

Corunna Downs

CO-CA-03 and CO-WS-14 Monitoring Strategy

Biologic Environmental Survey

Prepared for Atlas Iron

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1 INTRODUCTION

1.1 Project Overview

Atlas Iron Pty Ltd (Atlas Iron) are looking to develop the Corunna Downs Project (the Project), located approximately 25 kilometres (km) south-west of Marble Bar within the Chichester subregion of Western Australia's Pilbara bioregion (Figure 1.1). The Project involves the development and operation of an open cut iron ore mine and associated mining infrastructure, waste rock dumps, borefield, and accommodation camp. The Project will source iron ore from five open pits (Split Rock, Razorback, Shark Gully, Runway North and Runway South) using conventional drill and blast, load and haul methods (Atlas Iron, 2019).

1.2 Project Background

In January 2017, Atlas Iron referred the Project to the Department of Environment and Energy (now the Department of Agriculture, Water and the Environment, DAWE) under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The DAWE determined that the Project was a controlled action under Section 75 of the EPBC Act and required assessment by Preliminary Documentation, on the basis it was likely to have a significant impact on listed threatened species and communities (sections 18 and 18A), including the Pilbara Leaf-nosed Bat.

This species was recorded on 41 occasions, including within 16 caves. Two of which, cave CO-CA-01, a permanent diurnal roost, and cave CO-CA-03, a non-permanent breeding roost, are considered critical habitat for the species (Figure 1.1). The remaining 14 caves were classified as nocturnal refuges (MWH, 2016b). There were also a number of perennial pools located within the vicinity of the Project including pool CO-WS-14 located directly in front of the entrance of Cave CO-CA-03 (Figure 1.1), regarded as important due to the species' high levels of water loss (Baudinette *et al.*, 2000),

To minimise mining related impacts, and consequently ensure the long-term viability of the local population, exclusion zones (delineated zone within which development will be excluded) were applied to these two significant caves (Atlas Iron Limited, 2018). An assessment of the geology and review of Atlas Iron's other operations determined that a 50 m lateral buffer from cave CO-CA-03 was adequate to maintain a suitable level of structural integrity of this cave (Atlas Iron Limited, 2018). Atlas Iron subsequently revised and optimised the pit design outside of this 50 m buffer and surveyed and laser scanned this cave. Consequently, this 50 m lateral buffer is now known to translate to a distance of 100 m overland from the entrance of the cave to the nearest edge of the Razorback pit, and 68 m from the back of the cave to the nearest point inside the Razorback pit (Figure 1.2).

Given the proximity of cave CO-CA-03 to the Razorback pit and the species' sensitivity to blasting noise, vibration and dust impacts the assessment considered the potential that the Project may result in the temporary relocation/abandonment of this species from cave CO-CA-03. However, the return of this species following cessation of mining is anticipated where the structural integrity and microclimate of this cave could be maintained along with the persistence of pool CO-WS-14. It was also considered probable that this species could continue to utilise this cave as a nocturnal refuge and for foraging during this time, as supported by monitoring at Atlas Iron's Mt Dove operations (MWH, 2014).

The Project was granted approval on 23 February 2018 (EPBC 2017/7861) subject to 12 conditions. Four of these conditions related directly to the Pilbara leaf-nosed bat, including condition 4 pertaining to the development and implementation of a Monitoring Strategy:

4. *The approval holder must develop and submit a Monitoring Strategy to the Minister for approval. The Monitoring Strategy must be based on:*
   - *mapping and monitoring of cave CO-CA-03 by an independent scientific expert(s) approved by the Department;*
   - *the collection of at least 12 months of baseline humidity and temperature recordings inside cave CO-CA-03; and*
   - *12 months of baseline water quality sampling of pool CO-WS-14.*

   The Monitoring Strategy must be designed to demonstrate that the structure of cave CO-CA-03 remains unchanged from the pre-mining structure during mining of the Razorback Pit. The Monitoring Strategy must also be designed to demonstrate, unless otherwise justified and approved by the Minister, that:

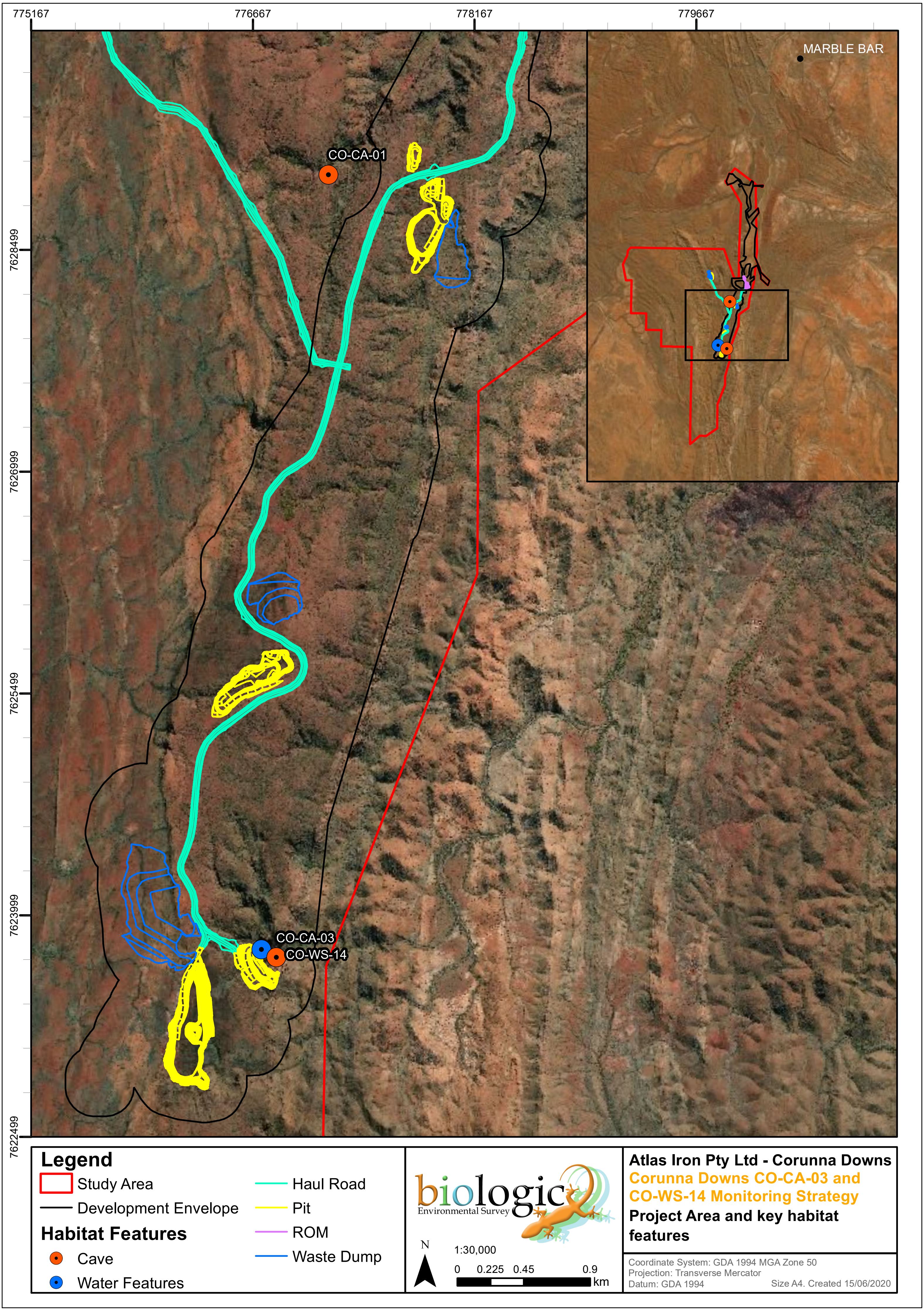
   a) *without anthropogenic supplementation of its water level, waterhole CO-WS-14 has water in it during and continuously for three consecutive years following the cessation of mining of Razorback Pit; and*
   b) *the water quality of pool CO-WS-14 remains suitable for Pilbara leaf-nosed bat during and continuously for three consecutive years following the cessation of mining of Razorback Pit; and*
   c) *cave CO-CA-03 maintains:*
      i. *humidity between 85-100 per cent relative humidity;*
      ii. *temperature between 28 and 32 degrees Celsius during and continuously for five years following cessation of the mining of Razorback Pit.*

   Mining in Razorback Pit cannot commence until the Monitoring Strategy has been approved by the Minister.

This Monitoring Strategy will also be used to inform condition 3 of the EPBC Approval Decision.

3. *The approval holder must demonstrate that, both during and after mining ceases at the Razorback Pit, cave CO-CA-03 and pool CO-WS-14 remain suitable habitat available for use by the Pilbara leaf-nosed bat.*

Biologic Environmental Survey Pty Ltd (Biologic) was commissioned by Atlas Iron to prepare the CO-CA-03 and CO-WS-14 Monitoring Strategy. The strategy is designed to wholly address conditions 3 and 4 from the EPBC Approval Decision. Furthermore, the overall objective is to ensure that the long-term viability of CO-CA-03, and inherently CO-WS-14, as habitat for Pilbara Leaf-nosed Bat is maintained. This is accomplished by prescribing achievable performance criteria for CO-CA-03 and CO-WA-14 following the collection and analysis of 12 months of baseline data, which may differ from those stipulated in condition 4 of the EPBC Approval Decision, as well as establishing methods to monitor and assess the achievement of these criteria.



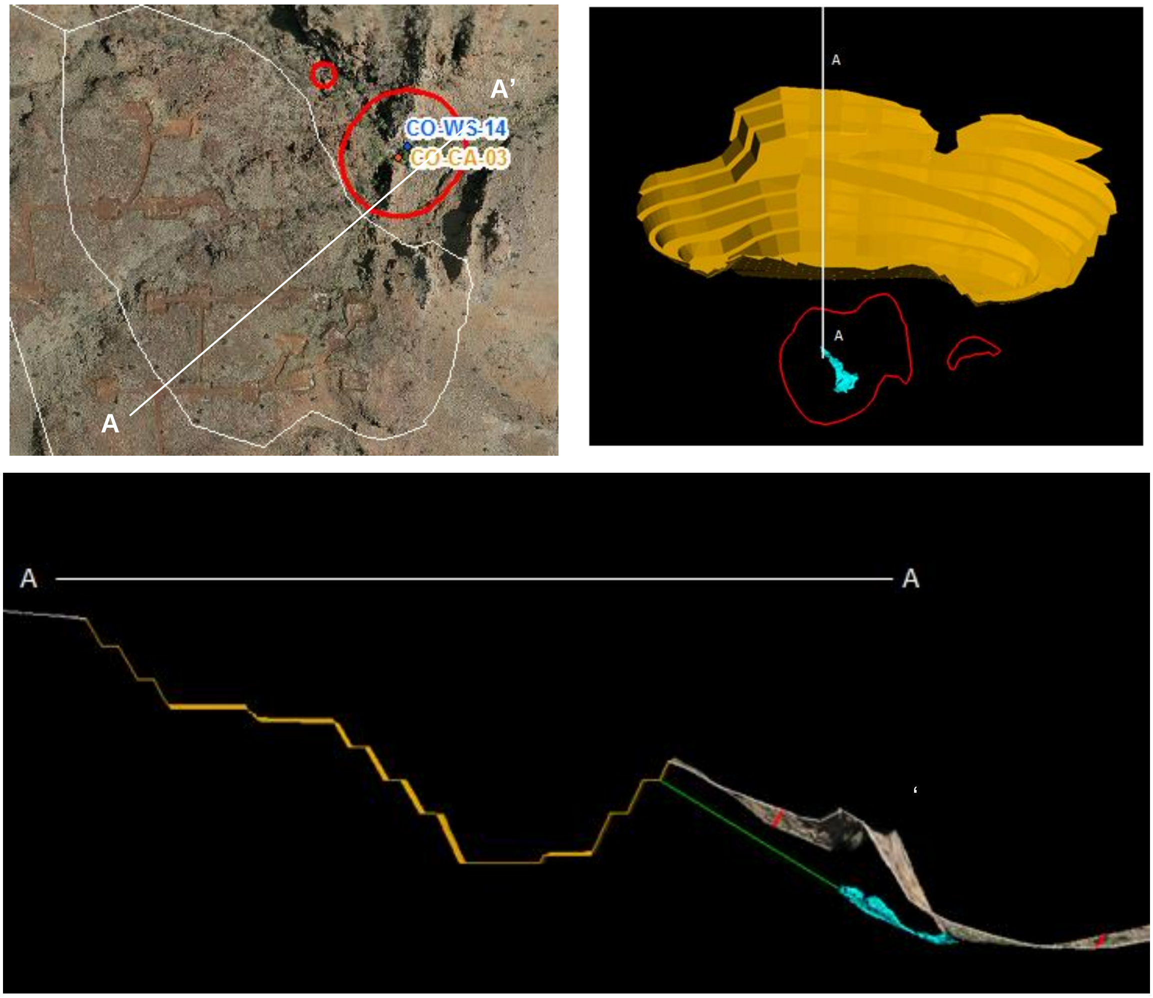
Atlas Iron Pty Ltd - Corunna Downs

Corunna Downs CO-CA-03 and CO-WS-14 Monitoring Strategy

Project Area and key habitat features

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Size A4. Created 15/06/2020



Note: The green line denotes a distance of 68 m between the Razorback pit (in orange) and the rear of cave CO-CA-03 (in light blue).

