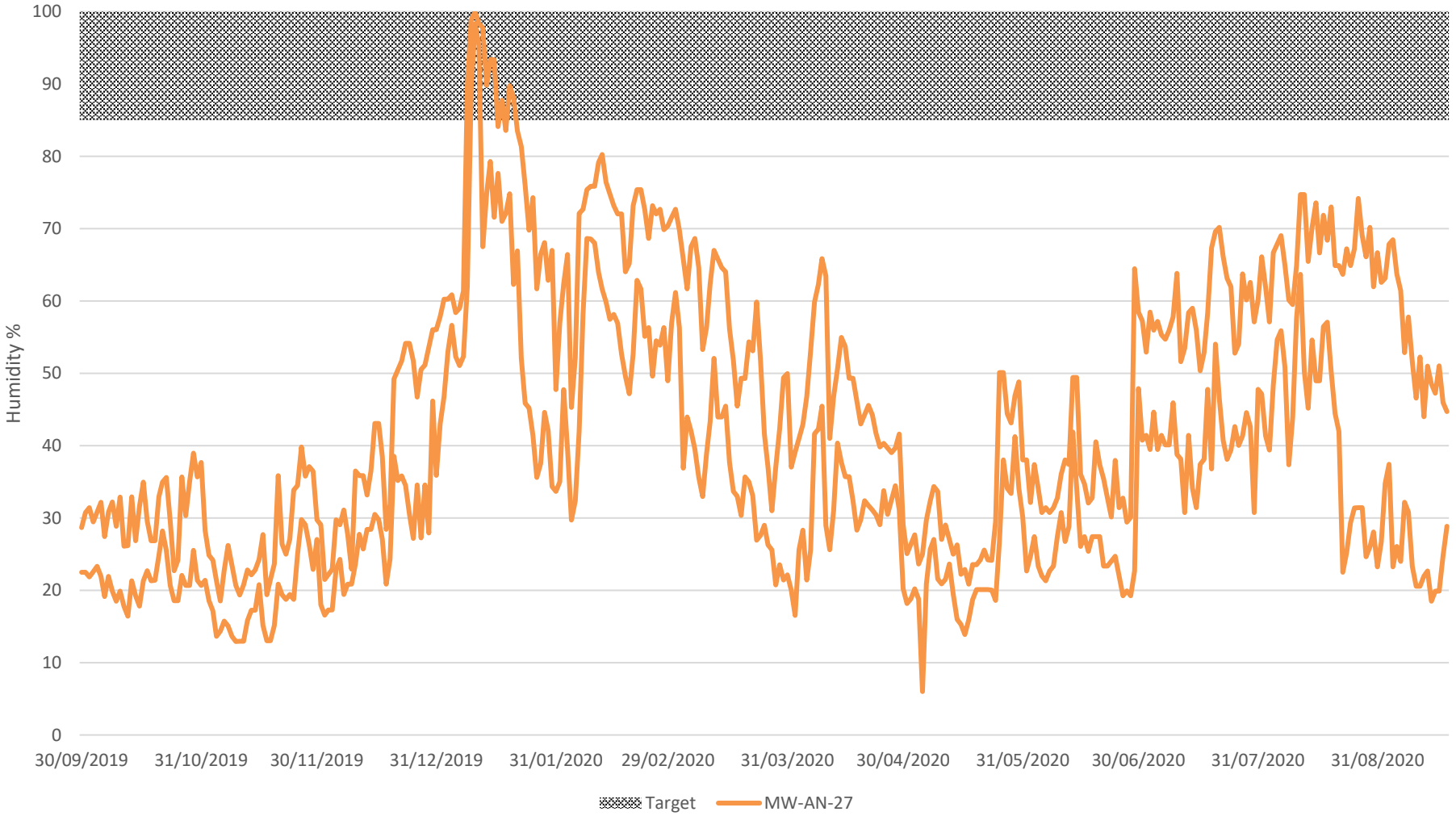


Figure 4.10: Daily relative humidity range recorded inside MW-AN-27 during the monitoring period

4.1.6 MW-AN-17 and MW-AN-25

Temperature

The nocturnal refuges, particularly MW-AN-25, recorded minimal fluctuations in temperature (Figure 4.11; Table 4.11). The temperatures at MW-AN-17 and MW-AN-25 ranged from 25.61ºC to 34.10ºC (8.49ºC difference) and 30.59ºC to 35.10ºC (4.51ºC difference), respectively. The nocturnal refuges averaged 29.66ºC (± 0.05) at MW-AN-17 and 32.82ºC (± 0.01) at MW-AN-25 Initially, both roosts were within the temperature range (25ºC to 32ºC) before increasing in September 2019 (Figure 4.11). MW-AN-25 remained above the target range until mid-August before decreasing to within the target range for the remainder of the monitoring period (Figure 4.11). MW-AN-17 was slightly above the target range of a nocturnal refugee (25ºC to 32ºC) during the summer months (December 2019 and March 2020 – missing data during January to February). However, temperatures decreased slightly to within the temperature range in April 2020 (Figure 4.11).

Table 4.11: Summary of temperature data recorded inside MW-AN-17 and MW-AN-25

Summary Statistics - Temperature		
Roost	**MW-AN-17**	**MW-AN-25**
Mean (± standard deviation)	29.66ºC (± 0.05)	32.82ºC (± 0.01)
Minimum	25.61ºC	30.59ºC
Maximum	34.10ºC	35.10ºC
Difference between Minimum and Maximum	8.49ºC	4.51ºC
Number of recordings within target range	1,544 / 2,132	407 / 2,841
Percentage of recordings within target range	72.42%	14.33%

Relative Humidity

During the monitoring period, the RH ranged from 7.74% to 52.57% at MW-AN-17 and 5.87% to 95.32% at MW-AN-25 (Table 4.12, Figure 4.12). The RH at MW-AN-17 and MW-AN-25 averaged 27.80% (± 0.17) and 51.21% (± 0.47), respectively. RH at MW-AN 17 and MW-AN-25 was within the RH range (25 to 60%) of a nocturnal refuge for 64.68% and 45.34%, respectively (Table 4.12, Figure 4.12). The RH in both roosts followed a similar cyclical pattern until April 2020; RH was below the target range from September to December 2019 before remaining within the target range for the majority of January to April 2020 (Figure 4.12). At the end of April 2020, MW-AN-25 recorded a dramatic increase in RH and continued to rise until September 2020 before decreasing (Figure 4.12).

Table 4.12: Summary of relative humidity data recorded inside MW-AN-17 and MW-AN-25

Summary Statistics – Relative Humidity		
Roost	**MW-AN-17**	**MW-AN-25**
Mean (± standard deviation)	27.80% (± 0.17)	51.21% (± 0.47)
Minimum	7.74%	5.87%
Maximum	52.57%	95.32%
Difference between minimum and maximum	44.83%	89.45%
Number of recordings within target range	977 / 2132	1,248 / 2,841
Percentage of recordings within target range	64.68%	45.34%

Combined Microclimate

Temperature and RH were within the target range (25 to 32 ^{o}C and 25 to 100%) at MW-AN-17 and MW-AN-25 concurrently for 48.08% and 6.43% of the monitoring period.

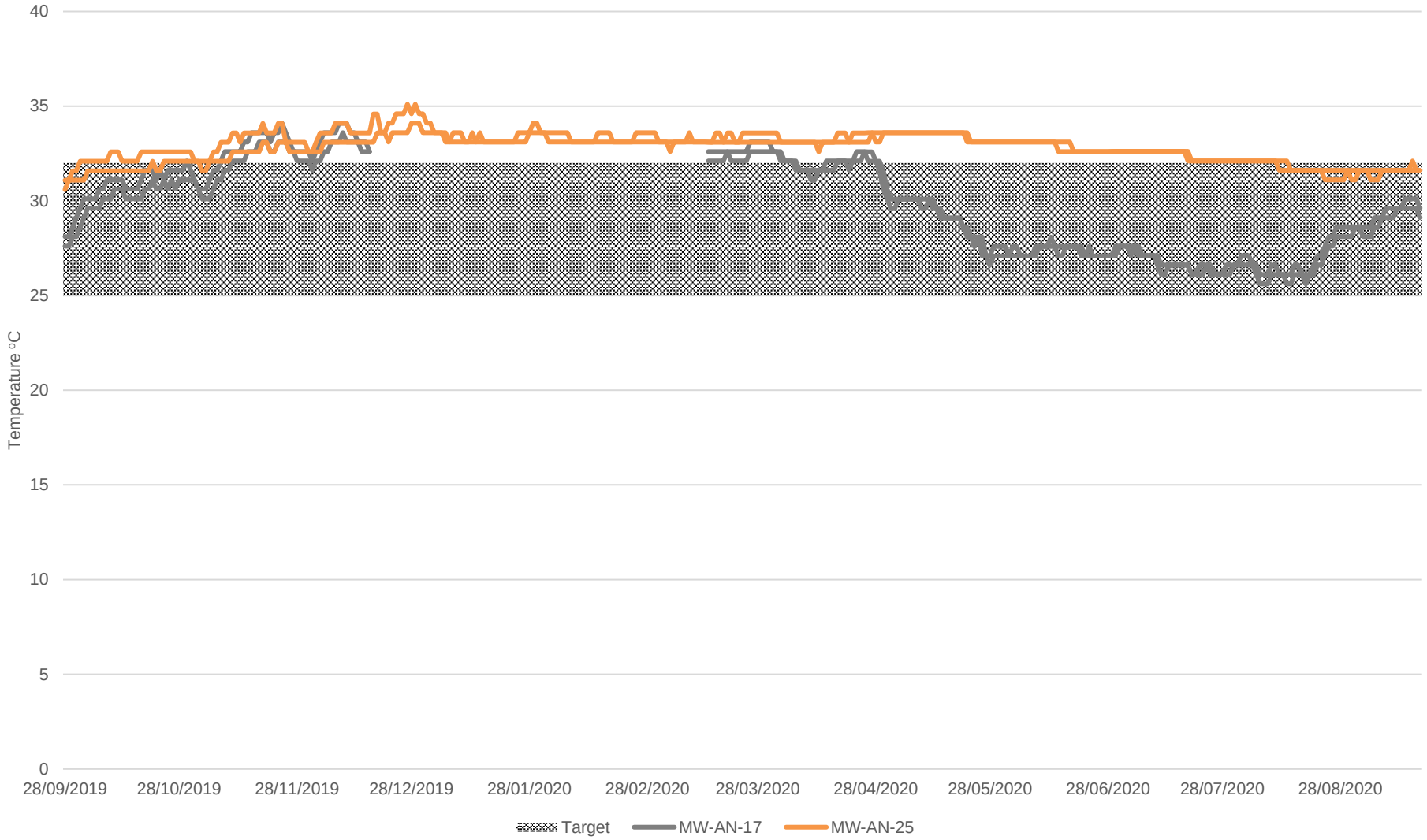


Figure 4.11: Daily temperature range recorded inside MW-AN-17 and MW-AN-25 during the monitoring period

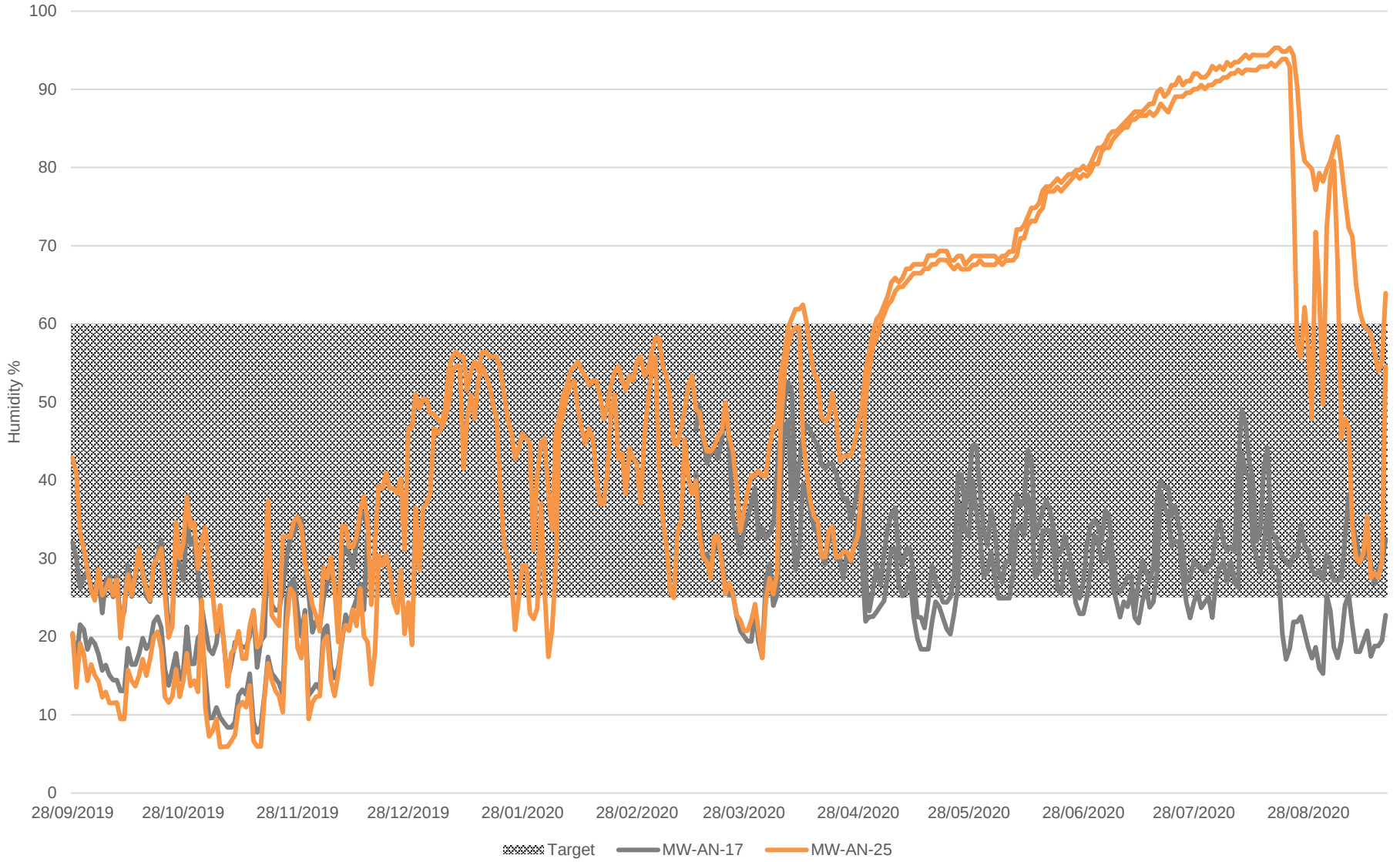


Figure 4.12: Daily relative humidity range recorded inside MW-AN-17 and MW-AN-25 during the monitoring period

4.2 Ultrasonic Analysis

4.2.1 MW-AR-01

No Pilbara leaf-nosed bats were detected inside the main roosting chamber during the current monitoring period. Since the ultrasonic recorder was relocated inside the monitoring tube of the roost (11th May 2019), no calls from the Pilbara leaf-nosed bat have been recorded. Common bat species were detected sporadically on three nights in January 2020.

No ghost bats were detected during the current monitoring period (no data was recorded in December 2019 and March to April 2020).

4.2.2 MW-AR-02

No Pilbara leaf-nosed bats were detected inside the main roosting chamber during the current monitoring period. Since the ultrasonic recorder was relocated inside the monitoring tube of the roost (11th May 2019), no calls from the Pilbara leaf-nosed bat have been recorded. A single *Taphozous* species was detected inside the artificial roost on one occasion in November 2019 and on one occasion in January 2020 (no data was recorded in December 2019 and February to April 2020).

4.2.3 MW-AR-03

Pilbara leaf-nosed bat were detected at the entrance of the artificial roost during the current monitoring period. The species was detected at the entrance to the roost on 21 of the 33 recording nights (63.63%) (October 2019). In each instance, the calls were detected more than 30 minutes after civil dusk and/or over an hour prior to civil dawn, suggesting the individual/s were in flight, potentially foraging, but had originated from an alternate roosting location (most likely MW-AN-27). As there were no paired calls (calls close to dusk and dawn), roosting was not indicated during the monitoring period. Detections were consistently low throughout the monitoring period ranging from one to thirteen calls (on the 9th October 2019) per night (Figure 4.13).

No bats, including the Pilbara leaf-nosed bat were detected inside the artificial roost during the current monitoring period (due to data loss monitoring occurred from May to September 2020).

4.2.4 MW-AR-04

The Pilbara leaf-nosed bat was detected at the roost entrance on 12 of the 83 recording nights (14.45%). In each instance, the first and last Pilbara leaf-nosed bat calls were detected over an hour after civil dusk and an hour prior to civil dawn, respectively. Furthermore, there were no paired calls (calls close to dusk and dawn) suggesting that the species did not roost at the artificial roost. The timing of the calls suggests that the individuals were in flight, potentially foraging, but had originated from an alternate roosting location (most likely MW-AN-27). The number of calls recorded were consistently low throughout the monitoring period (October 2019 and January 2020), ranging from one to two calls per night, with the highest number of calls occurring on the 12th, 16th and 18th of October 2019 (Figure 4.14).

No Pilbara leaf-nosed bats were detected inside the artificial roost during the monitoring period (January to September 2020). Other bat species () were detected inside the roost on 13 of the 99 recording nights (13.13%).

4.2.5 MW-AN-27

The Pilbara Leaf-nosed bat was detected on all recording nights (100% of 327 nights). The calls regularly occurred before civil dusk and after civil dawn, indicating diurnal roosting throughout the monitoring period at MW-AN-27. The reference diurnal roost (MW-AN-27) had significantly higher call counts than those recorded at the artificial roosts (MW-AR-01, MW-AR-02, MW-AR-03 and MW-AR-04). The number of calls recorded per night over the monitoring period ranged from 580 (on 17th January 2020) to 28,268 (on the 18th May 2020) The number of calls recorded was relatively low between September 2019 and the end of March 2020 averaging 3,201 calls per night. In comparison, in April and May 2020 the number of calls recorded increased significantly, averaging 18,823 calls per night (Figure 4.13). A peak in calls (17,475 calls) was recorded on the 8th January 2020, coinciding with a cyclone in the area (Cyclone Blake).

Ghost bat calls were recorded sporadically during the monitoring period, however, due to high background noise levels across the range of frequencies that ghost bats use calls could not be consistently isolated.

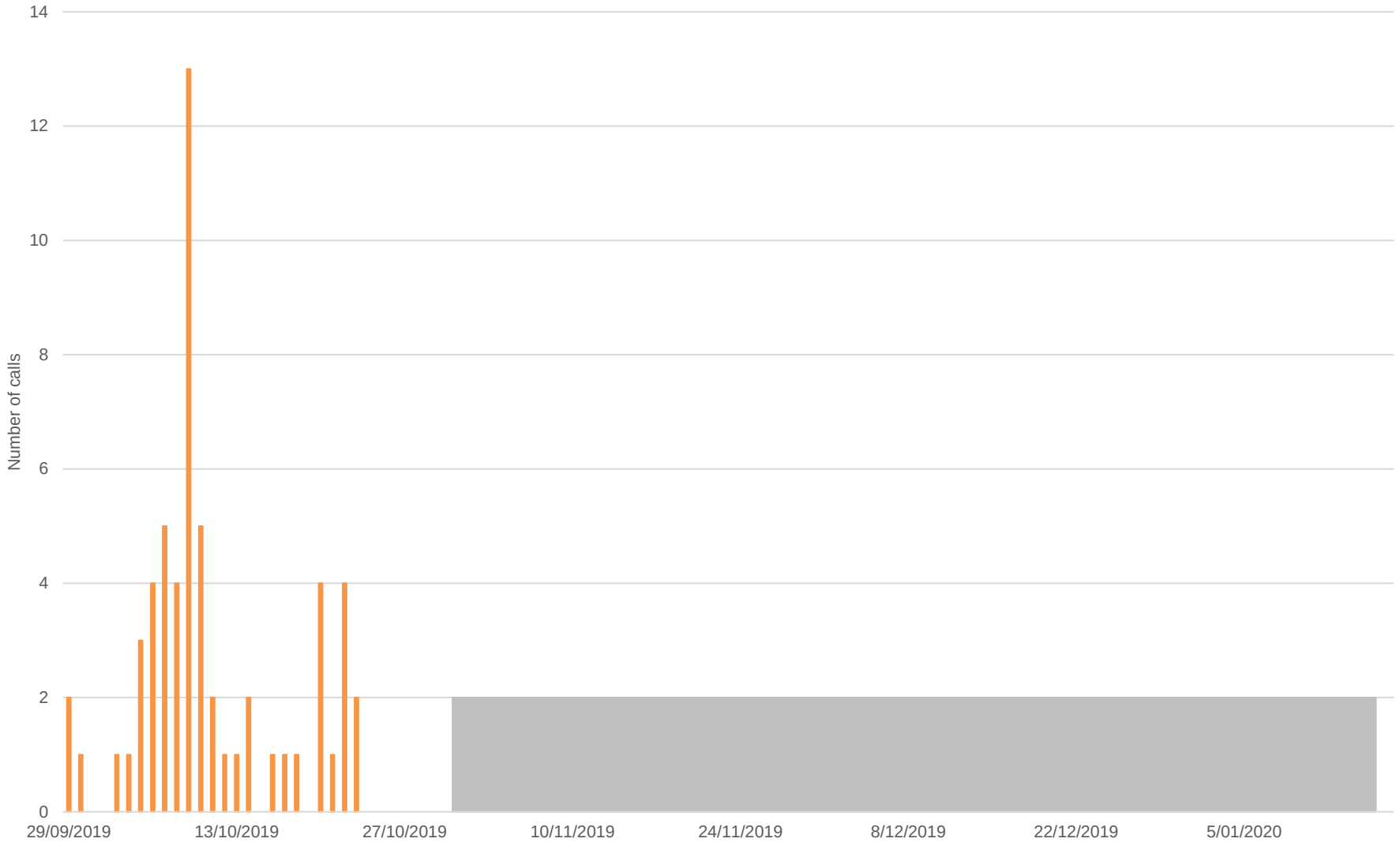


Figure 4.13: Number of Pilbara leaf-nosed bat calls per day at the entrance of MW-AR-03 during the monitoring period

The grey box illustrates the period during which no data was recorded on account of technical issues

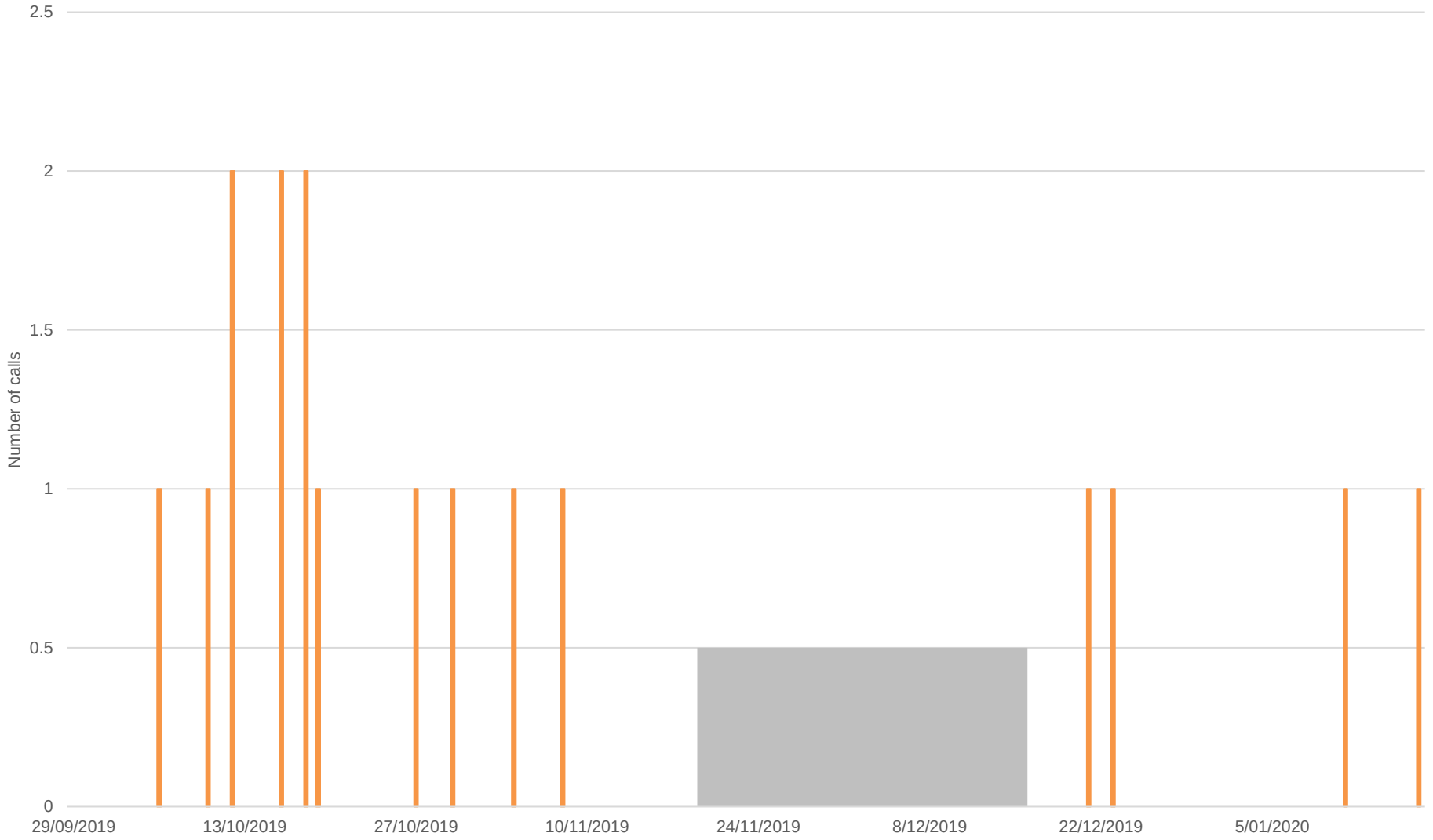


Figure 4.14: Number of Pilbara leaf-nosed bat calls per day at the entrance of MW-AR-04 during the monitoring period