Figure 1.2: Plan and Cross-section Illustrating the 2D Buffer and 3D Distance Between Non-Permanent Breeding Roost CO-CA-03 and Razorback Pit

2 BACKGROUND INFORMATION

2.1 Pilbara Leaf-nosed Bat

The Pilbara leaf-nosed bat is listed as Vulnerable under the EPBC Act and the Western Australian *Biodiversity Conservation Act 2016* (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 are believed to require warm (28-32 ºC) 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).

Foraging sites surrounding known or suspected roosts can be critical to the survival of the species as the species forages within the vicinity of roost caves and more broadly along waterbodies with suitable fringing vegetation supporting prey species (TSSC, 2016). 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 grass and woodland (Priority 5). The species is predicted to travel up to 20 km from roost caves during nightly foraging (Cramer *et al.*, 2016) in the dry season and up to 50 km during the wet season (Bullen, 2013).

2.2 Pilbara Leaf-nosed Bat Habitat

2.2.1 Cave CO-CA-03

Overview

Cave CO-CA-03 (Plate 2.1) was discovered in 2014 (MWH, 2016a). The cave is situated in geological layer defined as “very competent chert” (ACG, 2017), at the bottom of a gorge within Rocky Ridge and Gorge habitat (MWH, 2016a). It is surrounded *“by multiple water seepages and a large spring system that feeds into a large water pool*” (MWH, 2016a) (CO-WS-14) approximately 5 m downslope from the mouth of the cave. The cave comprises a large/ deep entrance and one major internal chamber. The entrance faces north-east and is triangular in shape measuring 5 metres (m) high by 18 m wide. The entrance extends 30 m backward toward a constriction (entrance to the main chamber) measuring 2 m high by 2 m wide. The chamber measures 4 m high by 4 m wide by 10 m deep (adapted from Terra Rosa, 2017). Two water seeps have been noted within the second chamber along the western wall (ACG, 2017; MWH, 2016a), the presence of which persist independent of season (Stantec, 2018). The presence of permanent water inside and immediately surrounding CO-CA-03 may contribute to a suitable microclimate within the cave.

Previous studies have undertaken isolated measurements of the cave’s microclimate, which show that the cave’s microclimate fluctuates throughout the year (Bat Call, 2018; Biologic, 2019a; MWH, 2018). In addition, Pilbara leaf-nosed bat have intermittently roosted with CO-CA-03 during some previous surveys (Bat Call, 2018; Biologic, 2019b; Ecology, 2014; MWH, 2017, 2018) but on every recording night during the breeding season of other surveys (Biologic, 2019a; MWH, 2016a) consequently classifying it as a Non-Permanent Breeding Roost (Priority 2) as defined in Section 2.1.

A 12 month study of ultrasonic recordings and microclimate data was recently undertaken to provide an indication of baseline levels and natural fluctuations in cave microclimate (to compare to those specified in Condition 4c-i and 4c-ii), to determine the scale and frequency with which the cave is used by the Pilbara leaf-nosed bat (to meet Condition 3) and to assess whether the internal microclimate of CO-CA-03 is the primary factor influencing Pilbara leaf-nosed bat roosting preferences (Biologic, 2020). The results of this analysis are summarised below and provided in full in Appendix C.

Plate 2.1: Cave CO-CA-03 (photo taken in 2018)

Microclimate

During the baseline review period (April 2019 to April 2020), temperatures inside CO-CA-03 were notably stable, with minimal daily fluctuation (Biologic, 2020). Temperatures inside the roost remained within the target range (28-32°C) for the entire monitoring period and did not appear to be influenced by ambient (i.e. external to the cave) temperatures.

Overall, humidity ranged from 18.1% to 99.5%, averaging 85.2% (*SE* ± 0.34). During the monitoring period, relative humidity (RH) inside CO-CA-03 was relatively high and stable from April to October 2019, whereby 100% of recordings fell within the target range (85-100%). Following this, RH declined until January 2020, whereby 12.1% of recordings fell within the target range. Finally, RH increased again from January 2020 until the end of the monitoring period. Internal RH was found to be negatively correlated with ambient temperature (above 35°C), and the relationship was mediated by two-week rainfall. Specifically, cave RH was highest when ambient temperature was between 35-40°C and two-week rainfall was ≥250 mm.

Species Use of Cave

Pilbara leaf-nosed bats were recorded on every night during the study at CO-CA-03 except for a single night; on the 8th January 2020 when Cyclone Blake hit Marble Bar. Activity ranged from 64 calls (on the 18th of January 2020) to 56,699 calls (12th of July 2019), averaging 7,033 (±619) calls per night. Roosting was indicated on 47% of recording nights during the monitoring period, of which 91.3% of roosting events occurred between April and October 2019. The level of activity and the consistency of roosting observed over this period coincides with the species mating period and therefore may indicate such activities at the cave and supports the caves classification as a Non-Permanent Breeding Roost (Priority 2). Between October 2019 and April 2020, roosting was only indicated on 8.4% of recording nights. The timing of the remaining calls suggested that individuals were in flight, possibly foraging, and roosting at another location (likely CO-CA-01).

Maximum ambient temperature, maximum cave temperature, range in cave RH and percentage moon illumination were not significant variables influencing roosting status at CO-CA-03. However, roosting (93%) and peaks in activity typically occurred when conditions were more favourable (i.e. temperature and RH within the target ranges) suggesting that these conditions are a prerequisite for roosting. Activity and roosting were however influenced by day of sampling, indicating fluctuations in roosting activity at certain times of the year, exclusive to the other variables tested. This indicates that roosting was driven by untested variables related to timing and/or a behavioural response (e.g. reproductive cues). Moreover, activity was also significantly influenced by range in RH. Therefore, it can be inferred that activity levels and the probability of roosting at CO-CA-03 increases during the mating and gestation period prior to parturition when cave RH is high and relatively stable.

2.2.2 Waterhole CO-WS-14

Overview

Along with the discovery of CO-CA-03, waterhole CO-WS-14 was discovered in 2014 (MWH, 2016a). CO-WS-14 is a 5 m wide by 5 m long (Stantec, 2018) by ~0.9-1 m deep perennial pool (SRK, 2019; Stantec, 2018), located approximately 5 m downslope from the mouth of cave CO-CA-03 and likely constitutes an important drinking source for the Pilbara leaf-nosed bat (MWH, 2016a). The TSSC (2016) defines gorges with pools as Priority 1 Foraging Habitat; "*watercourses through upland areas bounded by sheer rock walls for parts of their length, often containing pools that remain for weeks or months, sites of relatively large biomass production, sometimes containing caves*". For this reason, CO-WS-14 was considered a significant feature for the species within the local area.

During a hydrogeological investigation undertaken between October 2017 and March 2018, it was noted that water levels marginally fluctuated by 0.01 m, which reflected the recession that was observed within the water table (Stantec, 2018). Therefore, while rainfall would periodically replenish water levels within CO-WS-14, it was concluded that the pool was likely groundwater dependant (SRK, 2019; Stantec, 2018). Moreover, the waterhole is located directly under a ledge over which water flows continually. While the water flowing over the ledge may be replenished by surface water overland flow following a rainfall event, it has been observed independent of seasonality. Therefore, the seepage is likely fed by a combination of groundwater discharge and unsaturated flow (Stantec, 2018).

A 12 month study of this pool was recently undertaken to provide an indication of baseline levels and natural fluctuations in pool water quality and levels (required by Condition 4.3), to inform Condition 4a and Condition 4b (Biologic, 2020). The results of this analysis are summarised below and provided in full in Appendix C.

Plate 2.2: Pool CO-WS-14 (photo taken in 2018)

Water Level

Water was observed at CO-WS-14 during the entire monitoring period and has been observed at the pool since its discovery. The pool base level equates to 320.09 metres reduced level (mRL). During the monitoring period (April 2019 to April 2020), water depth at CO-WS-14 was relatively stable (Biologic, 2020). Field observations of water depth ranged from 320.98 mRL to 321.04 mRL (0.06 m difference), averaging ~0.91 meters (m) relative to a staff gauge of 321.00 (std = 0.02) mRL (Table 2.1). Results were emulated in supplementary water logger data (available from the 1st April 2019 until the 30th July 2019) as well as long-term field observations and long-term water logger data (from October 2017 until April 2020; ~2.5 years) recorded at the site (Table 2.1).

Table 2.1: Water depth (mRL) at CO-WS-14

Summary Stats	Field Observations		Water Logger Data	
	April 2019 – April 2020	Long-Term	April – July 2019	Long-Term
Average	321.00	320.99	320.96	320.98
Std	0.02	0.02	0.03	0.03
Min	320.98	320.94	320.90	320.90
Max	321.04	321.04	321.03	321.57
Difference	0.06	0.95	0.1	0.7

Water Quality

Due to the relative locations of CO-CA-03 and CO-WS-14, Pilbara leaf-nosed bat activity recorded at CO-CA-03 is inferred to represent activity for both sites. Pilbara leaf-nosed bats were recorded at CO-CA-03 on every night during the study period, except for a single night (on the 8th January 2020 when Cyclone Blake hit Marble Bar) suggesting the water quality at the CO-WS-14 through the monitoring period was suitable for the species.

During the baseline review period (April 2019 to April 2020), 42 organics, inorganics, physicals, and dissolved metals were analysed to delineate water quality parameters at the site (Biologic, 2020). Water quality was generally good and characterised by circum-neutral to slightly basic pH, fresh waters, with generally low dissolved metals and nutrient concentrations. For analytes with corresponding ANZECC (2000) default guideline values (DGVs), comparisons were made to the 95% DGVs for the protection of aquatic systems (ANZECC, 2000). While most analytes were within ANZG DGV's, two were in excess of the 95% DGV (electrical conductivity and N_NOx). Iron concentrations were within DGVs during the baseline review period. However, the 95% DGV for iron was exceeded on one occasion in December 2017.

3 REVIEW OF CONDITIONS RELATING TO MONITORING STRATEGY

Following the completion of 12 months of baseline monitoring (Biologic, 2020; Appendix C), required by Condition 4.2 and 4.3 of the EPBC Approval (2017/7861) to inform this Monitoring Strategy, it has become apparent that some of the other components of Condition 4 may not be achievable, specifically Condition 4(c). This section aims to review and provide justification for any proposed alternative condition components/ performance objective (Table 3.1). All alternatives have been developed using the SMART principles of specific, measurable, achievable, realistic, and timely.