The grey box illustrates the period during which no data was recorded on account of technical issues

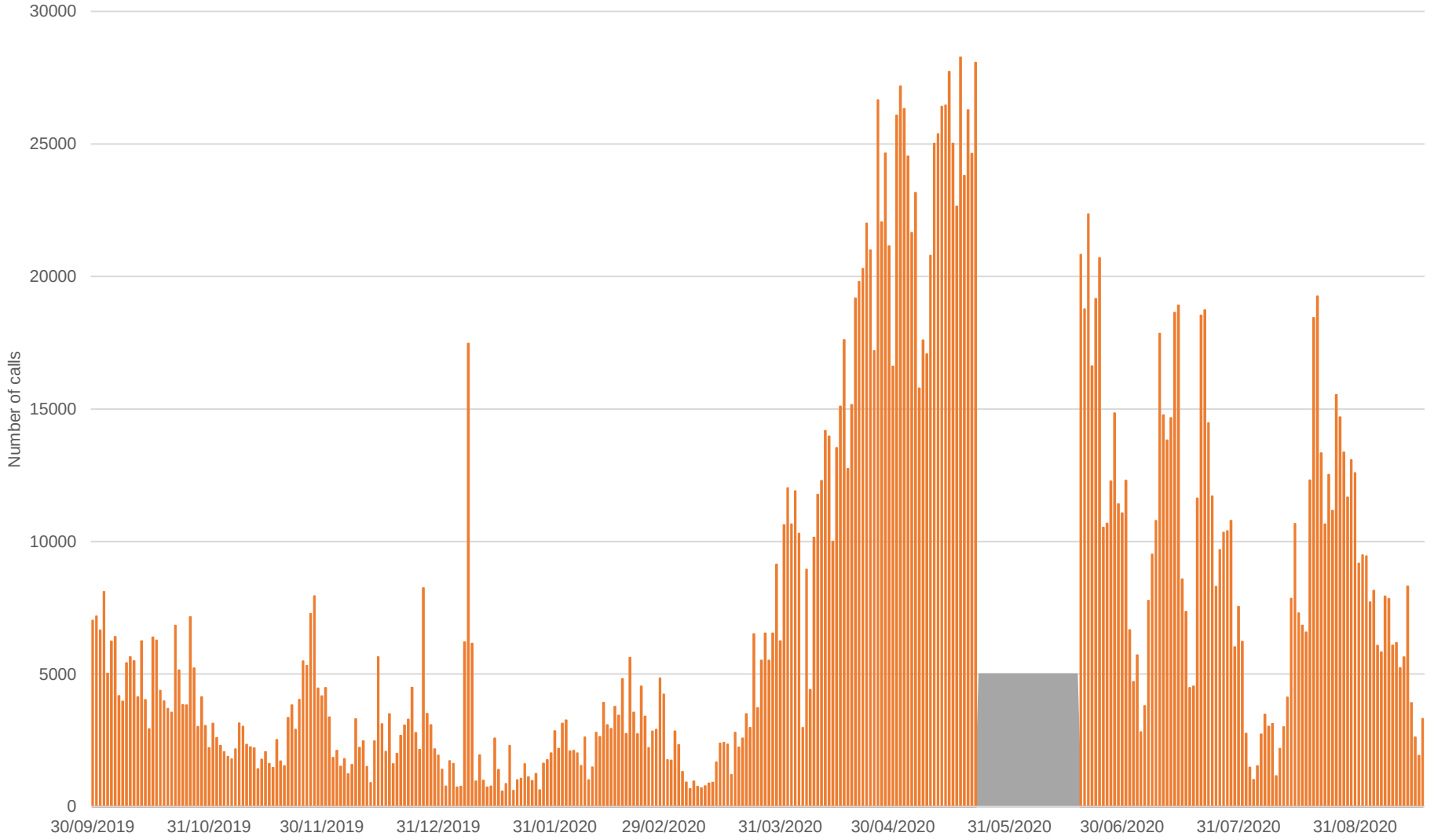


Figure 4.15: Number of Pilbara leaf-nosed bat calls per day at the entrance of MW-AN-27 during the monitoring period

The grey box illustrates the period during which no data was recorded on account of technical issues

5 DISCUSSION

5.1 Artificial Roost Microclimate

Pilbara leaf-nosed bats typically roost in undisturbed caves, deep fissures or abandoned mine shafts (Armstrong, 2000, 2001). The species' limited ability to conserve heat and water (Baudinette *et al.*, 2000) means they require warm (28-32 ºC) and very humid (85-100 %) roost sites to persist in arid and semi-arid climates (Armstrong, 2001; Churchill, 1991). Temperature and RH are recognised to be important factors influencing visitation and colonisation of roosts by Pilbara leaf-nosed bats. Temperature and RH are measured and managed within the artificial roosts in order to replicate and maintain the conditions inside a naturally occurring nocturnal refuge.

5.1.1 Temperature

MW-AN-27 was within the temperature range (28-32ºC) of a diurnal roost for only 57.19% of the monitoring period and uncharacteristic of permanent diurnal roosts previously studied (Armstrong, 2001). Anecdotal evidence suggests that an additional chamber exists (bats have been seen flying further into the roost, likely into an additional chamber where microclimate conditions are more optimal) that is yet to be monitored due to access difficulty. As the chamber has limited access and could cause significant disturbance to the Pilbara leaf-nosed bats when entering, long-term monitoring options are advisable (i.e., wired remote access microclimate loggers). Together this data, coupled with anecdotal evidence, demonstrates that the main roosting chamber used by the colony is not currently being accessed and sampled, and thus not reflective of the conditions sought by the species. For this reason, the temperature of MW-AN-27 is no longer discussed within this report.

The temperatures recorded inside the four artificial roosts remained more stable than those recorded at the entrance or outside the roosts. Data loggers deployed at MW-AR-01, MW-AR-02, MW-AR-03 and MW-AR-04 indicate that temperatures inside the roosts were within the target range (25 to 32ºC) for most of the monitoring period; 74.59%, 92.17%, 70.18% and 93.38%, respectively. The temperature averaged 30.65ºC (± 0.03) at MW-AR-01, 29.28ºC (± 0.04) at MW-AR-02, 29.16ºC (± 0.05) at MW-AR-03 and 28.63ºC (± 0.04) at MW-AR-04. Overall, the artificial roosts recorded minimal variations in temperature compared to outside (difference between minimum and maximum of 5.99ºC at MW-AR-01, 7.72ºC at MW-AR-02, 10.60ºC at MW-AR-03 and 8.72ºC at MW-AR-04). Notably, the temperature fluctuations inside MW-AR-01 and MW-AR-02 were lower than MW-AR-03 and MW-AR-04. Internally, the artificial roosts recorded a gradual increase in temperature over the summer months before decreasing in winter, however, they appeared to be minimally impacted by daily external temperature fluctuations. The temperatures recorded inside the reference nocturnal refuges were within the target range (25 to 32ºC) for 82.42% at MW-AN-17 and 14.33% at MW-AN-25 of the monitoring period. The temperature at MW-AN-17 and MW-AN-25 averaged 29.66ºC (± 0.05) and 32.82ºC (± 0.01) respectively. Both roosts recorded stable temperatures throughout the monitoring period, increasing above the typical limits of a nocturnal refuge during the summer months (34.1ºC at MW-AN-17 and 35.1ºC at MW-AN-25). Although there was little variability in temperatures experience during the monitoring period (October 2019 to October 2020).

The artificial roosts all exhibited a greater range and degree of variability in temperature than the reference nocturnal refuges. The temperatures exhibited in the caves followed similar patterns, suggesting that the factor/s influencing temperature are likely the same i.e. seasonal changes in temperature. Importantly, the monitoring from this survey demonstrated that even the temperatures of the natural nocturnal refuges fluctuate outside the 'target range'. While no ultrasonic sampling was undertaken to verify the species presence during these out-of-range periods, it demonstrates that even natural nocturnal refuges are not completely bound by the range recommended by Bat Call (2018).

Artificial roosts MW-AR-02, MW-AR-03 and MW-AR-04 all recorded temperatures within the target range for an increased portion of the monitoring period, compared to the previous monitoring period (difference of 6.77°C at MW-AR-02, 60.82°C at MW-AR-03, and 86.64°C at MW-AR-04) (Biologic, 2020b). However, the percentage of recordings within the target range at MW-AR-01 decreased from 88.4% during the previous monitoring survey (Biologic, 2020b) to 74.59% during the current monitoring survey. This reduction in the 'target range' was also noted at the reference sites, MW-AN-17 and MW-AN-25 (difference of 17.22°C at MW-AN-17 and 85.3°C at MW-AN-25) suggesting that the decrease may have been influenced by seasonal variation between monitoring periods.

5.1.2 Relative Humidity

Bats, and particularly bats of small body size, experience a disadvantage in temperature regulation and evaporative water loss on account of greater surface area and vascularisation of flight membranes (Baudinette *et al.*, 2000). The rate of evaporative water loss in the Pilbara leaf-nosed bat is double that of other bat species meaning that humid microclimates are preferred to help reduce the consequence of dehydration (Baudinette *et al.*, 2000). Furthermore, the species is dependent on warm and humid roosting sites, especially during the dry Pilbara winter months (Baudinette *et al.*, 2000). Typically the species' is confined to very humid caves which range annually between 85 and 100% RH (Armstrong, 2001; Churchill, 1991), which are usually host to large colonies of several hundred individuals year-round. MW-AN-27 is recognised as such a cave. Relative humidity within MW-AN-27 was within the target range of a diurnal roost for 1.81% of the monitoring period, again confirming that sampling to date has not been within the roosting chamber. For this reason, the RH of MW-AN-27 is no longer discussed within this report.

The artificial roosts followed similar cyclical patterns as those experienced outside the roost. The roosts recorded considerable variations in RH (difference between minimum and maximum of 63.78% at MW-AR-01, 55.44% at MW-AR-02, 65.72% at MW-AR-03 and 88.91% at MW-AR-04) whereby MW-AR-04 recorded the highest degree of variability compared to the other artificial roosts. The RH averaged 34.50% (± 0.25) at MW-AR-01, 33.83% (± 0.21) at MW-AR-02, 33.12% (± 0.26) at MW-AR-03 and 41.90% (± 0.39) at MW-AR-04. The RH levels recorded inside the artificial roosts were within the target range (25-100%) for most of the monitoring period (72.25% at MW-AR-01, 78.48% at MW-AR-02, 65.61% at MW-AR-03 and 73.35% at MW-AR-04). During the monitoring period, MW-AN-17 and MW-AN-25 were within the RH target range (25-60%) of a nocturnal refuge for 64.68% and 45.34%, respectively. The RH averaged 27.80% (± 0.17) at MW-AN-17 and 51.21% (± 0.47) at MW-AN-25. The conditions experienced inside the nocturnal refuges seem to reflect external climatic fluctuation.

The artificial roosts were within the target range for similar periods of time as MW-AN-25 and slightly below MW-AN-17. Differences between minimum and maximum RH within the artificial roosts as well as the reference sites were highly variable and fluctuated throughout the year. MW-AN-25 recorded a spike in RH causing it to be with the target range [25-60%] of a nocturnal roost for a reduced period of time. As this spike was not recorded at the other monitoring caves it is unlikely to be caused by natural variation and is may be caused by the placement of microclimate loggers or faulty equipment. In a similar manner to temperature, the results of this year's monitoring demonstrate the 'target range' specified for the artificial roosts, is not something permanently experienced by naturally occurring nocturnal refuges.

In comparison to the previous monitoring period (Biologic, 2020b) the percentage of recordings within the target range decreased at MW-AR-01, MW-AR-02 and MW-AR-04 (difference of 10.94% at MW-AR-01, 10.52% at MW-AR-02, and 92.65% at MW-AR-04) but increased by 18.71% at MW-AR-03. During Year 1, monitoring at MW-AR-03, MW-AR-04, MW-AR-17 and MW-AR-25 only occurred for approximately 3 months due to technical difficulties, limiting any interpretations or comparisons from previous years.

Based on observations during the monitoring period, multiple wet seasons may be necessary to allow the build-up and retention of water in the artificial roosts. For example, MW-AR-04 experienced several recordings of RH of 100% which coincided with high rainfall events in the area. Similarly, natural caves have recorded variation in RH being negatively correlated with ambient temperature and mediated by two-week rainfall (Biologic, 2020a). However, the peaks experienced at MW-AR-04 were often with dips, suggesting that the moisture can be lost to the surrounding environment. The location and surrounding structure of the artificial roosts may be influencing the variation in and retention of RH. Specifically, there may be insufficient substrate surrounding the artificial roost to provide adequate insulation from the external environment and/or the concrete material may be absorbing residual moisture from the air. In some instances, it was likely that gaps in the monitoring tubes were allowing moisture to escape, this has since been rectified (post wet season) and may take some time for the results to be apparent. It is expected that RH will increase and stabilise over time, following consecutive wet seasons and significant rainfall events (MW-AR-01 and MW-AR-02 have experienced two wet seasons, whereas MW-AR-03 and MW-AR-04 have only experienced one).

5.1.3 Combined Microclimate

Temperature and RH were within the target range (25 to 32^{o}C and 25 to 100%) concurrently for 49.36% at MW-AR-01, 74.82% at MW-AR-02, 42.34% at MW-AR-03 and 52.24% at MW-AR-04. MW-AR-02 was within the target range concurrently for the majority of the monitoring period. Whereas MW-AR-01, MW-AR-03 and MW-AR-04 were within the target ranges for a less than half the monitoring period. Temperature and RH were within the target range (25 to 32^{o}C and 25 to 60%) concurrently for 48.08% at MW-AN-17, 6.43% at MW-AN-25 and 0.42% at MW-AN-27. The naturally occurring nocturnal refuges and diurnal roost were within the target range for a minimal amount of time, in particular at MW-AN-25 and MW-AN-27. This further demonstrates that even natural nocturnal refuges are not completely bound by the range recommended by Bat Call (2018) (the location of microclimate loggers may also influence these results).

5.2 Artificial Roost Utilisation

At MW-AN-27, the Pilbara Leaf-nosed bat was detected on all recording nights (100% of 327 nights). The calls regularly occurred before civil dusk and after civil dawn, indicating diurnal roosting throughout the monitoring period, confirming its status as a diurnal roost. During the current monitoring period, MW-AN-27 showed seasonal variation, with call counts increasing from April onwards, most likely caused by the onset of the breeding season (Churchill, 1995).

No recorder was in place at the entrance of MW-AR-01 and MW-AR-02 during the current monitoring period. However, Pilbara leaf-nosed bats were recorded on multiple occasions at the entrance of MW-AR-03 and MW-AR-04 during the current monitoring period (September 2019 to January 2020 – prior to ultrasonic recorder being redeployed inside the artificial roosts). The species was detected at MW-AR-03 on 21 of the 33 recording nights (63.63%) and 12 of the 83 recording nights (14.45%) at MW-AR-04. Both artificial roosts recorded low call counts when recording occurred (Table 3.3). Based on the limited data recorded (MW-AR-03 October 2019, MW-AR-04 October 2019 and January 2020), it is likely that the presence of the species is represented by a single individual or a small number of individuals flying past or nearby the artificial roosts. Timing of calls indicated roosting was likely occurring at another location, presumably at the permanent diurnal roost MW-AN-27. MW-AR-03 recorded higher and more frequent calls than MW-AR-04, an outcome that was also noted in the previous monitoring period and is likely influenced by the location of the artificial roost relative to MW-AR-27 (MW-AR-03 is located approximately 300 m closer to MW-AN-27). The frequency of calls recorded at both MW-AR-03 and MW-AR-04 has decreased slightly since the previous monitoring period (-19.37% and -22.55%, respectively), this is likely a reflection of seasonal fluctuation as monitoring occurred over different time periods (Year 1 June to October 2019; Year 2 October 2019 to January 2020), however, due to loss of data interpretations are limited. It is possible that visitation by the species is occurring at the entrance of MW-AR-01 and MW-AR-02 as indicated in Year 1 (Biologic, 2020b), however, without an ultrasonic recorder deployed this cannot be confirmed.

No Pilbara leaf-nosed bat calls were recorded inside the main chamber at the four artificial roosts (MW-AR-01, MW-AR-02, MW-AR-03 and MW-AR-04) during the current monitoring period. However, common bat species were recorded sporadically during the monitoring period at MW-AR-01, MW-AR-02, and MW-AR-04.

The number of calls recorded at all four artificial roosts were lower than those recorded in 2018 and 2019 at naturally occurring nocturnal refuges in the area during the Atlas Significant Species Monitoring over a period of 7 days (e.g. MW-AN-17 – 269 calls per night in 2018, 282 call per night in 2019, MW-AN-25 – 20 calls per night in 2018, 46 calls per night in 2019) (Biologic, 2019, 2020c). Additionally and as anticipated, the number of calls at the artificial roost were substantially less than the nearby permanent diurnal roost MW-AN-27 (12,005 calls per night in 2018, 10,382 calls per night in 2019, and 4,921 calls per night during the current monitoring period) (Biologic, 2019, 2020c).

Interpretations of the data are limited due to the technical difficulties experienced with the recorders. There is limited foraging habitat located around the artificial roosts and this is likely to limit the number of encounters of the artificial roosts by the Pilbara leaf-nosed bat. Furthermore, thick vegetation was

observed to be obstructing the entrance to the artificial roosts, preventing bats from entering. This has now been rectified during a recent maintenance visit (Section 5.4). Confirmation of Pilbara leaf-nosed bats at the entrance of MW-AR-03 and MW-AR-04 demonstrates that waste-rock landforms will be visited by the species and gives confidence that artificial roosts in rehabilitated habitats may be successful.

5.3 Preliminary Evaluation of Key Performance Objectives

A preliminary evaluation of the roosts and monitoring data against key performance indicators detailed in the ARRP, and where applicable Bat Call (2018), are provided in Table 5.1. This monitoring event and report primarily aims to address those performance indicators relating to microclimate and Pilbara leaf-nosed bat utilisation as a nocturnal refuge.

The performance indicator *'create and maintain a microclimate deemed suitable for supporting Pilbara leaf-nosed bat'* is yet to be achieved. Temperature was within the target range for most of the monitoring period at the four artificial roosts (74.59% at MW-AR-01, 92.17% at MW-AR-02, 70.18% at MW-AR-03 and 93.38% at MW-AR-04). RH was within the target range for most of the monitoring period (72.25% at MW-AR-01, 78.48% at MW-AR-02, 65.61% at MW-AR-03 and 73.35% at MW-AR-04). These results suggest that the artificial roosts are currently suitable for use as a nocturnal refuge for temporary periods and require time to stabilise in humidity and temperature. It is anticipated that the microclimate within the four artificial roost will stabilise within the target range with time/age. The humidity within the reference roosts (MW-AN-17, MW-AN-25 and MW-AN-27) was not consistently within the target range, demonstrating that even natural nocturnal refuges experience the 'target range' year round.

The performance indicator *'presence of Pilbara leaf-nosed bat detected at the entrance or within the chambers of the artificial roosts'* has been achieved. The Pilbara leaf-nosed bat was detected at the entrance of all four artificial roosts on multiple occasions at some point since their installation. As of yet, no Pilbara leaf-nosed bats have been recorded on the internal recorders at any of the artificial roosts. Continued monitoring via the use of recorders is necessary to determine if the species is entering the artificial roosts in the future. Undertaking the recommended adjustments to the roost may increase the potential for Pilbara leaf-nosed bat utilisation and colonisation of the artificial roosts.

The performance indicator '*Pilbara Leaf-nosed Bat colonising artificial roost(s)*' is an additional aspirational target, given the primary aim is to establish roosts that are suitable as nocturnal refuges rather than diurnal roosts. Data from MW-AR-01 and MW-AR-04 suggested possible roosting events during the first year of monitoring, however, this was not verified by an internal ultrasonic recorder. No calls have been detected inside the roost during the current monitoring period, suggesting that establishment of the artificial roosts as a diurnal roost is yet to occur. Future monitoring will help to verify the occurrence of diurnal roosting and confirm whether this performance objective has been met.

Table 5.1: Preliminary evaluation of artificial roosts against key performance objectives prescribed in the ARRP

Performance objective	Key performance indicator (following ARRP and Bat Call (2018) where applicable)	Objective met	Justification
Design artificial roosts	Completed design for artificial roosts for Pilbara leaf-nosed bat with technical specifications (i.e. materials, dimensions, location, in cooperation with bat specialists and engineers)	Yes	Artificial roosts (nocturnal refuges) have been designed with all consideration for optimal conditions for Pilbara leaf-nosed bat where possible, including structure and appropriate microclimatic conditions to support the species.
Construct four artificial roosts	Four roosts constructed according to design specifications	Yes	Four artificial roosts have been constructed (MW-AR-01, MW-AR-02, MW-AR-03 and MW-AR-04) to design specifications.
Create and maintain a microclimate deemed suitable for supporting Pilbara leaf-nosed bat within the artificial roosts	Microclimate at different seasons characterised by: • temperature of 25–32°C • RH of 25–100%	No – Temperature and RH were not maintained within the target range.	Temperature was within the target range for most of the monitoring period at the four artificial roosts (74.59% at MW-AR-01, 92.17% at MW-AR-02, 70.18% at MW-AR-03 and 93.38% at MW-AR-04). RH was within the target range for most of the monitoring period (72.25% at MW-AR-01, 78.48% at MW-AR-02, 65.61% at MW-AR-03 and 73.35% at MW-AR-04). It is anticipated that the microclimate within the four artificial roost will stabilise within the target range with time/age.
Pilbara leaf-nosed bat utilising artificial roosts	Presence of Pilbara leaf-nosed bat detected at the entrance or within the chambers of the artificial roosts (i.e. pattern of activity indicating transitory visitation or greater)	Yes – Species detected at the entrance of all four roosts at some point since their installation.	The Pilbara leaf-nosed bat was detected at the entrance of all four artificial roosts on multiple occasions at some point since their installation. As of yet, no Pilbara leaf-nosed bats have been recorded on the internal recorders at any of the artificial roosts. Continued monitoring via the use of recorders is necessary to determine if the species is entering the artificial roosts in the future.
PLNB colonising artificial roost(s)	Status of roost(s) established as daytime roost (i.e. bats residing within main chamber during daytime hours and exhibiting an activity profile of exiting at dusk and entering prior to dawn)	Uncertain	This objective is an aspirational goal and not a measure of the success of these roosts providing a nocturnal refuge. Data from MW-AR-01 and MW-AR-04 suggested possible roosting events during Year 1 of monitoring, however, this was not verified by an internal ultrasonic recorder. No calls have been detected inside the roost during the current monitoring period, suggesting that establishment of the artificial roosts as a diurnal roost is yet to occur. Future monitoring will help to verify the occurrence of diurnal roosting and confirm whether this performance objective has been met.

5.4 Implementation of previous recommendations and maintenance

The recommendations from the 2018-2019 Artificial Roost monitoring (Biologic, 2020b) aimed to improve the artificial roosts and the quality of data collected during subsequent monitoring events. Table 5.2 outlines the implementation and outcomes of these recommendations.

In addition, following results of the monitoring period, a trip was completed in October 2020 to perform maintenance on the monitoring equipment and adjustments to resolve any issues affecting microclimate and/or bat utilisation. The following tasks were completed:

- All solar panels were secured using pickets and metal brackets to the ground.
- All microphone cables were replaced. All microphones were tested.
- All batteries and solar converters were replaced at the artificial roosts.
- The cases containing the recording equipment were covered with sheets of reflective insulation to reduce exposure to direct sun and heat.
- Atlas staff created a divot in the monitoring pipe to allow the microphone cable to pass the lip of the monitoring tube without being crushed by the lid.
- Rubber tubing was used to line the top of the monitoring tube to create a seal. A small piece of the tubing was placed on the bottom of each divot made for the microphone cables (to travel down into the monitoring tube), ensuring the cables have a soft surface on which to sit. The point along each cable that rests on the lip of the monitoring tube was marked with a ring of electrical tape.
- Where required, a small amount of silicon was required to seal the point where the cables entered the monitoring tube.
- The monitoring tube lids were replaced with larger ones to prevent damage to the microphone cable and create a seal to prevent humidity loss.
- The SongMeter at MW-AR-04 was changed due to corrupting files.
- Vegetation blocking the entrance to MW-AR-01 and MW-AR-02 was removed by Atlas staff (Plate 5.1).