Table 3.1: Review of EPBC Approval (2017/7861) Condition 4 and Proposed Alternatives

Original Condition Component	Alternate Condition Component/ Performance Objective	Justification
4. The approval holder must develop and submit a Monitoring Strategy to the Minister for approval. The Monitoring Strategy must be based on: ● mapping and monitoring of cave CO-CA-03 by an independent scientific expert(s) approved by the Department; ● the collection of at least 12 months of baseline humidity and temperature recordings inside cave CO-CA-03; and ● 12 months of baseline water quality sampling of pool CO-WS-14.	N/A	Atlas Iron has complied with all three requirements: ● In 2017, pre-mining structure was reported by ACG (2017); ● a subsequent 3D laser scan of the cave interior was completed by (Terra Rosa, 2017). ● 12 months of consecutive baseline monitoring of Cave CO-CA-03 and pool CO-WS-14 was completed between April 2019 and April 2020 (Biologic, 2020; Appendix C).
The Monitoring Strategy must be designed to demonstrate that the structure of cave CO-CA-03 remains unchanged from the pre-mining structure during mining of the Razorback Pit.	The Monitoring Strategy must be designed to demonstrate that during the mining of Razorback Pit, the structure of cave CO-CA-03 is not significantly altered in any way that would prevent its ongoing use as a non-permanent breeding roost for Pilbara Leaf-nosed Bats	Atlas note that this condition varies from the associated performance objective in the Significant Species Management Plan reviewed and approved by the DAWE (Condition 7), which states: ‘*No significant damage to identified caves* [cave CO-CA-03 and cave CO-CA-01 not within the scope of this monitoring strategy] *that would prevent their ongoing use by Pilbara Leaf-nosed bats*.’ The assessment and SSMP recognised that there may be minor structural damage (i.e., rock fall) within the cave which would present no risk to the species. Also note that the approval defined Pre-mining structure as: *‘…The structure of cave CO-CA-03 as described in the document (particularly figures 2 and 3) dated 7 August 2017, authored by Dr Phil Dight of Australian Centre of Geomechanics, entitled Corunna Cave Project – CO-CA_03 Cave Stability Assessment, which was provided to the Department on 15 August 2017.’* Atlas Iron note that subsequent to the above report a 3D laser scan of the cave interior was completed by (Terra Rosa, 2017). This pre-mining structure (Figures 2 and 3 of ACG (2017)) has been adapted in consideration of the more accurate laser scan data and is provided in Appendix A

Original Condition Component	Alternate Condition Component/ Performance Objective	Justification
The Monitoring Strategy must also be designed to demonstrate, unless otherwise justified and approved by the Minister, that: 4a) without anthropogenic supplementation of its water level, pool CO-WS-14 has water in it during and continuously for three consecutive years following the cessation of mining of Razorback Pit	N/A	This condition is appropriate, pool CO-WS-14 has been confirmed to be permanent (i.e. contains water all year round) as detailed in Section 2.2.2.
The Monitoring Strategy must also be designed to demonstrate, unless otherwise justified and approved by the Minister, that: 4b) the water quality of pool CO-WS-14 remains suitable for Pilbara leaf-nosed bat during and continuously for three consecutive years following the cessation of mining of Razorback Pit	N/A	While there is no published research/data on suitable water quality parameters for this species, given the consistency at which the species utilises this site as a foraging location (i.e. CO-CA-03 and by virtue CO-WS-14) it suggests water quality recorded at CO-WS-14 during the baseline monitoring was suitable for the species. Data collected over the 12 month baseline monitoring period, in conjunction with national freshwater standards (ANZECC, 2000) will serve to inform the establishment of suitable water quality parameter targets as detailed in Section 2.2.2. A total of 32 analytes will be used to monitor water suitability (Appendix B).
The Monitoring Strategy must also be designed to demonstrate, unless otherwise justified and approved by the Minister, that: 4c-i) cave CO-CA-03 maintains humidity between 85-100 per cent relative humidity during and continuously for five years following cessation of the mining of Razorback Pit	4c-i) cave CO-CA-03 maintain 85-100 per cent relative humidity for at least 50% of each year during, and for five years following cessation of, mining of Razorback Pit	Over the 12-month baseline monitoring period, humidity ranged from 18.1% to 99.5%, averaging 85.2% (SE ± 0.32). However, only 75.3% of humidity recordings over this period fell within the target range (85-100%). Roosting was only indicated at CO-CA-03 on 47% of the sampling days, indicating that humidity is not the only factor influencing roosting behaviour. Relative humidity was significantly correlated with rainfall. A total of 725 mm of rainfall was received during the monitoring period, higher than the long term average for the same period. It is therefore likely that the occurrence of relative humidity within the target range (85-100%) will be less than what was recorded during the baseline monitoring (~75%). Given that Pilbara leaf-nosed bats utilised cave CO-CA-03 as a diurnal roost for approximately 50% of the monitoring year, it is recommended that the relative humidity remain within the optimal range for a similar portion of each monitoring year, to permit consistent use by the species. This target, whilst lower than that recorded, takes into consideration annual rainfall variability (and therefore annual relative humidity variation) and ensures that relative humidity is within the optimal range for at least 25% of the 9 month breeding cycle (July to March), therefore increasing likelihood the cave being used as non-permanent breeding roost for Pilbara Leaf-nosed Bats.

Original Condition Component	Alternate Condition Component/ Performance Objective	Justification
The Monitoring Strategy must also be designed to demonstrate, unless otherwise justified and approved by the Minister, that: 4c-ii) cave CO-CA-03 maintains temperature between 28 and 32 degrees Celsius during and continuously for five years following cessation of the mining of Razorback Pit	4c-ii) cave CO-CA-03 maintains temperature between 28 and 32 degrees Celsius for at least 95% of each year during, and for five years following cessation of, mining of Razorback Pit	Over the 12-month baseline monitoring period, temperature within this cave were notably stable with very little daily fluctuation and ranged from 28.0 to 31.6ºC, averaging 30.3ºC (SE ± 0.02ºC). Temperatures inside the roost remained within the target range (28-32ºC) for the entire monitoring period (100%). However, as the minimum temperature recorded was also the lower limit of the target range (28.0°C), it is possible that the temperature may drop below this threshold under natural conditions not captured within the 12-month baseline monitoring period. Therefore, temperatures maintained between 28 and 32 degrees Celsius for at least 95% of each year would allow for natural year to year variability in temperature to be captured.

4 MONITORING STRATEGY

This Monitoring Strategy aims to document changes to the suitability of CO-CA-03 and CO-WS-14 as habitat for Pilbara leaf-nosed bat, in line with condition 4 of EPBC Approval Decision 2017/7861, during and following the cessation of mining at Razorback pit.

Following the review and proposal of alternative condition components/ performance objectives in Section 3, key performance indicators (KPI's) have been defined and outlined in Table 4.1. Trigger values were also developed to monitor progress toward achieving the key performance objective and to indicate when corrective actions need to be investigated and implemented. Key performance objectives, KPI's, trigger values and likely corrective actions are provided in Table 4.1 along with a summary of the relevant monitoring methods and timing which are discussed further in the following sections.

Table 4.1: Monitoring Strategy Overview

Alternative Condition Components/ Performance Objectives	Key Performance Indicators	Monitoring Technique/ Frequency	Trigger Values	Corrective Actions
No significant damage to CO-CA-03 that would prevent its ongoing use by Pilbara Leaf-nosed bats as a non-permanent breeding roost	Development and implementation of Razorback Blast Management Plan prior to mining commencing by a qualified specialist, which establishes appropriate blast parameters, blast vibration limits at the cave, blasting procedures and blast vibration monitoring.	Blast vibration monitoring as detailed within the Razorback Blast Management Plan (*in prep.).*	• Exceedance of Blast vibration limit. • Non-compliance with Razorback Blast Management Plan.	Where any of these trigger values are recorded, Atlas Iron will, within one month, review the likely cause (with input by suitably qualified specialists as required) and implement one or more of the following corrective actions as appropriate: • Review Razorback Blast Management Plan; • Increase frequency of cave inspections; • Review cave microclimate data; • Commission additional laser scan of cave; • Undertake a geotechnical assessment to reassess the structural integrity and the susceptibility of the cave to structural changes, in light of blast monitoring details and laser scans. • Undertake any practical corrective rehabilitation (e.g. removal of rock fall or sealing of significant fractures), where any identified damage is considered to have the potential to affect ongoing use by bats (i.e. damage which may prevent exit/entry or alter microclimate).
	No major structural damage to cave CO-CA-03 (i.e., collapse of cave entrance or entrance to main chamber, or opening of large fractures which result in loss/change microclimate).	Monthly visual cave inspections during mining (at Razorback pit) and annually thereafter as detailed in Section 4.2.2. Blast vibration monitoring as detailed within the Razorback Blast Management Plan (*in prep.).* Annual laser scan of cave CO-CA-03 during, and a year after cessation of, mining of Razorback pit.	• Minor to moderate rock fall within or at the entrance of the cave (i.e. does not impede bat movements/entrance into the cave and rear chamber). • New fractures.	
	CO-CA-03 is used as a non-permanent breeding roost by Pilbara leaf-nosed bat at least once in the five years following the cessation of mining of Razorback Pit.	Annual Pilbara leaf-nosed bat ultrasonic monitoring annually for up to five years following the cessation of mining at Razorback pit, in accordance with the methodology detailed in the SSMP (Condition 7) and summarised in Section 4.2.6.	• No record of Pilbara Leaf-nosed Bat roosting in the first two years following cessation of mining at Razorback pit.	
Maintain suitable microclimate for Pilbara leaf-nosed bats within cave CO-CA-03 during, and for five years following cessation of, mining of Razorback Pit	Cave CO-CA-03 maintain 85-100 per cent relative humidity for at least 50% of each year of monitoring.	Continuous microclimate monitoring, during (to be analysed quarterly and reported annually) and for up to five years following the cessation of mining (to be analysed and reported annually) at Razorback pit, as detailed in Section 4.2.5.	• Cave CO-CA-03 maintain 85-100 per cent relative humidity for less than 75% of a monitoring year	
	Cave CO-CA-03 maintains a temperature between 28 and 32 degrees Celsius for 95% of each year of monitoring.		• Cave CO-CA-03 maintains a temperature between 28 and 32 degrees Celsius for less than 98% of a monitoring year	
Persistence of CO-WS-14 during, and continuously for three consecutive years following the cessation of, mining of Razorback Pit	CO-WS-14 continuously contains water during, and for three consecutive years following the cessation of, mining of Razorback pit. No anthropogenic supplementation of CO-WS-14 water level	Monthly visual inspection of pool staff gauge (and download of data loggers) during mining of the Razorback pit as detailed in Section 4.2.3. This monitoring will continue for three years following the cessation of mining at the Razorback pit quarterly in the first year and annually thereafter.	• Water level drops below 320.77 mRL (or 320.17 mRL on staff gauge) – equates to 95% of the minimum baseline reading.	Where this trigger value is recorded, Atlas Iron will, within one month, review the likely cause and implement one or more of the following corrective actions as appropriate: • Review WL field measurement and logger data. • Increase pool monitoring frequency. • Review Site Water Operating Plan, monitoring data and water abstraction rates and requirements. • Investigate ongoing use by Pilbara leaf-nosed bats.