Plate 5.1: Artificial roost pre- and post-vegetation removal from the entrance.

Table 5.2: Implementation of previous recommendations

Previous recommendation (Biologic, 2020b)	Was the recommendation adopted	Outcome
Deploy recording units within roosts – As required in the ARRP, continue to record within the roost at MW-AR-01 and MW-AR-02, and relocate existing units at MW-AR-03 and MW-AR-04 inside the roost, to obtain more accurate data about Pilbara-Leaf-nosed Bat occurrence and activity patterns within the artificial roosts themselves.	Yes	All recording units at the artificial roosts have been redeployed inside the roosts to obtain data on Pilbara leaf-nosed bat occurrence and activity patterns.
Continue to monitor reference roosts (MW-AN-17, MW-AN-25 and MW-AN-27) to provide information on the natural patterns in roost microclimate and bat activity.	Yes	The reference roosts (MW-AN-17, MW-AN-25 and MW-AN-27) have continued to be monitored.
Ensure caps on monitoring conduits are sealing appropriately to ensure no loss of/maintenance of internal microclimate.	Yes	As per Section 5.4, maintenance was undertaken to ensure the caps on the monitoring tubes are now sealed correctly.
Remove ibuttons within the entrance of each artificial roost, as this data has limited value in measuring performance against KPIs.	No	This recommendation has yet to be implemented, however, it would require amendments to the monitoring plan (MWH, 2015b).
Updating iButtons – Consider replacing ibuttons for more reliable technologies, including Bluetooth capable data loggers.	Partially	A portion of the microclimate loggers (Table 3.2) have been replaced with HOBO (MX2301A) temperature/RH Bluetooth data loggers, a more reliable technology method than the iButton (Biologic, 2020b).
Analyse data upon retrieval from the field to reduce gaps in the data due to faulty equipment or tech	Yes	Upon retrieval from the field, data is being analysed as soon as possible to reduce gaps in data caused by faulty equipment or technical faults.
Consider video monitoring – Where Pilbara Leaf-nosed Bats are positively recorded within the roosts, investigate the application of video monitoring. The installation of a video recording device within the artificial roosts would potentially allow for visual confirmation of species presence, abundance and behaviour within the roosts	No	This recommendation has yet to be implemented and should be considered once Pilbara leaf-nosed bats are regularly utilising the space.
Consider using lures or attractants – Should further monitoring show that Pilbara Leaf-nosed Bats are not entering the artificial roosts and microclimate is suitable, the use of lures or attractants (such as scats collected from confirmed roosts in the area) can be considered as a way of attracting passing individuals into the roosts.	No	This recommendation has yet to be implemented.

5.5 Recommendations

The following recommendations aim to improve the artificial roosts and the quality of data collected during subsequent monitoring events to provide more information about the success of artificial roosts in providing suitable habitat for the Pilbara leaf-nosed bat:

- Continue to monitor within roosts – As required in the ARRP, continue to record within the roost at MW-AR-01, MW-AR-02, MW-AR-03 and MW-AR-04 to obtain accurate data about Pilbara-Leaf-nosed Bat occurrence and activity patterns within the artificial roosts themselves.
- Continue to monitor microclimate of reference roosts (MW-AN-17, MW-AN-25 and MW-AN-27) to provide information on the natural patterns in roost microclimate.
- Consider ultrasonic recording at MW-AN-17 and MW-AN-25 – As it has been demonstrated that the microclimate of naturally occurring nocturnal refuges does not maintain within the target ranges, additional ultrasonic monitoring may demonstrate that Pilbara leaf-nosed bats do not require the microclimate conditions year round.
- Remove microclimate loggers within the entrance of each artificial roost, as this data has limited value in measuring performance against KPIs.
- Updating microclimate loggers – Consider replacing microclimate loggers with remote access wired loggers to increase consistency and accuracy (e.g. a wired HMP60 Vaisala Intercap Humidity and Temperature Probe).
- Consider opening gate to the entrance of roosts – Should further monitoring show that Pilbara leaf-nosed bats are not entering the roost, the gate from two roosts could be removed to encourage individuals to enter the artificial roosts.
- Consider adding water to the roosts – adding water to the roost may increase the humidity inside the artificial roosts and be used to assess the artificial roosts ability to retain moisture.
- Consider adding additional substrate above the artificial roosts – Increasing the amount of substrate above the artificial roosts may increase their ability to insulate and maintain optimal temperature and RH.
- Consider using lures or attractants – As the monitoring has indicated that Pilbara leaf-nosed bats are not entering the artificial roosts and microclimate is suitable, the use of lures or attractants (such as scats collected from confirmed roosts in the area) can be considered as a way of attracting passing individuals into the roosts.
- Consider video monitoring – When Pilbara leaf-nosed bats are positively recorded within the roosts, investigate the application of video monitoring. The installation of a video recording device within the artificial roosts would potentially allow for visual confirmation of species presence, abundance, and behaviour within the roosts.

5.6 Conclusions

The microclimate within the four artificial roosts is currently suitable for use as nocturnal refuges for temporary periods of time, however, the artificial roosts are yet to meet the key objective to maintain temperature and humidity consistently within the target range. Initial results suggest it may require time for the artificial roosts to achieve maximum thermal and water retention. As the reference nocturnal refuges also show seasonal variation and do not always exhibit a microclimate within the target range, it is unlikely that the condition stipulated by Bat Call (2018) are required for the artificial roosts to be used by the species.

Regardless, it has been demonstrated that the microclimate of all the artificial roosts has been similar to naturally occurring nocturnal refuges and within the target range for much of the year. For this reason, microclimate cannot be exclusively used to explain the lack of Pilbara leaf-nosed bats within the roosts. The recent upgrades and maintenance in October 2020 are predicted to improve the microclimate conditions within and at the entrance of the artificial roosts. If further monitoring does not record Pilbara leaf-nosed bats within the artificial roosts it is highly recommended that further action be taken to increase the activity.

The results of the monitoring at the four artificial roosts demonstrate that Pilbara leaf-nosed bats were sometimes present at the entrances to the artificial roosts and that the microclimate within the roosts was suitable for use as nocturnal refuges for much of the monitoring period. Pilbara leaf-nosed bats are yet to be confirmed to enter the artificial roosts, with only limited visitations from common bat species. Further monitoring of the artificial roosts and bat utilisation will provide more clarification on this.

Key performance indicators in the ARRP stipulated that Pilbara leaf-nosed bats be detected at the entrance or within the chambers of the artificial roosts to determine if transitory roosts can be recreated. Pilbara leaf-nosed bats have been recorded at the entrance of all roosts, inclusive of the Year 1 monitoring period, satisfying the objective for the species to utilize the artificial roosts. However, no Pilbara leaf-nosed bats were recorded entering or roosting within the artificial roosts throughout monitoring. Interpretations of the data are limited due to the loss of data experienced at the artificial roosts. As such, the artificial roosts are yet to achieve the aspiration goal of roost colonization.

Overall, assessment of monitoring data against key performance objectives detailed in the ARRP, or subsequent revisions, indicated most key performance objectives are either being met or are on a positive trajectory towards being achieved. Implementation of recommended roost alterations may increase the potential for a stable artificial roost microclimate and utilisation by Pilbara leaf-nosed bats. Future monitoring will play an important role in revealing more about the suitability of the artificial roosts as nocturnal refuges and the extent to which the performance objectives are to be achieved.

6 REFERENCES

Armstrong, K. N. (2000). Roost microclimates of the bat *Rhinonicteris aurantius* in a limestone cave in Geike Gorge, Western Australia. *Australian Mammalogy, 22*, 69-70. doi:https://doi.org/10.1071/AM00069

Armstrong, K. N. (2001). The distribution and roost habitat of the orange leaf-nosed bat, *Rhinonicteris aurantius*, in the Pilbara region of Western Australia. *Wildlife Research, 28*(95-104). doi:https://doi.org/10.1071/WR00011

Bat Call. (2018). *Atlas Mt Webber Pilbara leaf-nosed bat, alternative roost specification*. Unpublished report prepared for Atlas Iron Limited. Bat Call WA, Hillarys, WA.

Baudinette, R. V., Churchill, S. K., Christian, K. A., Nelson, J. E., & Hudson, P. J. (2000). Energy, water balance and the roost microenvironment in three Australian cave-dwelling bats (Microchiroptera). *Journal of Comparative Physiology B, 170*(5), 439-446. doi:http://10.1007/s003600000121

Biologic. (2019). *Mt Webber DSO project, Pilbara leaf-nosed bat and ghost bat monitoring survey 2018*. Unpublished report prepared for Atlas Iron Pty Ltd. Biologic Environmental Survey, East Perth, WA.

Biologic. (2020a). *Corunna Downs Pilbara leaf-nosed bat roost analysis*. Unpublished report prepared for Atlas Iron. Biologic Environmental Survey, East Perth, WA.

Biologic. (2020b). *Mt Webber artificial bat roost monitoring Year 1: October 2018 to October 2019*. Unpublished report for Atlas Iron Pty Ltd. Biologic Environmental Survey, East Perth, WA.

Biologic. (2020c). *Mt Webber DSO project, Pilbara leaf-nosed bat and ghost bat monitoring survey 2019*. Unpublished report for Atlas Iron. Biologic Environmental Survey, East Perth, WA.

BoM. (2020). Climate data online. Retrieved 2020, from Bureau of Meteorology http://www.bom.gov.au./climate/data/index.shtml

Bullen, R. D. (2013). *Pilbara leaf-nosed bat (Rhinonicteris aurantia); summary of current data on distribution, energetics, threats*. Paper presented at the Pilbara Leaf-nosed Bat workshop, Kensington, Western Australia.

Bullen, R. D., & McKenzie, N. L. (2011). Recent developments in studies of the community structure, foraging ecology and conservation of Western Australian bats. In B. Law, P. Eby, D. Lunney, & L. Lumsden (Eds.), *The Biology and Conservation of Australasian Bats* (pp. 31-43). Mosman, New South Wales: Royal Zoological Society of NSW.

Bullen, R. D., & Reiffer, S. (2019). A record of movement of a Pilbara leaf-nosed bat between distant diurnal roosts using PIT tags. *Australian Mammalogy, 42*(4), 119-121. doi:https://doi.org/10.1071/AM18054

Churchill, S. K. (1991). Distribution, abundance and roost selection of the orange horseshoe-bat, *Rhinonycteris aurantius*, a tropical cave-dweller. *Wildlife Research, 18*, 343-353.

Churchill, S. K. (1994). Diet, prey selection and foraging behaviour of the Orange Horseshore-bat, *Rhinonycteris aurantius*. *Wildlife Research, 21*, 115-130.

Churchill, S. K. (1995). Reproductive ecology of the orange horseshoe bat, *Rhinonicteris aurantius [Hipposideridae: Chiroptera]*, a tropical cave-dweller. *Wildlife Research, 22*, 687-698.

Cramer, V. A., Armstrong, K. N., Bullen, R. D., Ellis, R., Gibson, L. A., McKenzie, N. L., . . . van Leeuwen, S. (2016). Research priorities for the Pilbara leaf-nosed bat (*Rhinonicteris aurantia* Pilbara form). *Australian Mammalogy, 38*(2), 149-157. doi:https://doi.org/10.1071/AM15012

Leighton, K. A. (2004). Climate. In A. M. E. van Vreeswyk, A. L. Payne, K. A. Leighton, & P. Hennig (Eds.), *An Inventory and Condition Survey of the Pilbara Region, Western Australia*. Perth, Western Australia: Technical Bulletin No. 92. Western Australian Department of Agriculture.

McKenzie, N. L., & Bullen, R. D. (2009). The echolocation calls, habitat relationships, foraging niches and communities of Pilbara microbats. *Records of the Western Australian Museum Supplement, 78*, 123-155.

McKenzie, N. L., van Leeuwen, S., & Pinder, A. M. (2009). Introduction to the Pilbara biodiversity survey, 2002-2007. *Records of the Western Australian Museum Supplement, 78*, 3-89.

MWH. (2015a). *Mt Webber DSO project: Pilbara leaf-nosed bat and ghost bat monitoring survey 2015*. Unpublished report prepared for Atlas Iron Limited. MWH Australia, Jolimont, WA.

MWH. (2015b). *Mt Webber project: artificial roost research plan for the Pilbara leaf-nosed bat*. Unpublished report prepared for Atlas Iron Limited. MWH Australia, Jolimont, WA.