Alternative Condition Components/ Performance Objectives	Key Performance Indicators	Monitoring Technique/ Frequency	Trigger Values	Corrective Actions
Maintain suitable water quality for Pilbara Leaf-nosed Bats within pool CO-WS-14 during, and for three consecutive years following cessation of, mining of Razorback Pit	Development and implementation of a specific Razorback Hydrocarbon (and chemical) Spill Management Procedure prior to mining of the Razorback pit commencing. Exceedance of acceptable Naphthalene levels (in accordance with ANZECC (2000) 95% GV's (Appendix B)	Quarterly water sampling and testing during mining of the Razorback pit as detailed in Section 4.2.4. This monitoring will continue for three years following the cessation of mining at the Razorback pit quarterly in the first year and annually thereafter.	• Non-compliance with Razorback Hydrocarbon (and chemical) Spill Management Procedure. • Exceedance of acceptable Naphthalene levels (in accordance with ANZECC (2000) 99% GV's (Appendix B)	Where any of these trigger values are recorded, Atlas Iron will within one month review the likely cause (with input by suitably qualified specialists as required) and implement one or more of the following corrective actions as appropriate: • Additional sampling and testing for hydrocarbons after a non-compliance with Razorback Hydrocarbon (and chemical) Spill Management Procedure. • Increase pool monitoring frequency. • Review Razorback Hydrocarbon (and chemical) Spill Management Procedure. • Review Site Water Operating Plan, monitoring data and water abstraction rates and requirements. • Investigate surface water and sediment runoff around the pit and implement any necessary repairs to surface water controls (i.e. bunds). • Review recommendation for exceedances provided by (ANZG, 2018).
	Water quality of pool CO-WS-14 shall not exceed site-specific GV (SSGV's) (Appendix B).		• Exceedance of 80th percentile SSGVs (Appendix B) over two consecutive quarterly monitoring events.	

4.1 Monitoring Schedule

This Monitoring Strategy comes into action at the commencement of mining at the Razorback pit (currently planned for September 2021) and stays in force for up to 5 years following the cessation of mining of this pit (currently anticipated July 2023). A summary of the monitoring schedule is outlined in Table 4.2. To adequately capture the breeding season, quarterly monitoring should occur in January, April, July and October of each year. Please note these dates are subject to change dependent on the actual start and end of mining at Razorback and will be adjusted accordingly.

Table 4.2: Monitoring schedule

Monitoring Technique	Frequency	During Mining*			Post-mining				
		2021	2022	2023	2024	2025	2026	2027	2028
Visual cave inspection	Monthly during mining, annually thereafter	Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec			Between Apr-Sep				
Laser scan	Annually	Between Oct-Mar			Oct-Mar	-			
Pool monitoring – water levels	Monthly during mining, quarterly for the first year post-mining, annually thereafter	Jan, Feb, Mar, Apr, May, Jun, Jul, Aug, Sep, Oct, Nov, Dec			Jan, Apr, Jul, Oct	Oct		-	
Pool monitoring – water quality	Quarterly during mining and for the first year post-mining, annually thereafter	Jan, Apr, Jul, Oct			Jan, Apr, Jul, Oct	Oct		-	
Microclimate monitoring	Continuous collection of data with quarterly analysis during mining and annual analysis thereafter	Jan, Apr, Jul, Oct			Between Apr-Mar				
Ultrasonic monitoring	Annually in conjunction with SSMP requirements	Between Apr-Sep			Between Apr-Sep				

Note: Above schedule based on the commencement of mining at the Razorback pit in September 2021 and completion of mining in July 2023. these dates are subject to change dependent on the actual start and end of mining at Razorback and will be adjusted accordingly.

4.2 Monitoring Methods

4.2.1 Visual cave inspection

Visual cave inspections will be conducted in accordance with the frequency and schedule in Table 4.2 to compare physical features of the cave against the pre-mining structure, as adapted from Terra Rosa (2017), to document any changes over time. In addition, a visual cave inspection will also be conducted a month ahead of mining commencing to inform current baseline condition and to install drop sheets across the cave floor to support the identification of any rockfall during mining. Each visual cave inspection will record the following characteristics (see Appendix A):

- Entrance photographs (at two established photo monitoring points);
- Evidence of structural damage;
    - Are there any new open or intersecting joints or fractures along the roof, wall or bedding planes of the cave?
    - Are there any loose rocks or signs of fresh rock fall within the cave? If yes, note;
        - Amount of dust and/or fallen rocks
        - Size of largest rock
- Water presence; and
- Presence of target species: no. individuals, and/or secondary evidence.

Given the proximity of the proposed Razorback Pit, mining activity during visual cave inspections will need to be considered to ensure the safety of personnel inspecting the cave.

Visual cave inspections will be supplemented by blast monitoring conducted in accordance with the Razorback Blast Management Plan (*in prep*.), which will include monitoring for changes in cave condition during blasting by geotechnical engineers.

4.2.2 Laser scan cave CO-CA-03

A suitably qualified professional will be commissioned by Atlas Iron to undertake a laser scan of cave CO-CA-03 each year between October-March (outside the breeding season to limit disturbance to the species) during mining of the Razorback pit and in the first year after mining.

The results of the laser scan will be compared to the baseline (conducted by, Terra Rosa, 2017) and any subsequent scans to identify whether there has been any change in pre-mining condition/structure of the cave.

4.2.3 Pool monitoring – water levels

Routine monitoring of waterhole CO-WS-14 will be undertaken in accordance with the frequency and schedule in Table 4.2 to track changes in water quantity.

To delineate water quantity visual observations including water height (relative to the staff gauge), water colour and water flow as well as temperature, pH and conductivity will be noted. To supplement these observations, a water logger will be deployed in the water body to measure water temperature, pressure, and depth on a more regular basis.

4.2.4 Pool monitoring – water quality

Routine monitoring of waterhole CO-WS-14 will be undertaken in accordance with the frequency and schedule in Table 4.2 to track changes in water quality.

Water quality samples will need to be collected from the site using best practice procedures to minimise any potential for contamination (Ahlers *et al.*, 1990; Batley, 1989; Madrid & Zayas, 2007). Undisturbed water samples should be taken for laboratory analyses of ionic composition, nutrients, dissolved metals and total suspended solids and Polycyclic Aromatic Hydrocarbons (PAH) (Table 4.3). Samples collected for dissolved metals should be filtered through 0.45 μm Millipore nitrocellulose filters in the field (up to 250 mL). All water samples should be collected using clean Nalgene sample bottles, and clean/new filters and syringes. All water quality sampling equipment should be stored in polyethylene bags, and samplers should wear polyethylene gloves whilst sampling water quality. All water samples need to be kept cool in an esky whilst in the field, and either refrigerated (ions, dissolved metals, nutrients, general water), or frozen (total nutrients) as soon as possible for subsequent transport to the laboratory. A NATA accredited chemical analysis laboratory should always be used that can achieve sufficiently low LODs to allow comparison with ANZECC (2000) DGVs and/or site-specific guideline values (SSGVs) developed here.

Table 4.3: Water quality analytes to be monitored

Analyte	Unit	Analyte	Unit
pH		Dissolved Antimony (dSb)	mg/L
Electrical Conductivity (EC)	µS/cm	Dissolved Arsenic (dAs)	mg/L
Nitrate as NO_3	mg/L	Dissolved Barium (dBa)	mg/L
Nitrite as NO_2	mg/L	Dissolved Boron (dBo)	mg/L
NOx as N (N_NOx)	mg/L	Dissolved Cadmium (dCd)	mg/L
Calcium (Ca)	mg/L	Dissolved Chromium (dCr)	mg/L
Potassium (K)	mg/L	Dissolved Cobalt (dCo)	mg/L
Magnesium (Mg)	mg/L	Dissolved Copper (dCu)	mg/L
Sodium (Na)	mg/L	Dissolved Iron (dFe)	mg/L
Bicarbonate HCO_3	mg/L	Dissolved Lead (dPb)	mg/L
Carbonate CO_3^{2-}	mg/L	Dissolved Manganese (dMn)	mg/L
Total Alkalinity	mg/L	Dissolved Mercury (dHg)	mg/L
Chloride (Cl)	mg/L	Dissolved Molybdenum (dMo)	mg/L
Sulphate (SO_4)	mg/L	Dissolved Nickel (dNi)	mg/L
Silica (Si)	mg/L	Dissolved Selenium (dSe)	mg/L
Dissolved Aluminium (dAl)	mg/L	Dissolved Zinc (dZn)	mg/L
		Polycyclic Aromatic Hydrocarbons (PAH) - Napthalene	mg/L

The data collected during each monitoring event will be compared to the baseline review (Biologic, 2020) to determine any significant changes to the water quality at CO-WS-14. For analytes that were within ANZECC/ANZECC (2000) guidelines during the baseline review, the DGV's are proposed as the operational guideline. Additionally, where the ANZG DGV for 95% species protection was greater than the 80th percentile value derived from the baseline data, the default ANZG DGV is proposed as the operational guideline. Analytes within DGVs include pH, nitrate, dAl, dAs, dBo, dCd, dCr, dCu, dPb, dMn, dNi, dFe, dZn and dSe (see Appendix B for levels). For analytes where the 80th percentile value of baseline data was greater than the default 95% GV, the 80th percentile value is proposed as the operational guideline. Moreover, for the analytes which do not have a corresponding ANZG GV, SSGVs were based solely on the 80% percentile of reference data. Analytes for which the 80th percentile will be used for ongoing monitoring include EC, nitrite, N_NOx, Ca, K, Mg, Na, HCO_3, CO_3^{2-}, total alkalinity, Cl, SO_4, Si, dSb, dBa, dCo, dHg and dMo (see Appendix B for levels).

4.2.5 Microclimate monitoring

Cave microclimate (temperature and relative humidity) will be monitored continuously, analysed quarterly, and reported annually during mining (analysed and reported annually thereafter). To assess the interior microclimate within CO-CA-03, temperature and humidity loggers will be deployed in the same location as during the baseline review (Biologic, 2020). Data loggers will be set to record at a minimum of every 6 hours starting from 00:00.

The temperature and humidity range recorded (daily minimum and maximum) will then be plotted against the target ranges; 28–32°C for temperature and 85–100% for RH. The data collected during each monitoring event will be statistically compared to the baseline review (Biologic, 2020) and any previous monitoring event (Biologic, 2019a; MWH, 2018).

4.2.6 Ultrasonic monitoring

To supplement the microclimate monitoring, and to track the use of CO-CA-03 during mining so as to better inform its' use following the cession of mining at Razorback pit, an ultrasonic recorder will be established at CO-CA-03 (deployed in the same location as during the baseline review (Biologic, 2020). To determine ongoing use of cave CO-CA-03 during and post mining, ultrasonic monitoring will be undertaken in accordance with the frequency and schedule in Table 4.2. Monitoring will be undertaken in accordance with SSMP.

The data collected during each monitoring visitation will be analysed following the methods of the review (Biologic, 2020) and statistically compared to the baseline monitoring data (Biologic, 2020) and any previous monitoring event (Biologic, 2019a; MWH, 2018).

4.2.7 Pre-mining activities

Prior to the commencement of mining at Razorback, the following will need to be implemented to ensure monitoring can be effectively completed as per this document:

- One baseline visual cave inspection needs to be conducted and drop sheets need to be placed in the floor of cave CO-CA-03 to inform cave inspections;
- Ultrasonic bat recording system to be established in way to permit regular download of data without need to enter cave;
- Microclimate monitoring system to be established in way to permit regular download of data without need to enter cave. Equipment should be set to allow comparison with baseline dataset

4.3 Reporting

Microclimate data will be analysed and reported to Atlas Iron on a quarterly basis to ensure regular assessment against the trigger values and Key Performance Indicators. All results are to be summarised and presented in annual monitoring period. A standalone report at the conclusion of each annual monitoring period (January to December) will be prepared. Annual reporting should follow activity within a calendar year to best align with species reproductive cycle.

The report will be compiled by a suitably qualified zoologist, and will:

- Summarise the analysis of microclimate and ultrasonic data as well as water quality and quantity data including methods, results, discussion.
- Compare microclimate and ultrasonic data with baseline levels.
- Summarise the outcomes of cave inspections and laser scans.
- Assess performance against each of the monitoring strategies key performance objectives and KPIs.
- Detail any corrective actions undertaken or considered (or reasoning as to why any corrective actions were not undertake or considered)
- Make any necessary recommendations.

The report will be appended to Atlas Irons AER and submitted to the DAWE by 30 June of each year.

5 REFERENCES

ACG, Australian Centre for Geomechanics. (2017). *Corunna cave project: CO-CA-03 cave stability assessment*. Unpublished report prepared for Atlas Iron Limited.

Ahlers, W. W., Reid, M. R., Kim, J. P., & Hunter, K. A. (1990). Contamination-free sample collection and handling protocols for trace elements in natural fresh waters. *Australian Journal of Marine and Freshwater Research, 41*, 713-720. doi:https://doi.org/10.1071/MF9900713

ANZECC, Australian and New Zealand Environment and Conservation Council. (2000). *National Water Quality Management Strategy: Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. PAPER No. 4. Artarmon, New South Wales:

ANZG. (2018). Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Retrieved from www.waterquality.gov.au/anz-guidelines

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

Atlas Iron, Pty Ltd. (2019). *Corunna Downs project supplementary report - EPA referral*. Unpublished report for the Environmental Protection Authority (EPA).

Atlas Iron Limited. (2018). *Corunna Downs project mine closure plan*.

Bat Call, WA. (2018). *Corunna Downs cave CO-CA-03 Pilbara leaf-nosed bat roost census, November 2017*. Unpublished report prepared for Atlas Iron Limited.

Batley, G. E. (1989). Collection, preparation and storage of samples for speciation analysis. In G. E. Batley (Ed.), *Trace Element Speciation: Analytical Methods and Problems* (pp. 1-24). Boca Raton: CRC Press, Inc.

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, Environmental Survey. (2019a). *Corunna Downs project Pilbara Leaf-nosed Bat and Ghost Bat monitoring survey 2019*. Unpublished report prepared for Atlas Iron Limited.

Biologic, Environmental Survey. (2019b). *Corunna Downs project, northern quoll monitoring survey 2018*. Unpublished report prepared for Atlas Iron Limited.

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

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.

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.

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

Ecology, O. (2014). *Corunna Downs project: Terrestrial vertebrate fauna baseline assessment*. Unpublished report prepared for Atlas Iron Limited.

Madrid, Y., & Zayas, Z. P. (2007). Water sampling: Traditional methods and new approches in water sampling strategy. *Trends in Analytical Chemistry, 26*(4), 293-299.

MWH, Australia. (2014). *Mt Dove DSO Project: Pilbara Leaf-nosed Bat Monitoring 2014*. Unpublished report prepared for Atlas Iron Limited.

MWH, Australia. (2016a). *Corunna Downs project: Terrestrial vertebrate fauna survey*. Unpublished report prepared for Atlas Iron Limited.

MWH, Australia. (2016b). *Corunna Downs project: Vertebrate fauna impact assessment*. Unpublished report prepared for Atlas Iron Limited.

MWH, Australia. (2017). *Current understanding of the importance of CO-CA-03 for the pilbara leaf-nosed bat*. Unpublished report prepared for Atlas Iron Limited.

MWH, Australia. (2018). *Corunna Downs project: Pilbara leaf-nosed bat and ghost bat baseline monitoring survey*. Prepared For Atlas Iron Limited:

SRK, Consulting. (2019). *Corunna Downs mine water supply: H3 hydrogeological assessment*. Unpublished report prepared for Atlas Iron Limited.

Stantec, Australia. (2018). *Corunna Downs Project Hydrogeological Investigation*. Unpublished report prepared for Atlas Iron.

Terra Rosa. (2017). *CO-CA-03 Laser Scan*. Unpublished dataset prepared for Atlas Iron Limited.

TSSC, Threatened Species Scientific Committee. (2016). *Conservation Advice: Rhinonicteris aurantia (Pilbara form), Pilbara Leaf-nosed Bat*. Canberra, Australian Capital Territory:

6 APPENDICES

Appendix A: Visual Cave Inspection Checklist

Visual Cave Inspection at CO-CA-03 Against the Pre-mining Structure	
Date: ____/_____/_____	Personnel:
Time:	
Assessment Criteria	**Observation**
Presence of Pilbara leaf-nosed bats (no. individuals and/or secondary evidence)	
Main Entrance	
Any new open or intersecting joints or fractures along the roof, wall or bedding planes?	
Loose rocks or signs of fresh rock fall within the cave? If yes, note; • Amount of dust/fallen rocks • Size of largest rock	
Entrance to Roosting Chamber	
Any new open or intersecting joints or fractures along the roof, wall or bedding planes?	
Loose rocks or signs of fresh rock fall within the cave? If yes, note; • Amount of dust/fallen rocks • Size of largest rock	
Roosting Chamber	
Water Seeps Present?	
Any new open or intersecting joints or fractures along the roof, wall or bedding planes?	
Loose rocks or signs of fresh rock fall within the cave? If yes, note; • Amount of dust/fallen rocks • Size of largest rock	

Visual Cave Inspection at CO-CA-03 Against the Pre-mining Structure

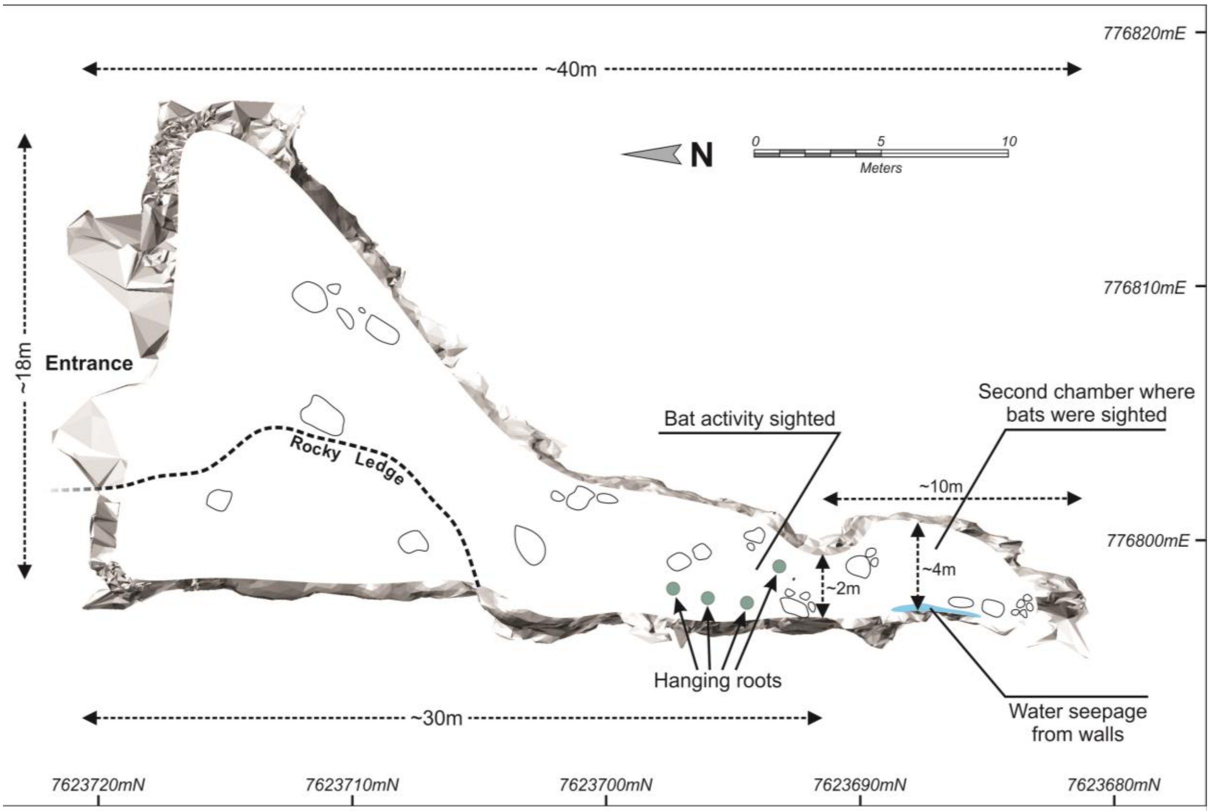


Figure 6.1: Bird Eye View of CO-CA-03 (adapted from Terra Rosa, 2017)

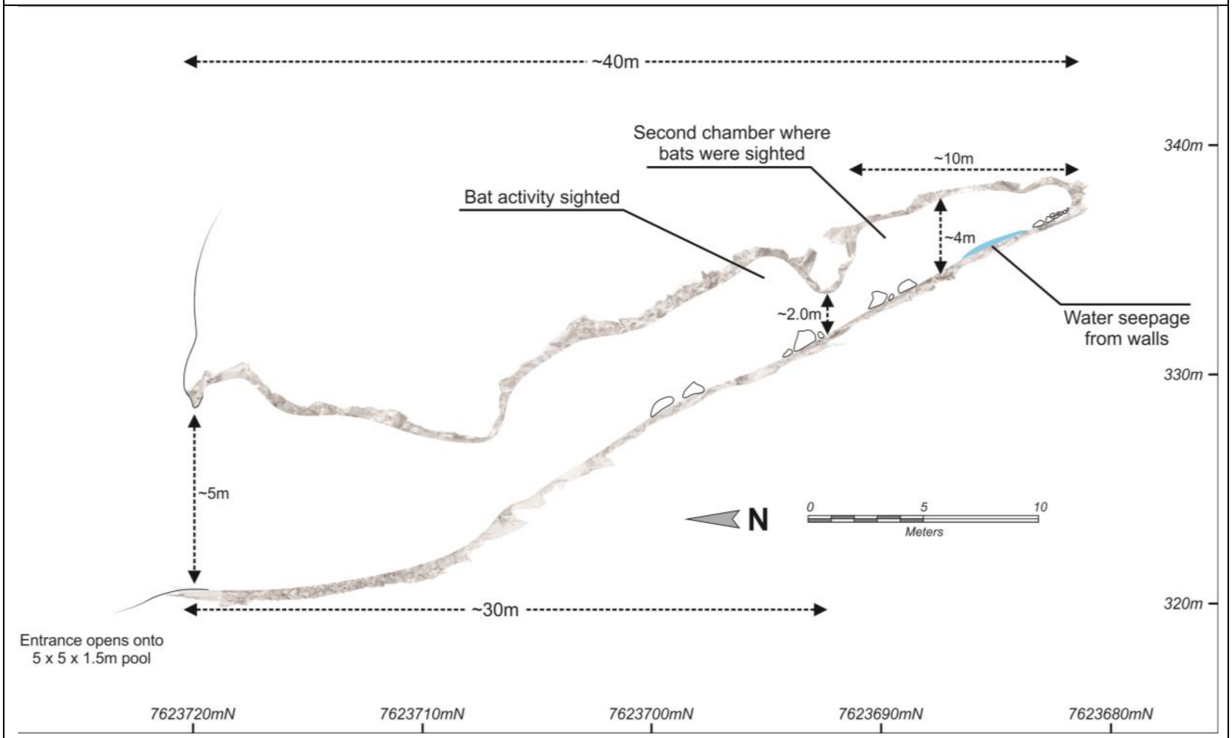


Figure 6.2: Lateral View of CO-CA-03 (adapted from Terra Rosa, 2017)

Appendix B: Water Quality

Where baseline levels of the analytes exceeded the 95% GV (prescribed by ANZECC, 2000) or where 95% GV were unavailable, 95th percentiles were calculated as site specific GVs [SSGVs]. SSGVs are usually set as targets in which to maintain a system; once the values fall outside of the SSGV, a level of disturbance may be inferred. SSGVs are usually set in terms of some identified, acceptable level of change from 'reference' condition, with the extent of allowable change sufficiently small as to represent a low level of risk of considerable disturbance to the ecosystem. ANZECC (2000) provide the national standard for developing these targets with respect to water and sediment quality and set SSGVs at the 80th percentile and/or 20th percentile (for analytes which also require a lower GV, i.e. pH and dissolved oxygen) of the baseline condition. These percentiles are deemed to be approximately equivalent to ± one standard deviation around the median, and this level of change is considered unlikely to result in a high risk of disturbance to the ecosystem (ANZECC, 2000).

Note that the number of monitoring analytes has been reduced to those that reflect quality of freshwater for aquatic systems (e.g. removing laboratory checks and tests such as ionic balance, sum on anions, sum of cations etc.) and to avoid duplicating tests (e.g. TDS which is a surrogate of EC).