MWH. (2016). *Mt Webber DSO project: Pilbara leaf-nosed bat and ghost bat monitoring survey 2016*. Unpublished report prepared for Atlas Iron Limited. MWH Australia, Jolimont, WA.

Stantec. (2017). *Mt Webber project Pilbara leaf-nosed bat and ghost bat monitoring survey 2017*. Unpublished report prepared for Atlas Iron Limited. Stantec Australia, Jolimont, WA.

Thackway, R., & Cresswell, I. D. (1995). *An Interim Biogeographical Regionalisation for Australia*. Canberra, Australian Capital Territory: Australian Nature Conservation Agency.

TSSC, Threatened Species Scientific Committee. (2016). *Conservation advice: Rhinonicteris aurantia (Pilbara form), Pilbara leaf-nosed bat*. TSSC,, Threatened Species Scientific Committee, Canberra, Australian Capital Territory.

van Dyck, S., & Strahan, R. (2008). *Mammals of Australia* (Third ed.). Sydney, New South Wales: Australian Museum.

7 APPENDIX

Appendix A – Combined temperature and relative humidity graphs

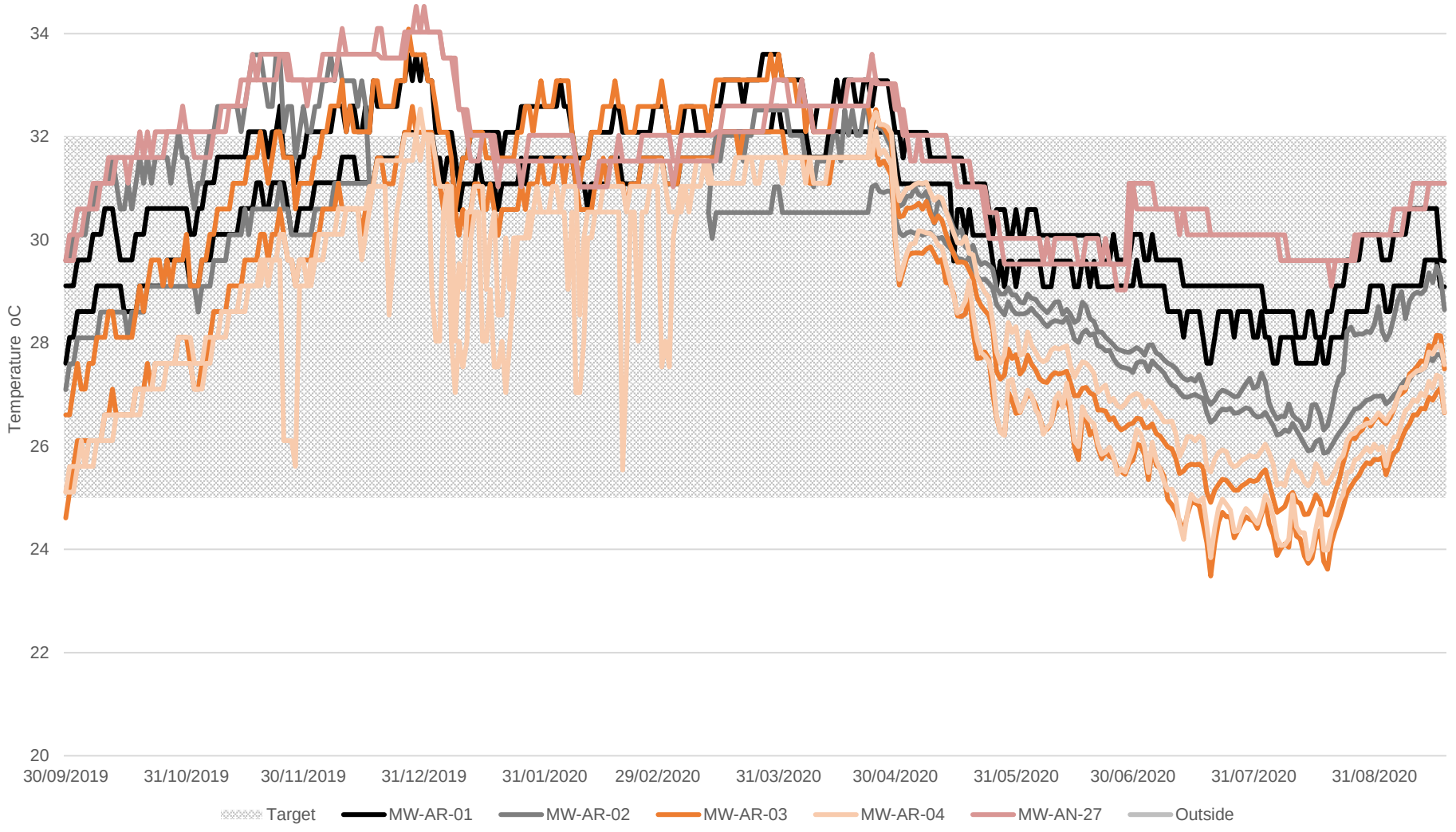


Figure 7.1: Daily temperature range recorded inside MW-AR-01, MW-AR-02, MW-AR-03, MW-AR-04 and MW-AN-27 during the monitoring period

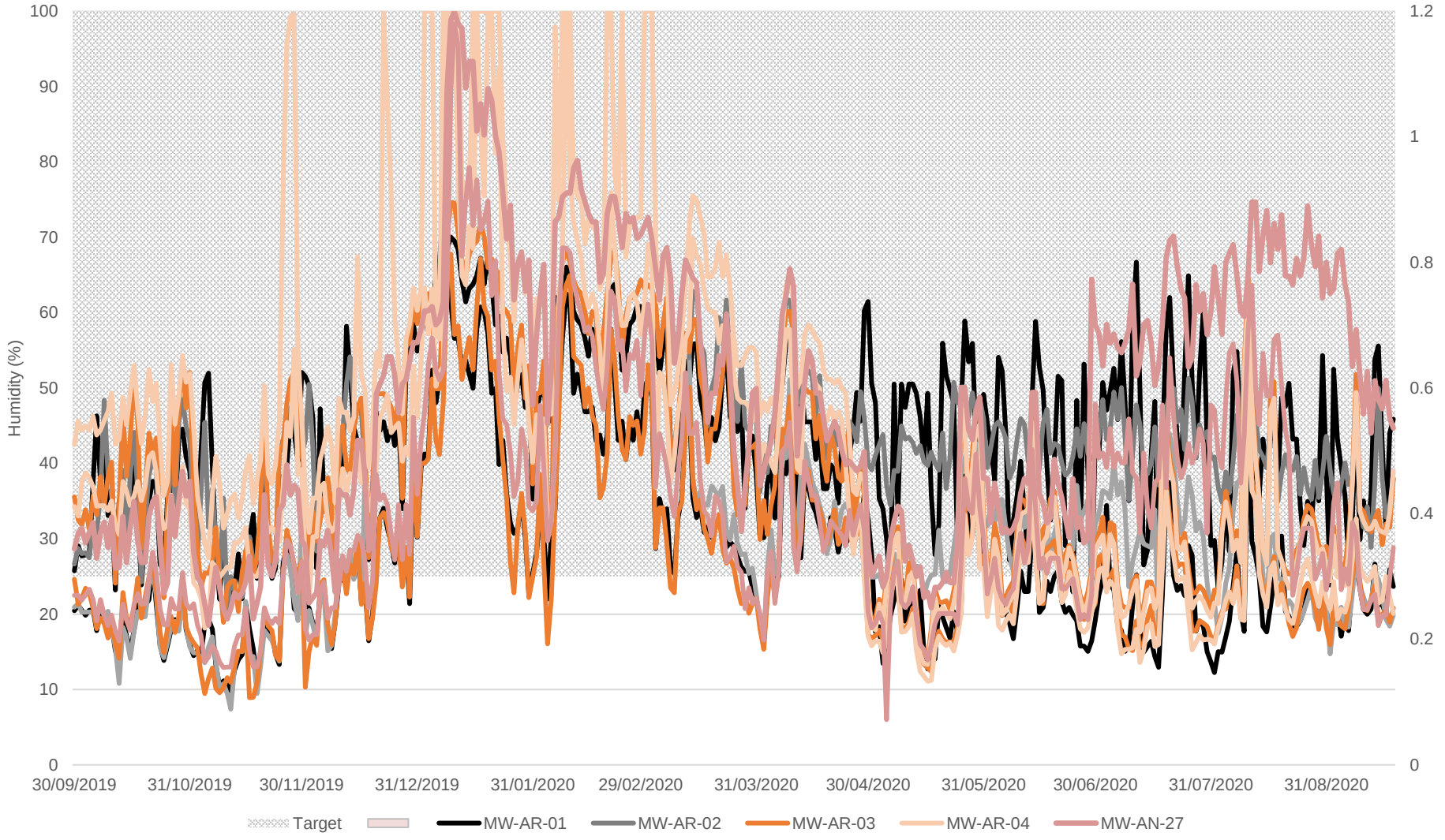
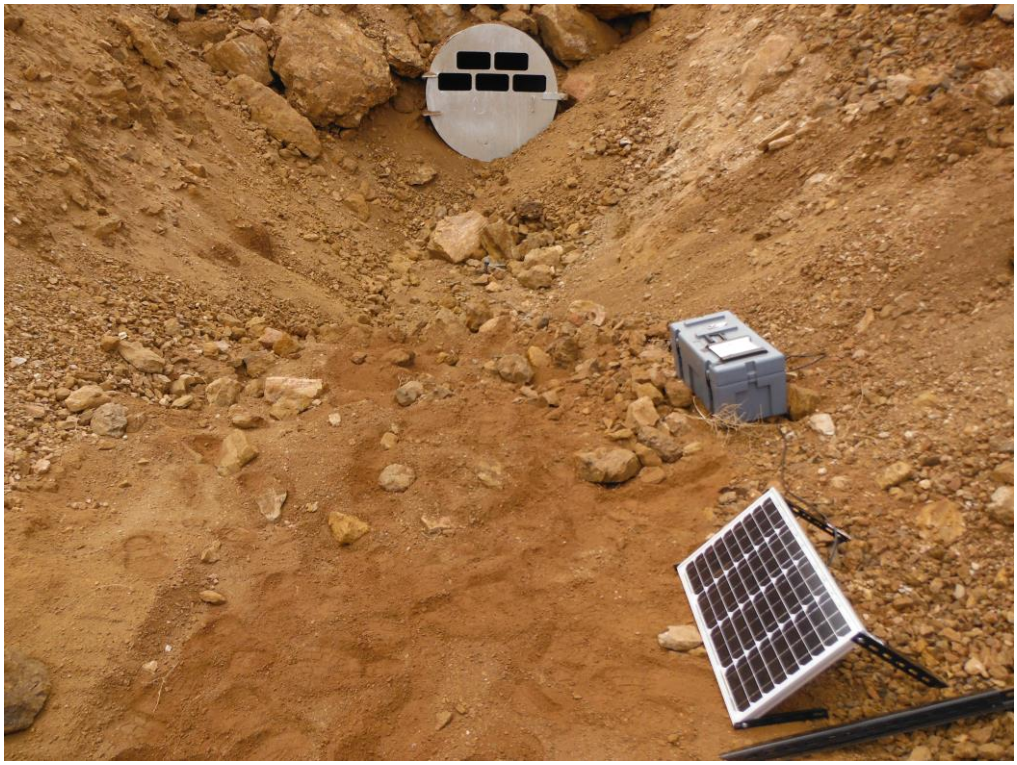


Figure 7.2: Daily relative humidity recorded inside MW-AR-01, MW-AR-02, MW-AR-03, MW-AR-04 and MW-AN-27 during the monitoring period

Appendix B – Location of monitoring equipment at artificial roost

Setup of monitoring equipment at MW-AR-01 showing recording equipment (in grey box) and solar power supply.



Setup of recording equipment at MW-AR-02 showing recording equipment (in grey box with external microphone in front of rock pile below roost entrance) and solar power supply.

Purpose-built tiles installed at MW-AR-04, designed to mimic the roof of natural caves.

Appendix C – Pilbara leaf-nosed bat visitation details

Date	Civil Dusk	Civil Dawn	MW-AR-03			MW-AR-04			MW-AN-27		
			First Call	Last Call	Total Calls	First Call	Last Call	Total Calls	First Call	Last Call	Total Calls
29/09/2019	18:23	5:23	0:12	2:03	2			0	18:06	5:19	7529
30/09/2019	18:23	5:22	21:56	21:56	1			0	18:22	5:12	7019
1/10/2019	18:23	5:21			0			0	18:21	5:20	7182
2/10/2019	18:24	5:20			0			0	18:26	5:10	6652
3/10/2019	18:24	5:19	1:26	1:26	1			0	18:39	5:14	8102
4/10/2019	18:24	5:18	20:44	20:44	1			0	18:28	5:30	5026
5/10/2019	18:25	5:17	22:40	0:54	3			0	18:26	5:14	6234
6/10/2019	18:25	5:16	22:58	2:10	4	23:26	23:26	1	18:22	5:11	6402
7/10/2019	18:25	5:15	0:49	2:19	5			0	18:29	5:19	4179
8/10/2019	18:26	5:15	23:35	0:44	4			0	18:23	5:09	3974
9/10/2019	18:26	5:14	22:29	1:49	13			0	18:24	5:17	5422
10/10/2019	18:26	5:13	23:06	1:01	5	22:56	22:56	1	18:26	5:36	5647
11/10/2019	18:27	5:12	23:39	23:42	2			0	18:21	5:07	5494
12/10/2019	18:27	5:11	23:07	23:07	1	1:44	2:31	2	18:10	5:16	4128
13/10/2019	18:28	5:10	23:26	23:26	1			0	18:29	5:01	6250
14/10/2019	18:28	5:09	20:43	23:14	2			0	18:23	5:01	4026
15/10/2019	18:28	5:08			0			0	18:26	4:51	2928
16/10/2019	18:29	5:08	2:20	2:20	1	3:58	4:07	2	18:26	5:12	6389
17/10/2019	18:29	5:07	19:50	19:50	1			0	18:17	5:07	6274
18/10/2019	18:30	5:06	0:17	0:17	1	21:43	0:57	2	18:37	4:55	4383
19/10/2019	18:30	5:05			0	23:22	23:22	1	18:39	5:00	3985
20/10/2019	18:31	5:04	22:16	23:16	4			0	18:30	4:57	3698
21/10/2019	18:31	5:04	19:50	20:50	1			0	18:36	4:55	3553
22/10/2019	18:31	5:03	19:21	1:43	4			0	18:15	5:07	6833
23/10/2019	18:32	5:02	19:25	2:00	2			0	18:37	5:00	5145
24/10/2019	18:32	5:01			0			0	18:42	4:59	3835
25/10/2019	18:33	5:01			0			0	18:37	5:02	3827
26/10/2019	18:33	5:00			0			0	18:40	5:04	7154

Date	Civil Dusk	Civil Dawn	MW-AR-03			MW-AR-04			MW-AN-27		
			First Call	Last Call	Total Calls	First Call	Last Call	Total Calls	First Call	Last Call	Total Calls
27/10/2019	18:34	4:59			0	22:12	22:12	1	18:22	5:11	5225
28/10/2019	18:34	4:58			0			0	18:38	4:49	3013
29/10/2019	18:35	4:58			0			0	18:42	4:50	4128
30/10/2019	18:35	4:57			0	23:57	23:57	1	18:35	4:46	3052
31/10/2019	18:36	4:56			0			0	18:38	4:48	2219
1/11/2019	18:37	4:56						0	18:48	4:52	3133
2/11/2019	18:37	4:55						0	18:36	4:47	2594
3/11/2019	18:38	4:55						0	18:30	4:48	2303
4/11/2019	18:38	4:54				23:58	23:58	1	18:42	4:48	2066
5/11/2019	18:39	4:54						0	18:35	4:46	1887
6/11/2019	18:39	4:53						0	18:36	4:45	1786
7/11/2019	18:40	4:53						0	18:25	4:48	2169
8/11/2019	18:41	4:52				0:44	0:44	1	18:27	4:53	3146
9/11/2019	18:41	4:52						0	18:30	4:47	3025
10/11/2019	18:42	4:51						0	18:42	4:50	2343
11/11/2019	18:43	4:51						0	18:22	5:15	2249
12/11/2019	18:43	4:50						0	18:38	5:15	2208
13/11/2019	18:44	4:50						0	18:37	5:09	1423
14/11/2019	18:45	4:50						0	18:35	4:44	1779
15/11/2019	18:45	4:49						0	18:39	4:48	2066
16/11/2019	18:46	4:49						0	18:41	4:52	1615
17/11/2019	18:47	4:49						0	18:31	4:49	1463
18/11/2019	18:47	4:48						0	18:45	4:42	2517
19/11/2019	18:48	4:48							18:33	4:42	1710
20/11/2019	18:49	4:48							18:44	4:44	1538
21/11/2019	18:49	4:48							18:54	4:45	3357
22/11/2019	18:50	4:48							18:39	4:40	3827
23/11/2019	18:51	4:47							18:53	4:41	2911

Date	Civil Dusk	Civil Dawn	MW-AR-03			MW-AR-04			MW-AN-27		
			First Call	Last Call	Total Calls	First Call	Last Call	Total Calls	First Call	Last Call	Total Calls
24/11/2019	18:51	4:47							19:00	4:37	4037
25/11/2019	18:52	4:47							18:42	4:41	5488
26/11/2019	18:53	4:47							18:44	4:49	5318
27/11/2019	18:54	4:47							18:41	4:41	7276
28/11/2019	18:54	4:47							18:45	4:40	7940
29/11/2019	18:55	4:47							18:53	4:49	4460
30/11/2019	18:56	4:47							19:09	4:43	4173
1/12/2019	18:56	4:47							19:06	4:56	4483
2/12/2019	18:57	4:47							18:38	5:08	3378
3/12/2019	18:58	4:47							19:00	4:41	1848
4/12/2019	18:58	4:47							18:39	4:44	2116
5/12/2019	18:59	4:48							18:44	4:47	1519
6/12/2019	19:00	4:48							18:58	4:47	1800
7/12/2019	19:00	4:48							18:40	4:45	1232
8/12/2019	19:01	4:48							18:52	4:40	1585
9/12/2019	19:02	4:48							18:55	4:48	3309
10/12/2019	19:02	4:49							19:02	4:42	2229
11/12/2019	19:03	4:49							18:45	4:48	2474
12/12/2019	19:04	4:49							18:56	4:46	1502
13/12/2019	19:04	4:50							18:44	4:48	898
14/12/2019	19:05	4:50							18:52	4:48	2470
15/12/2019	19:06	4:50							18:45	4:41	5647
16/12/2019	19:06	4:51							18:49	5:08	3116
17/12/2019	19:07	4:51						0	19:00	4:44	2072
18/12/2019	19:07	4:51						0	18:59	4:47	3496
19/12/2019	19:08	4:52						0	19:10	4:47	1611
20/12/2019	19:08	4:52						0	19:16	4:46	1995
21/12/2019	19:09	4:53				20:32	20:32	1	18:58	4:59	2684

Date	Civil Dusk	Civil Dawn	MW-AR-03			MW-AR-04			MW-AN-27		
			First Call	Last Call	Total Calls	First Call	Last Call	Total Calls	First Call	Last Call	Total Calls
22/12/2019	19:09	4:53						0	19:04	4:51	3074
23/12/2019	19:10	4:54				22:00	22:00	1	18:51	4:46	3289
24/12/2019	19:10	4:54						0	18:54	4:46	4495
25/12/2019	19:11	4:55						0	19:12	5:08	2783
26/12/2019	19:11	4:56						0	18:53	5:18	2146
27/12/2019	19:12	4:56						0	19:09	4:54	8242
28/12/2019	19:12	4:57						0	18:51	5:03	3509
29/12/2019	19:12	4:57						0	18:54	5:04	3079
30/12/2019	19:13	4:58						0	18:52	5:04	2169
31/12/2019	19:13	4:59						0	18:52	4:56	1929
1/01/2020	19:13	4:59						0	19:01	5:07	1397
2/01/2020	19:14	5:00						0	18:56	4:59	770
3/01/2020	19:14	5:01						0	18:54	4:54	1727
4/01/2020	19:14	5:01						0	19:06	4:54	1623
5/01/2020	19:14	5:02						0	18:58	5:04	727
6/01/2020	19:15	5:03						0	19:04	5:12	752
7/01/2020	19:15	5:03						0	19:13	5:12	6210
8/01/2020	19:15	5:04						0	18:54	5:29	17475
9/01/2020	19:15	5:05						0	18:54	5:25	6154
10/01/2020	19:15	5:05						0	19:03	5:02	956
11/01/2020	19:15	5:06				19:42	19:42	1	19:13	5:03	1944
12/01/2020	19:15	5:07						0	19:06	5:10	989
13/01/2020	19:15	5:08						0	19:22	5:05	728
14/01/2020	19:15	5:08						0	19:35	5:09	770
15/01/2020	19:15	5:09						0	19:35	4:50	2574
16/01/2020	19:15	5:10						0	19:40	5:16	1395
17/01/2020	19:15	5:11				2:58	2:58	1	19:36	4:50	580
18/01/2020	19:15	5:11							19:31	5:14	863

Date	Civil Dusk	Civil Dawn	MW-AR-03			MW-AR-04			MW-AN-27		
			First Call	Last Call	Total Calls	First Call	Last Call	Total Calls	First Call	Last Call	Total Calls
19/01/2020	19:15	5:12							19:34	5:10	2305
20/01/2020	19:15	5:13							19:21	5:08	603
21/01/2020	19:15	5:14							19:34	5:15	1003
22/01/2020	19:15	5:14							19:48	5:00	1061
23/01/2020	19:15	5:15							20:26	5:15	1608
24/01/2020	19:14	5:16							19:51	5:19	1119
25/01/2020	19:14	5:16							19:40	4:45	973
26/01/2020	19:14	5:17							19:44	4:50	1236
27/01/2020	19:14	5:18							19:53	5:21	624
28/01/2020	19:13	5:19							19:31	5:07	1629
29/01/2020	19:13	5:19							19:01	5:07	1763
30/01/2020	19:13	5:20							19:44	5:02	2016
31/01/2020	19:12	5:21							19:36	5:03	2849
1/02/2020	19:12	5:21							19:23	5:08	2184
2/02/2020	19:11	5:22							18:51	5:15	3133
3/02/2020	19:11	5:23							19:22	5:08	3256
4/02/2020	19:11	5:23							19:12	5:24	2089
5/02/2020	19:10	5:24							19:10	5:13	2110
6/02/2020	19:10	5:25							18:50	5:28	2022
7/02/2020	19:09	5:25							19:13	5:28	1547
8/02/2020	19:09	5:26							19:11	5:28	2610
9/02/2020	19:08	5:27							19:06	5:27	1000
10/02/2020	19:07	5:27							19:12	5:21	1491
11/02/2020	19:07	5:28							19:15	5:40	2797
12/02/2020	19:06	5:28							18:56	5:17	2638
13/02/2020	19:06	5:29							19:15	5:24	3922
14/02/2020	19:05	5:30							18:58	5:12	3077
15/02/2020	19:04	5:30							19:13	5:22	2935

Date	Civil Dusk	Civil Dawn	MW-AR-03			MW-AR-04			MW-AN-27		
			First Call	Last Call	Total Calls	First Call	Last Call	Total Calls	First Call	Last Call	Total Calls
16/02/2020	19:04	5:31							19:01	5:26	3776
17/02/2020	19:03	5:31							19:15	5:15	3437
18/02/2020	19:02	5:32							19:16	5:13	4812
19/02/2020	19:02	5:32							19:14	5:32	2752
20/02/2020	19:01	5:33							19:08	5:48	5625
21/02/2020	19:00	5:33							19:05	5:30	3551
22/02/2020	18:59	5:34							19:06	5:56	2736
23/02/2020	18:59	5:34							19:16	5:47	4541
24/02/2020	18:58	5:35							19:09	5:31	3403
25/02/2020	18:57	5:35							18:53	5:21	2217
26/02/2020	18:56	5:36							18:57	5:26	2842
27/02/2020	18:55	5:36							19:23	5:23	2904
28/02/2020	18:55	5:37							19:20	5:21	4842
29/02/2020	18:54	5:37							19:20	5:32	4235
1/03/2020	18:53	5:38							19:18	5:15	1759
2/03/2020	18:52	5:38							18:53	5:12	1743
3/03/2020	18:51	5:38							18:57	5:14	2842
4/03/2020	18:50	5:39							18:57	5:29	2330
5/03/2020	18:50	5:39							19:05	5:26	1315
6/03/2020	18:49	5:40							18:59	5:25	921
7/03/2020	18:48	5:40							19:13	5:30	668
8/03/2020	18:47	5:40							18:49	5:36	952
9/03/2020	18:46	5:41							19:10	5:19	755
10/03/2020	18:45	5:41							19:11	5:34	697
11/03/2020	18:44	5:42							18:44	5:45	775
12/03/2020	18:43	5:42							18:35	5:43	884
13/03/2020	18:42	5:42							18:31	5:18	906
14/03/2020	18:42	5:43							18:33	5:11	1679