Analyte	Unit	20th Percentile	80th Percentile	95th Percentile	ANZECC (2000) DGV95%	ANZECC (2000) DGV99%	SSGV
Naphthalene					0.016	0.0025	TV = 0.0025 KPI = 0.016
pH		7.5	7.98	8	6 - 8		6 - 8
Electrical Conductivity (EC)	µS/cm	-	348	360	250		360
Nitrate as NO_3	mg/L	-	0.25	1	2.4		2.4
Nitrite as NO_2	mg/L	-	0.25	1			1
NOx as N (N_NOx)	mg/L	-	0.0252	0	0.01		0.0252
Calcium (Ca)	mg/L	-	12	13			13
Potassium (K)	mg/L	-	1.64	3			3
Magnesium (Mg)	mg/L	-	22	23			23
Sodium (Na)	mg/L	-	22	24			24
Bicarbonate HCO_3	mg/L	-	93.8	100			100
Carbonate CO_3^{2-}	mg/L	-	2.5	3			3
Total Alkalinity	mg/L	-	93.8	100			100
Chloride (Cl)	mg/L	-	33	135			135
Sulphate (SO_4)	mg/L	-	30	79			79
Silica (Si)	mg/L	-	18.8	20			20
Dissolved Aluminium (dAl)	mg/L	-	0.005	0	0.055		0.055
Dissolved Antimony (dSb)	mg/L	-	0.0005	0			0.0005
Dissolved Arsenic (dAs)	mg/L	-	0.0005	0	0.024		0.024
Dissolved Barium (dBa)	mg/L	-	0.0086	0			0.0086
Dissolved Boron (dBo)	mg/L	-	0.1	0	0.37		0.37
Dissolved Cadmium (dCd)	mg/L	-	0.00005	0	0.0002		0.0002
Dissolved Chromium (dCr)	mg/L	-	0.0005	0	0.001		0.001
Dissolved Cobalt (dCo)	mg/L	-	0.0005	0			0.0005
Dissolved Copper (dCu)	mg/L	-	0.0005	0	0.0014		0.0014
Dissolved Iron (dFe)	mg/L	-	0.048	0	0.3		0.3
Dissolved Lead (dPb)	mg/L	-	0.0005	0	0.0034		0.0034
Dissolved Manganese (dMn)	mg/L	-	0.258	0	1.9		1.9
Dissolved Mercury (dHg)	mg/L	-	0.00005	0			0.00005

Analyte	Unit	20th Percentile	80th Percentile	95th Percentile	ANZECC (2000) DGV95%	ANZECC (2000) DGV99%	SSGV
Dissolved Molybdenum (dMo)	mg/L	-	0.0005	0			0.00005
Dissolved Nickel (dNi)	mg/L	-	0.0005	0	0.011		0.011
Dissolved Selenium (dSe)	mg/L	-	0.0005	0	0.011		0.011
Dissolved Zinc (dZn)	mg/L	-	0.0025	0	0.008		0.008

Appendix C: Corunna Downs Pilbara Leaf-nosed Bat Roost Analysis



Corunna Downs Pilbara Leaf-nosed Bat Roost Analysis

Biologic Environmental Survey

Report to Atlas Iron Pty Ltd

July 2020

Document Status				
Revision No.	Author	Review / Approved for Issue	Approved for Issue to	
			Name	Date
1	B. Downing; C. Knuckey; L. Dinis	C. Knuckey	N. Bell	5/06/2020
2	B. Downing;	C. Knuckey	N. Bell	17/06/2020
3	A. Hutchison	C. Knuckey	N. Bell	10/07/2020
4	B. Downing	C. Knuckey	N. Bell	13/07/2020

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EXECUTIVE SUMMARY

Atlas Iron Pty Ltd (Atlas Iron) are looking to develop the Corunna Downs Project (the Project) located approximately 25 kilometres (km) south-west of Marble Bar within the Chichester subregion of Western Australia's Pilbara bioregion. The Project was approved by the Department of the Environment and Energy (DoEE) on the 23rd of February 2018 (*Environment Protection and Biodiversity Conservation (EPBC) Act 1999* Approval Decision 2017/7861) subject to four conditions directly relevant to the Pilbara leaf-nosed bat, including condition 3 and 4 that specifically relate to the potential impacts to and management of cave CO-CA-03 and pool CO-WS-14. Biologic Environmental Survey Pty Ltd (Biologic) was commissioned by Atlas Iron to accurately define conditions and activity at the cave and the pool to inform the development of a 'CO-CA-03 Monitoring Strategy'. Focus was given to assessing whether Conditions specified in EPBC Approval Decision 2017/7861 are appropriate. The specific objectives of the review were to:

- review and summarise water sampling conducted at CO-WS-14 (Condition 4.3) to determine natural fluctuations in water level and quality (inform adequacy of Condition 4a and to inform parameters for Condition 4b).
- analyse and review 12 months of microclimate data collected from within the cave (Condition 4.2) to provide an indication of baseline levels and natural fluctuations to compare to those specified in Condition 4c-i and 4c-ii and where justified provide scientifically based alternative parameters.
- analyse ultrasonic recordings from CO-CA-03 to confirm the scale and frequency with which the cave is used by the Pilbara leaf-nosed bat (to meet Condition 3) and to assess whether the internal microclimate of CO-CA-03 is the primary factor influencing Pilbara leaf-nosed bat roosting preferences.

Ultrasonic and microclimate data from CO-CA-01 and CO-CA-03, and water depth and quality data from pool CO-WS-14 were collected over a 12 month period; from the 17th of April 2019 until the 25th of April 2020.

Cave Microclimate

During the monitoring period (April 2019 to April 2020), temperatures inside both CO-CA-01 and CO-CA-03 were notably stable, with minimal daily fluctuation. Overall temperatures were slightly higher inside CO-CA-03 than CO-CA-01, on average. Temperatures inside CO-CA-03 remained within the target range (28-32°C) for the entire monitoring period (100%), while temperatures inside CO-CA-01 remained within the target range for 99.89% of the monitoring period. Ambient temperatures appeared to have very little influence on temperatures inside the roost.

During the monitoring period, relative humidity (RH) inside CO-CA-03 occurred over a greater range than CO-CA-01, though was on average, significantly higher than at CO-CA-01. There was a non-linear monthly trend in humidity. Additionally, cave RH was found to be negatively correlated with ambient temperature (after 35°C), and the relationship was mediated by two-week rainfall. Specifically, cave RH was highest when ambient temperature was between 35-40ºC and two-week rainfall was ≥250 mm. Cave RH was relatively high and stable from April to late-September 2019 and from April to early-October 2019 at CO-CA-01 and CO-CA-03, respectively. During this period, 94.8% of recordings fell within the target range at CO-CA-01 and 100% fell within the target range at CO-CA-03. Following this, RH declined in both caves until January 2020, whereby 6.5% and 12.1% of recordings fell within the target range at CO-CA-01 and CO-CA-03, respectively. This coincided with an increase in ambient daily maxima (averaged 42.2ºC) and limited two-week rainfall. Finally, RH increased again within both caves from January 2020 until the end of the monitoring period. Water seeps have been noted in both caves and are likely to contribute to humid internal conditions. It is likely these seeps are supplemented by rainfall emanating through the rock strata.

Cave Utilisation

Pilbara leaf-nosed bats were recorded at both CO-CA-01 and CO-CA-03 on every night during the monitoring period except for a single night at CO-CA-03; on the 8th January 2020 when Cyclone Blake hit Marble Bar. Activity occurred over a greater range at CO-CA-03 compared to CO-CA-01 and was significantly higher on average.

Roosting was indicated on all recording nights during the monitoring period at CO-CA-01. The pattern of usage is consistent with a 'Permanent Diurnal Roost' as defined by Threatened Species Scientific Committee (TSSC) in the species conservation advise. Pilbara leaf-nosed bat activity and roosting events remained relatively constant throughout the monitoring period regardless of the apparent cyclic and delayed seasonal variation in cave RH.

Conversely, roosting at CO-CA-03 was indicated on 47% of recording nights during the monitoring period, of which 91.3% of roosting events occurred between the April 2019 and October 2019. The level of activity and the consistency of roosting observed over this period coincides with the species mating period and therefore may indicate such activities at the cave. Moreover, this pattern of usage is consistent with a 'Non-Permanent Breeding Roost' as defined by TSSC in the species conservation advise. Between October 2019 and the April 2020, the timing of most of these calls suggested that individuals were in flight, possibly foraging, and roosting at another location.

Maximum ambient temperature, maximum cave temperature, range in cave RH and percentage moon illumination were not significant variables influencing roosting status at CO-CA-03. However, roosting and peaks in activity typically occurred when conditions were more favourable (i.e. temperature and RH within the target ranges) suggesting that these conditions are a prerequisite for roosting. Activity and roosting were however influenced by day of sampling, indicating fluctuations in roosting activity at certain times of the year, exclusive to the other variables tested. This indicates that roosting was driven by untested variables related to timing and/or a behavioural response (e.g. reproductive cues). Moreover, activity was also significantly influenced by range in RH. Therefore, it can be inferred that activity levels and the probability of roosting at CO-CA-03 increases during the mating and gestation period prior to parturition when cave RH is high and relatively stable.

Water Monitoring

Water was continuously present within pool CO-WS-14 during the entire monitoring period (April 2019 to April 2020), as well as over the long-term (October 2017 to April 2020). During the current monitoring period water levels averaged ~1.1 meters (m) relative to a staff gauge or 321.00 (Std ±0.02) meters reduced level (mRL), indicating a permanent source of water for the species. Given the consistency at which the species uses CO-CA-03 (and by virtue CO-WS-14) as a foraging location (outside of roosting), it is inferred that the quality and the water levels recorded are suitable for Pilbara leaf-nosed bat usage. CO-WS-14 is likely to represent foraging habitat critical to Pilbara leaf-nosed bat presence.

1 INTRODUCTION

1.1 Project Background

Atlas Iron Pty Ltd (Atlas Iron) are looking to develop the Corunna Downs Project (the Project) located approximately 25 kilometres (km) south-west of Marble Bar within the Chichester subregion of Western Australia's Pilbara bioregion (Figure 1.1). The Project involves the development and operation of an open cut iron ore mine and associated mining infrastructure, waste rock dumps, borefield, and accommodation camp. The Project will source iron ore from five open pits using conventional drill and blast, load and haul methods (Atlas Iron, 2019). To date, several surveys have been conducted over the Project area to delineate environmental impacts to vertebrate fauna. A two phase Level 2 terrestrial vertebrate fauna survey was conducted between 2014 and 2016, which included extended deployments of ultrasonic recorders (MWH, 2016). Seven species of conservation significance were recorded within the Project area during these baseline surveys, including the Pilbara leaf-nosed bat, which was confirmed to permanently reside in the Study Area within a Permanent Diurnal Roost (CO-CA-01). In addition to this a Non-permanent Breeding Roost (CO-CA-03) for the species as well as a permanent and likely ground water dependent pool (CO-WS-14) at the base of CO-CA-03 was identified.

Several surveys and investigations have since been conducted to better understand the significance and classification of CO-CA-03, as well as the sources and mechanisms driving the discharge of water into cave CO-CA-03 (two water seeps have been noted within the second chamber) and pool CO-WS-14. These included bat echolocation monitoring (MWH, 2017), video census (Bat Call, 2018), cave stability (ACG, 2017) assessments and a laser scan by Terra Rosa in 2017, baseline monitoring surveys in 2017 (MWH, 2018), 2018 (Biologic, 2019c) and 2019 (Biologic, 2019a) as well as a hydrogeological investigation in 2018 (Stantec, 2018) and 2019 (SRK, 2019). Bat echolocation monitoring and a video census has also been conducted at the Permanent Diurnal Roost CO-CA-01 (Bat Call, 2018).