Date	Civil Dusk	Civil Dawn	MW-AR-03			MW-AR-04			MW-AN-27		
			First Call	Last Call	Total Calls	First Call	Last Call	Total Calls	First Call	Last Call	Total Calls
15/03/2020	18:41	5:43							18:38	5:17	2385
16/03/2020	18:40	5:43							18:35	5:20	2416
17/03/2020	18:39	5:44							18:20	5:13	2354
18/03/2020	18:38	5:44							18:20	5:27	1204
19/03/2020	18:37	5:44							18:37	5:38	2795
20/03/2020	18:36	5:45							18:37	5:38	2234
21/03/2020	18:35	5:45							18:28	5:38	2581
22/03/2020	18:34	5:45							18:20	5:31	3493
23/03/2020	18:33	5:46							18:19	5:23	2979
24/03/2020	18:32	5:46							18:49	5:47	6511
25/03/2020	18:31	5:46							18:52	5:38	3720
26/03/2020	18:31	5:47							19:15	5:39	5517
27/03/2020	18:30	5:47							19:35	5:38	6535
28/03/2020	18:29	5:47							19:01	5:55	5520
29/03/2020	18:28	5:48							18:55	5:44	6535
30/03/2020	18:27	5:48							18:13	5:33	9136
31/03/2020	18:26	5:48							18:58	5:28	6244
1/04/2020	18:25	5:49							18:48	6:07	10624
2/04/2020	18:24	5:49							19:18	5:55	12022
3/04/2020	18:23	5:49							19:01	5:44	10659
4/04/2020	18:22	5:49							19:11	5:53	11908
5/04/2020	18:22	5:50							19:10	6:05	10305
6/04/2020	18:21	5:50							18:22	5:56	2974
7/04/2020	18:20	5:50							18:09	5:50	8949
8/04/2020	18:19	5:51							18:40	5:53	4406
9/04/2020	18:18	5:51							18:28	5:38	10153
10/04/2020	18:17	5:51							18:17	5:40	11773
11/04/2020	18:16	5:52							18:19	5:41	12292

Date	Civil Dusk	Civil Dawn	MW-AR-03			MW-AR-04			MW-AN-27		
			First Call	Last Call	Total Calls	First Call	Last Call	Total Calls	First Call	Last Call	Total Calls
12/04/2020	18:16	5:52							18:13	5:43	14182
13/04/2020	18:15	5:52							18:28	5:47	13971
14/04/2020	18:14	5:53							18:15	5:40	9998
15/04/2020	18:13	5:53							18:22	6:08	13534
16/04/2020	18:12	5:53							18:17	5:46	15102
17/04/2020	18:12	5:53							18:14	5:46	17606
18/04/2020	18:11	5:54							18:19	5:58	12746
19/04/2020	18:10	5:54							18:10	5:52	15158
20/04/2020	18:09	5:54							17:59	5:45	19174
21/04/2020	18:09	5:55							18:20	5:59	19800
22/04/2020	18:08	5:55							18:20	6:08	20295
23/04/2020	18:07	5:55							18:28	5:46	22003
24/04/2020	18:07	5:56							18:16	5:42	20997
25/04/2020	18:06	5:56							18:23	5:41	17193
26/04/2020	18:05	5:56							18:23	6:14	26654
27/04/2020	18:05	5:57							18:07	6:05	22052
28/04/2020	18:04	5:57							18:21	5:58	24646
29/04/2020	18:03	5:58							18:16	5:40	21147
30/04/2020	18:03	5:58							18:22	4:51	16609
1/05/2020	18:02	5:58							18:19	5:39	26075
2/05/2020	18:02	5:59							18:13	5:48	27178
3/05/2020	18:01	5:59							18:11	5:33	26320
4/05/2020	18:00	5:59							18:11	5:38	24530
5/05/2020	18:00	6:00							18:11	5:54	21651
6/05/2020	17:59	6:00							18:14	5:46	23162
7/05/2020	17:59	6:00							18:10	5:32	15780
8/05/2020	17:58	6:01							17:56	5:41	17590
9/05/2020	17:58	6:01							18:10	5:53	17074

Date	Civil Dusk	Civil Dawn	MW-AR-03			MW-AR-04			MW-AN-27		
			First Call	Last Call	Total Calls	First Call	Last Call	Total Calls	First Call	Last Call	Total Calls
10/05/2020	17:57	6:02							18:07	5:53	20790
11/05/2020	17:57	6:02							18:04	5:36	25014
12/05/2020	17:57	6:02							18:12	5:50	25378
13/05/2020	17:56	6:03							18:07	5:52	26413
14/05/2020	17:56	6:03							18:11	5:49	26460
15/05/2020	17:55	6:03							18:13	6:26	27727
16/05/2020	17:55	6:04							17:52	5:43	25014
17/05/2020	17:55	6:04							18:00	5:36:00	22647
18/05/2020	17:54	6:05							18:07	6:04:00	28268
19/05/2020	17:54	6:05							18:05	5:43:00	23804
20/05/2020	17:54	6:05							18:08	5:48	26280
21/05/2020	17:54	6:06							18:07	5:48	24633
22/05/2020	17:53	6:06							18:06	5:56	28069
23/05/2020	17:53	6:07							18:08		
24/05/2020	17:53	6:07									
25/05/2020	17:53	6:07									
26/05/2020	17:53	6:08									
27/05/2020	17:52	6:08									
28/05/2020	17:52	6:09									
29/05/2020	17:52	6:09									
30/05/2020	17:52	6:09									
31/05/2020	17:52	6:10									
1/06/2020	17:52	6:10									
2/06/2020	17:52	6:10									
3/06/2020	17:52	6:11									
4/06/2020	17:52	6:11									
5/06/2020	17:52	6:12									
6/06/2020	17:52	6:12									

Date	Civil Dusk	Civil Dawn	MW-AR-03			MW-AR-04			MW-AN-27		
			First Call	Last Call	Total Calls	First Call	Last Call	Total Calls	First Call	Last Call	Total Calls
7/06/2020	17:52	6:12									
8/06/2020	17:52	6:13									
9/06/2020	17:52	6:13									
10/06/2020	17:52	6:13									
11/06/2020	17:52	6:13									
12/06/2020	17:52	6:14									
13/06/2020	17:52	6:14									
14/06/2020	17:52	6:14									
15/06/2020	17:52	6:15									
16/06/2020	17:53	6:15									
17/06/2020	17:53	6:15									
18/06/2020	17:53	6:15									
19/06/2020	17:53	6:16							18:10	6:30	20825
20/06/2020	17:53	6:16							18:03	5:58	18766
21/06/2020	17:54	6:16							18:01	6:40	22351
22/06/2020	17:54	6:16							17:58	5:56	16620
23/06/2020	17:54	6:16							17:59	5:40	19157
24/06/2020	17:54	6:17							18:10	6:26	20707
25/06/2020	17:55	6:17							18:00	6:25	10534
26/06/2020	17:55	6:17							18:03	6:40	10680
27/06/2020	17:55	6:17							17:52	6:03	12278
28/06/2020	17:55	6:17							17:43	6:32	14840
29/06/2020	17:56	6:17							18:07	5:58	11415
30/06/2020	17:56	6:17							18:00	6:05	11071
1/07/2020	17:56	6:17							17:58	6:23	12305
2/07/2020	17:57	6:17							17:55	6:26	6659
3/07/2020	17:57	6:17							17:59	6:17	4708
4/07/2020	17:57	6:17							17:55	6:02	5711

Date	Civil Dusk	Civil Dawn	MW-AR-03			MW-AR-04			MW-AN-27		
			First Call	Last Call	Total Calls	First Call	Last Call	Total Calls	First Call	Last Call	Total Calls
5/07/2020	17:58	6:18							17:56	5:54	2816
6/07/2020	17:58	6:17							17:54	5:58	3803
7/07/2020	17:58	6:17							17:55	5:50	7776
8/07/2020	17:59	6:17							18:01	5:58	9516
9/07/2020	17:59	6:17							18:08	6:07	10784
10/07/2020	17:59	6:17							18:09	5:50	17847
11/07/2020	18:00	6:17							18:08	6:02	14764
12/07/2020	18:00	6:17							18:08	5:50	13820
13/07/2020	18:00	6:17							18:06	6:01	14669
14/07/2020	18:01	6:17							18:06	5:55	18637
15/07/2020	18:01	6:17							18:15	5:59	18913
16/07/2020	18:01	6:16							18:07	5:56	8577
17/07/2020	18:02	6:16							18:10	6:10	7355
18/07/2020	18:02	6:16							17:56	6:37	4486
19/07/2020	18:02	6:16							18:00	5:52	4535
20/07/2020	18:03	6:15							18:06	6:00	11629
21/07/2020	18:03	6:15							18:05	6:34	18536
22/07/2020	18:04	6:15							18:15	5:53	18733
23/07/2020	18:04	6:15							18:09	6:16	14479
24/07/2020	18:04	6:14							18:12	6:03	11710
25/07/2020	18:05	6:14							18:06	5:57	8299
26/07/2020	18:05	6:13							18:04	5:55	9683
27/07/2020	18:05	6:13							18:14	6:01	10339
28/07/2020	18:06	6:13							18:16	5:53	10402
29/07/2020	18:06	6:12							18:16	5:56	10784
30/07/2020	18:06	6:12							18:11	6:11	6014
31/07/2020	18:07	6:11							18:12	6:26	7540
1/08/2020	18:07	6:11							18:16	6:01	6224

Date	Civil Dusk	Civil Dawn	MW-AR-03			MW-AR-04			MW-AN-27		
			First Call	Last Call	Total Calls	First Call	Last Call	Total Calls	First Call	Last Call	Total Calls
2/08/2020	18:07	6:10							18:08	6:31	2757
3/08/2020	18:08	6:10							18:14	5:59	1480
4/08/2020	18:08	6:09							18:06	6:29	1008
5/08/2020	18:08	6:09							18:05	6:06	1536
6/08/2020	18:09	6:08							18:10	6:25	2726
7/08/2020	18:09	6:08							18:10	5:44	3475
8/08/2020	18:09	6:07							18:16	6:04	3025
9/08/2020	18:10	6:06							18:12	5:53	3126
10/08/2020	18:10	6:06							18:11	5:35	1155
11/08/2020	18:10	6:05							18:09	5:55	2184
12/08/2020	18:11	6:05							17:59	5:32	3006
13/08/2020	18:11	6:04							18:16	6:06	4120
14/08/2020	18:11	6:03							18:09	5:46	7847
15/08/2020	18:11	6:03							18:19	5:59	10672
16/08/2020	18:12	6:02							18:07	5:43	7297
17/08/2020	18:12	6:01							18:02	5:31	6833
18/08/2020	18:12	6:00							18:19	6:24	6573
19/08/2020	18:13	6:00							18:22	5:58	12309
20/08/2020	18:13	5:59							18:14	5:48	18440
21/08/2020	18:13	5:58							18:25	6:07	19254
22/08/2020	18:13	5:57							18:22	6:05	13337
23/08/2020	18:14	5:56							18:18	6:13	10654
24/08/2020	18:14	5:56							18:18	6:07	12517
25/08/2020	18:14	5:55							18:20	5:47	11167
26/08/2020	18:14	5:54							18:20	5:46	15536
27/08/2020	18:15	5:53							18:18	6:15	14688
28/08/2020	18:15	5:52							18:16	5:45	13366
29/08/2020	18:15	5:51							18:22	5:58	11664

Date	Civil Dusk	Civil Dawn	MW-AR-03			MW-AR-04			MW-AN-27		
			First Call	Last Call	Total Calls	First Call	Last Call	Total Calls	First Call	Last Call	Total Calls
30/08/2020	18:15	5:51							18:07	5:40	13085
31/08/2020	18:16	5:50							18:16	5:55	12592
1/09/2020	18:16	5:49							17:59	6:05	9176
2/09/2020	18:16	5:48							18:11	5:36	9487
3/09/2020	18:16	5:47							18:12	5:53	9450
4/09/2020	18:17	5:46							18:03	5:41	7716
5/09/2020	18:17	5:45							18:16	5:41	8147
6/09/2020	18:17	5:44							18:14	5:46	6073
7/09/2020	18:17	5:43							18:11	5:32	5827
8/09/2020	18:18	5:42							18:05	5:56	7932
9/09/2020	18:18	5:42							18:13	5:31	7839
10/09/2020	18:18	5:41							18:14	5:31	6080
11/09/2020	18:18	5:40							18:15	5:51	6176
12/09/2020	18:19	5:39							18:19	5:36	5228
13/09/2020	18:19	5:38							18:29	5:25	5637
14/09/2020	18:19	5:37							18:32	5:32	8314
15/09/2020	18:19	5:36							18:32	5:31	3910
16/09/2020	18:20	5:35							18:23	5:27	2619
17/09/2020	18:20	5:34							18:32	5:19	1925
18/09/2020	18:20	5:33							18:21	5:23	3318