The Project was approved by the Department of the Environment and Energy (DoEE) on the 23rd of February 2018 (*Environment Protection and Biodiversity Conservation (EPBC) Act 1999* Approval Decision 2017/7861) subject to four conditions directly relevant to the Pilbara leaf-nosed bat, including condition 3 and 4 that specifically relate to the potential impacts to, and management of, cave CO-CA-03 and pool CO-WS-14:

3. The approval holder must demonstrate that, both during and after mining ceases at the Razorback Pit, cave CO-CA-03 and waterhole CO-WS-14 remain suitable habitat available for use by the Pilbara Leaf-nosed Bat.
4. The approval holder must develop and submit a Monitoring Strategy to the Minister for approval. The Monitoring Strategy must be based on:
   - 4.1 mapping and monitoring of cave CO-CA-03 by an independent scientific expert(s) approved by the Department;
   - 4.2 the collection of at least 12 months of baseline humidity and temperature recordings inside cave CO-CA-03; and
   - 4.3 12 months of baseline water quality sampling of waterhole CO-WS-14.

The Monitoring Strategy must be designed to demonstrate that the structure of cave CO-CA-03 remains unchanged from the pre-mining structure during mining of the Razorback Pit. The monitoring strategy must also be designed to demonstrate, unless otherwise justified and approved by the Minister, that:

a) without anthropogenic supplementation of its water level, waterhole CO-WS-14 has water in it during and continuously for three consecutive years following the cessation of mining of Razorback Pit; and

b) the water quality of pool CO-WS-14 remains suitable for Pilbara leaf-nosed bat during and continuously for three consecutive years following the cessation of mining of Razorback Pit; and

c) cave CO-CA-03 maintains:

   i. humidity between 85-100 per cent relative humidity

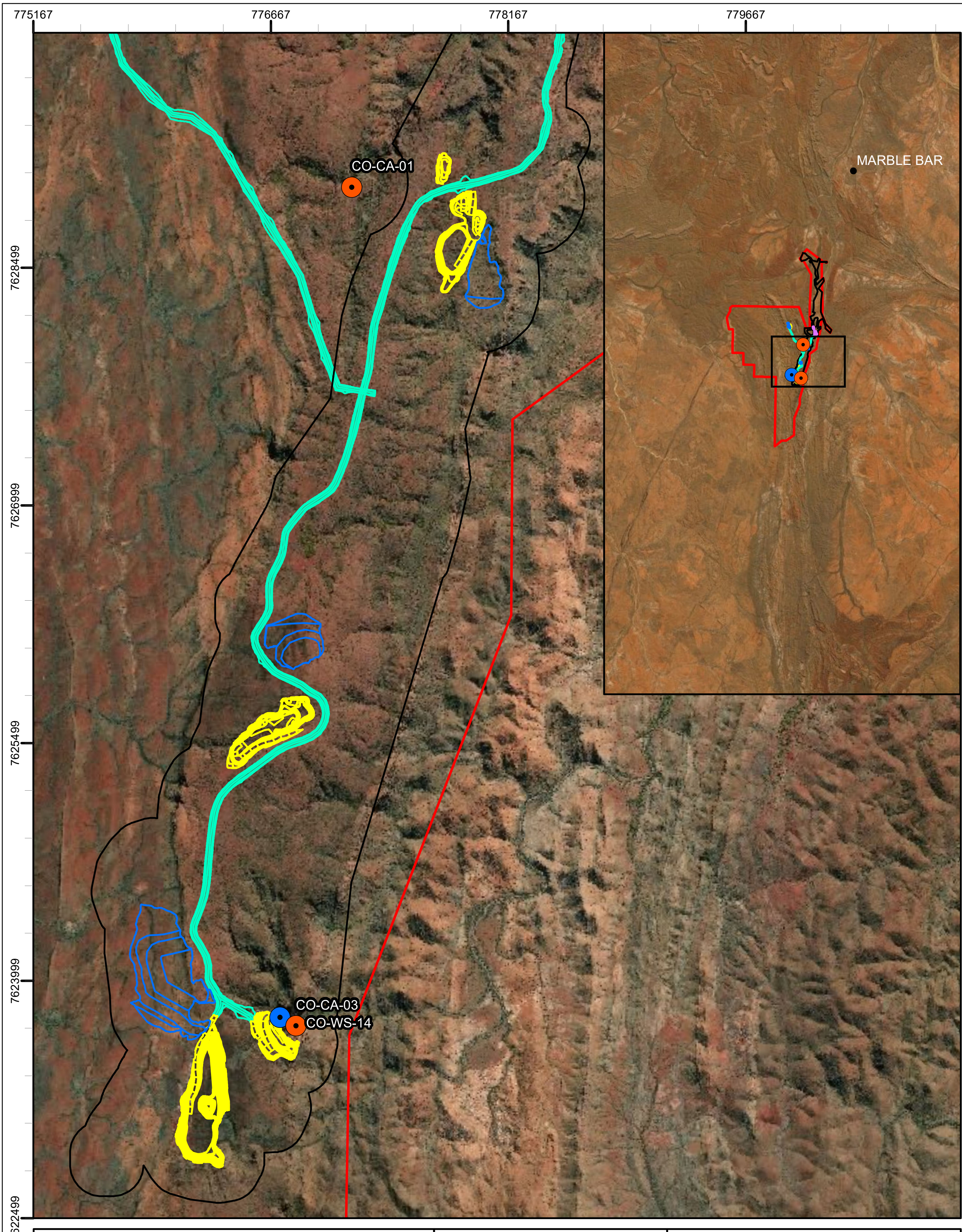
   ii. temperature between 28 and 32 degrees Celsius

   during and continuously for five years following cessation of the mining of Razorback Pit.

1.2 Survey Objectives

Biologic Environmental Survey Pty Ltd (Biologic) was commissioned by Atlas Iron to accurately define conditions and activity at the cave to inform development of a 'CO-CA-03 Monitoring Strategy'. Focus was given to assessing whether conditions specified in EPBC Approval Decision 2017/7861 were appropriate. The specific objectives of the review were to:

- review and summarise water sampling conducted at CO-WS-14 (Condition 4.3) to determine natural fluctuations in water level and quality (inform adequacy of Condition 4a and to inform parameters for Condition 4b).
- analyse and review 12 months of microclimate data collected from within the cave (Condition 4.2) to provide an indication of baseline levels and natural fluctuations to compare to those specified in Condition 4c-i and 4c-ii and where justified provide scientifically based alternative parameters; and
- analyse ultrasonic recordings from CO-CA-03 to confirm the scale and frequency with which the cave is used by the Pilbara leaf-nosed bat (to meet Condition 3) and to assess whether the internal microclimate of CO-CA-03 is the primary factor influencing Pilbara leaf-nosed bat roosting preferences.



Legend

Study Area

Development Envelope

Sites

Haul Road

Cave

Pit

Water

Rom

Waste Dump

biologic Environmental Survey

N

1:30,000

0 0.225 0.45 0.9 km

Atlas Iron Pty Ltd - Corunna Downs

Pilbara Leaf-nosed Bat roost analysis

Fig. 1.1: Study Area and monitoring locations

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Datum: GDA 1994

Size A4. Created 15/06/2020

2 SPECIES OF INTEREST

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 Western Australian *Biodiversity Conservation Act 2016* (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 are believed to require warm (28-32 ºC) 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 and roost 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).

Foraging sites surrounding known or suspected roosts can be critical to the survival of the species as the species forages within the vicinity of roost caves and more broadly along waterbodies with suitable fringing vegetation supporting prey species (TSSC, 2016). 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 grass and woodland (Priority 5). The species is predicted to travel up to 20 km from roost caves during nightly foraging (Cramer *et al.*, 2016) in the dry season and up to 50 km during the wet season (Bullen, 2013).

3 MICROHABITAT FEATURES OF INTEREST

3.1 Cave CO-CA-03

Cave CO-CA-03 (Plate 3.1) was discovered in 2014 during the first phase of the Level 2 terrestrial vertebrate fauna survey (MWH, 2016). The cave is situated in geological layer defined as "*very competent chert*" (ACG, 2017), at the bottom of a gorge within Rocky Ridge and Gorge habitat (MWH, 2016). It is surrounding *"by multiple water seepages and a large spring system that feeds into a large water pool*" (MWH, 2016) (CO-WS-14) approximately 5 m downslope from the mouth of the cave. The cave comprises a large/ deep entrance and one major internal chamber. The entrance faces north-east and is triangular in shape measuring 5 metres (m) high by 18 m wide. The entrance extends 30 m backward toward a constriction (entrance to the main chamber) measuring 2 m high by 2 m wide. The chamber measures 4 m high by 4 m wide by 10 m deep (adapted from Terra Rosa, 2017). Two water seeps have been noted within the second chamber along the western wall (ACG, 2017; MWH, 2016), "*the presence of which has also been observed to be independent of seasonality (i.e. persisting during the dry season*" (Stantec, 2018).

Plate 3.1: Cave CO-CA-03 (photo taken in 2018)

The presence of permanent water inside and immediately surrounding CO-CA-03 may contribute to a suitable microclimate within the cave. The internal microclimate of the cave was first measured during the baseline monitoring survey conducted between July and September 2017 (RH averaged 95.88% [Std ±1.12]). Temperature and humidity levels were found to be suitable for the species and consistent with the microclimates recorded at other diurnal roosts (including CO-CA-01) (MWH, 2018). Bat Call (2018) completed a roost census in November 2017 during which no Pilbara leaf-nosed bats were observed roosting within the cave and humidity was closer to ambient (52%). The lower humidity was said to be on account of outward flowing air. Bat Call (2018) noted that the "*presence of the outward flowing air was a significant observation that had not been observed previously. The reason for this airflow can only be explained by a crack in the rear chamber's strata that is either open through to the top of the ridge above or open to a very large cavity within the hill behind the cave. However, the lack of humidity in the air suggests that the former is most likely, as a large cavity within the hill is likely to be very humid due to the presence of ground water. This crack may at times be closed by ground water within the strata or some* *other process that cuts the airflow and allows the high humidity to form within the chamber*" (Bat Call, 2018).

Pilbara leaf-nosed bat have intermittently roosted with CO-CA-03 during previous surveys (Bat Call, 2018; Biologic, 2019b; MWH, 2017, 2018). The species was recorded roosting on every recording night during Phase 2 of the Level 2 terrestrial vertebrate fauna survey (late September to early October: MWH, 2016) and the 2019 baseline monitoring survey (July: Biologic, 2019a). As such the cave has been classified as a Non-Permanent Breeding Roost (Priority 2), as defined in Section 2.1.

To collect baseline data and to better understand the factors driving roosting by Pilbara leaf-nosed bats at CO-CA-03, an automated solar powered Song Meter (SM) unit was installed at the entrance of the main chamber, and a Hydrochron humidity and temperature logger (iButton) was deployed in a location as representative as possible of the roosting area in 2017 for the provision of permanent monitoring (MWH, 2017). Additionally, annual monitoring in accordance with the Corunna Downs Significant Species Management Plan (SSMP) has since been undertaken in 2017 (MWH, 2018), 2018 (Biologic, 2019c) and 2019 (Biologic, 2019a), prior to the commencement of mining.

3.2 Pool CO-WS-14

Along with the discovery of CO-CA-03, pool CO-WS-14 (Plate 3.2) was discovered in 2014 during the first phase of the Level 2 terrestrial vertebrate fauna survey (MWH, 2016). CO-WS-14 is a 5 m wide by 5 m long, (Stantec, 2018) by ~0.9-1 m deep (SRK, 2019) perennial pool (Stantec, 2018). It is located approximately 5 m from the mouth of cave CO-CA-03 and likely constitutes an important drinking source for the Pilbara leaf-nosed bat (MWH, 2016). The TSSC (2016) defines gorges with pools as Priority 1 Foraging Habitat; "*watercourses through upland areas bounded by sheer rock walls for parts of their length, often containing pools that remain for weeks or months, sites of relatively large biomass production, sometimes containing caves*". For this reason, CO-WS-14 was considered a significant feature for the species within the local area.

Plate 3.2: Pool CO-WS-14 (photo taken in 2018)

During a hydrogeological investigation undertaken between October 2017 and March 2018, it was noted that water levels marginally fluctuated by 0.01 m, which reflected the recession that was observed within the water table (Stantec, 2018). Therefore, while rainfall would periodically replenish water levels within CO-WS-14, it was concluded that the pool was likely groundwater dependant (SRK, 2019; Stantec, 2018). Moreover, the pool is located directly under a ledge over which water flows continuously. While the water flowing over the ledge may be replenished by surface water overland flow following a rainfall event, it has been observed independently of season. Therefore, the seepage is likely fed by a combination of groundwater discharge and unsaturated flow (Stantec, 2018).

The Pilbara leaf-nosed bat is frequently recorded via ultrasonic recorders in the vicinity of open water, suspected of using such features as drinking sources. The parameters surrounding water quantity and quality required by the species is however unknown. Though, it is assumed that if the Pilbara leaf-nosed bat currently utilises CO-WS-14 (either as a source of drinking water or a foraging location) then the current (natural) levels and fluctuations in water quantity and quality at CO-WS-14 are suitable for the species.

4 METHODS

4.1 Survey Locations and Timing

The current project aimed to provide a targeted analysis of the temporal use of CO-CA-03 (and by virtue CO-WS-14) and the natural factors that influenced its' use by the Pilbara leaf-nosed bat, including changes in cave microclimate and water quantity and quality at pool CO-WS-14.

The Permanent Diurnal Root (CO-CA-01) was also monitored during this period to better understand the relationship between the two caves (i.e. whether CO-CA-03 is a satellite cave for individuals from CO-CA-01) as well as to provide a comparison of the natural factors that may influence roosting by the Pilbara leaf-nosed bat. Microclimate data (refer to Section 4.3) and ultrasonic data (refer to Section 4.4) were collected from both caves over a 12 month period; from the 17th of April 2019 until the 25th of April 2020. Data was downloaded every one-to-three months by Atlas Iron staff, Theo Sprenkels (Atlas Iron Senior Environmental Advisor) and Arnold Slabber (Atlas Iron Environmental Advisor). Water level and quality data (refer to Section 4.54.4) at pool CO-WS-14 was collected monthly by Atlas Iron Staff over the same 12 month period (where not impeded by extreme weather events and associated loss of access).

4.2 Climate

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 January 2019 to April 2020, Marble Bar Station (weather station 004106) recorded 725 millimetres (mm) of rainfall, which is higher than the long term annual average rainfall for the same period (677.7 mm; Figure 4.1) (BoM, 2020). A substantial amount of rainfall was received in March 2019 (246.2 mm was received compared to the long-term average of 81.3 mm), on account of Cyclone Veronica, and in January 2020 (311.6 mm was received compared to the long-term average of 114.7 mm), on account of Cyclone Blake.

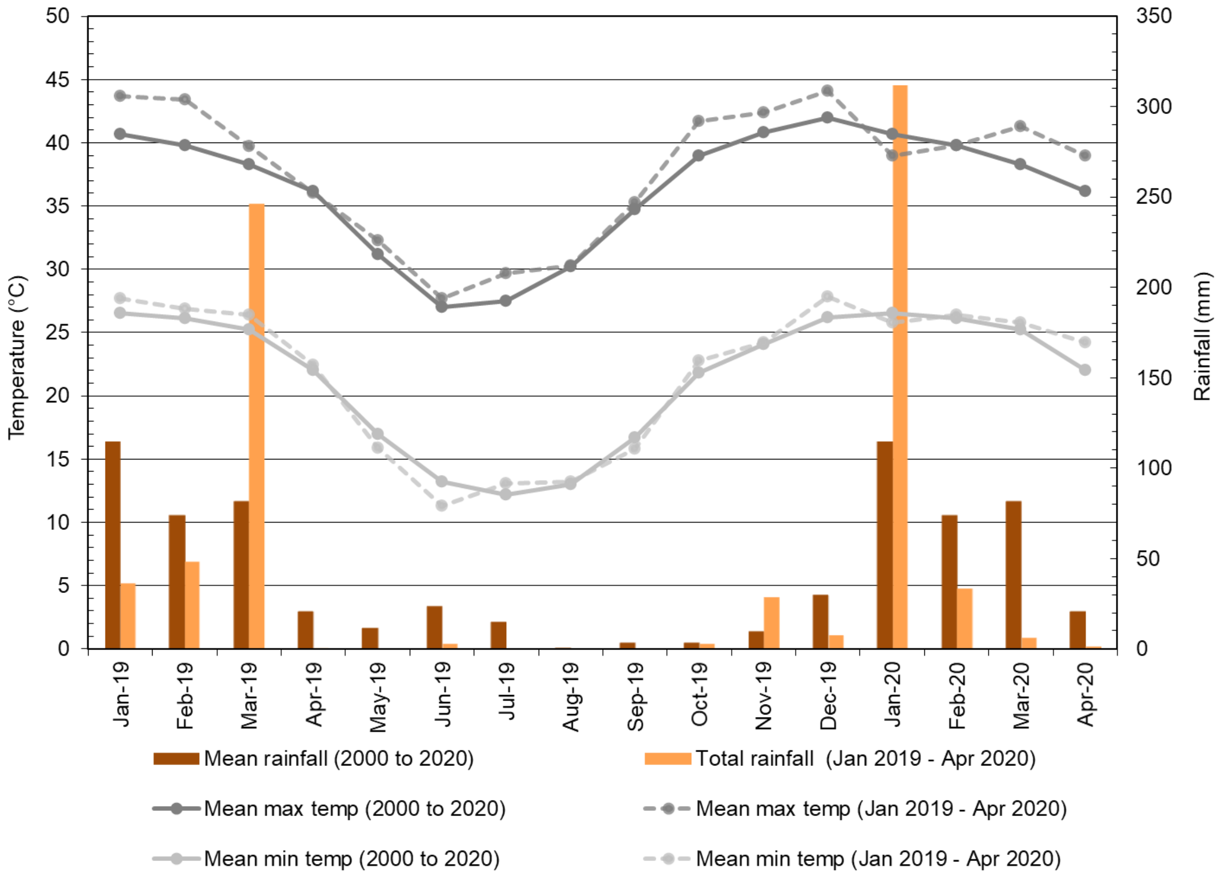


Figure 4.1: Long-term and current climatic data for Marble Bar (BoM, 2020)

4.3 Microclimate Monitoring

Hydrochron (DS1923) temperature and humidity loggers (iButtons; Plate 4.1) were deployed to assess the interior microclimate (temperate and relative humidity [RH]) within cave CO-CA-01 and CO-CA-03. Two iButtons (one for redundancy) were deployed in locations as representative as possible of the roosting area.

Plate 4.1: Hydrochron (DS1923) temperature and humidity loggers at CO-CA-03

4.4 Ultrasonic Monitoring

During a previous annual monitoring survey (Biologic, 2019c), Song Meter (SM4BAT FS) ultrasonic recorders (SM4; Wildlife Acoustics, USA) powered by an external solar power supply, were permanently installed at CO-CA-01 and CO-CA-03 (Plate 4.2) to record bat echolocation calls. The SM4 units were fitted with an external, directional SMX-US ultrasonic microphone. The unit was positioned to provide an unobstructed 'line of sight' between the microphone and the likely bat flyway. Recorders were preconfigured to activate at astronomical sunset each day and deactivate at astronomical sunrise the following morning. Audio settings and selectable filters used to preconfigure each unit, and hence define the volume and frequency ranges sought, followed the manufacturer's recommendations for bat detection (Wildlife Acoustics, 2017). Parameters used during this survey are outlined in Table 4.1.

Table 4.1: SM4 Software Parameters and Settings

Parameter	Setting
Sample rate	384kHz
Compression protocol	W4V-4
Gain	12dB
16k High filter	Off
Minimum Trigger Frequency	12kHz
Trigger Level	6dB
Triggering window	3 seconds

Due to technical issues, no ultrasonic data was captured between the 20th of April and the 20th of July 2019.

All recordings over the monitoring period 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 (first call and last call per recording night) and call numbers (total between first call and last call per recording night) using Cool Edit software (Adobe, USA). During analysis, a recording night was considered from sunset to sunrise the following day. Because any individual is likely to emit multiple calls at any site during any night, the call numbers were treated as a measure of 'activity' rather than providing a total number of individuals present. While activity is likely to reflect individuals present, the exact correlation between the two is likely to vary per site (i.e. depending on how the bats use and navigate the site) and per night (e.g. other animals present may change the time spend at a particular site).

Roosting was indicated if one of the following criteria were satisfied: (1) if last call during the previous recording night occurred after dawn, (2) if first call during the current monitoring night was within ≤10 minutes of dusk or (3) if last call during the previous recording night occurred ≤10 minutes before dawn or occurred after dawn and first call during the current monitoring night was within ≤30 minutes of dusk. First call at the permanently used CO-CA-01 was 7.9 minutes before dusk, on average, confirming its status as a permanent diurnal roost. If the Pilbara leaf-nosed bat flies at a rate of 22 km/hr (McKenzie & Bullen, 2009), it would take an individual at least 14.5 minutes to fly directly from CO-CA-01 to CO-CA-03. Consequently, any calls at cave CO-CA-03 received before 10 minutes after dawn eliminates the likelihood of foraging and confirms roosting behaviour at this cave.

During monthly retrieval of data, the number of Pilbara Leaf-nosed bats observed roosting in the cave was also noted. However, the absence of individuals is not considered conclusive, given the numerous cavities within which the Pilbara leaf-nosed bat could hide.

Plate 4.2: Ultrasonic recorders at monitoring caves CO-CA-01 (left) and CO-CA-03 (right)

4.5 Water Monitoring

Routine monitoring of pool CO-WS-14 was undertaken to assist in understanding how the pools' water quantity and quality may vary seasonally.

Atlas Iron staff conducted ten field visitations (approximately one month apart) between the 17th of April 2019 and the 25th of April 2020. During each visitation, six readings were taken including three visual observations (water height relative to the staff gauge, water colour and water flow) and three measured recordings (temperature, pH and conductivity). To supplement these monthly observations, water logger data was available from the 1st of April 2019 until the 30th July 2019. Variables including water temperature, pressure and depth were measured hourly via a Level TROLL 400. Long-term water logger data collected at pool CO-WS-14 (since October 2017) was also available and thus, compared to data collected during the current monitoring period to gain a better understanding of temporal trends.

To delineate water quality, water samples were also collected during each monitoring visitation. A 1 Litre (L) bottle was filled with site water for the analysis of routine organics, inorganics, or physicals (Table 4.2). Additionally, 250mL of water was filtered for the evaluation of metals (Table 4.2). The samples were then placed into a cooler on ice for the remainder of the sampling day. At the end of the sampling day, samples were stored in a refrigerator until they could be dispatched to ENVIROLAB for analysis (Appendix A). Long-term water quality data collected at pool CO-WS-14 (since October 2017) was also available and thus, compared to data collected during the current monitoring period to gain a better understanding of temporal trends.

Table 4.2: Routine Organics, Inorganics, Physicals and Metals Analysed

Analyte	Unit	Analyte	Unit
pH		Sum of Cations	meq/L
Electrical Conductivity	µS/cm	Silica	mg/L
Total Dissolved Solids	mg/L	Aluminium-Dissolved	mg/L
Total Suspended Solids	mg/L	Antimony-Dissolved	mg/L
Fluoride	mg/L	Arsenic-Dissolved	mg/L
Nitrate as NO_3	mg/L	Barium-Dissolved	mg/L
Nitrite as NO_2	mg/L	Boron-Dissolved	mg/L
NOx as N	mg/L	Cadmium-Dissolved	mg/L
Calcium - Dissolved	mg/L	Chromium-Dissolved	mg/L
Potassium - Dissolved	mg/L	Cobalt-Dissolved	mg/L
Magnesium - Dissolved	mg/L	Copper-Dissolved	mg/L
Sodium - Dissolved	mg/L	Iron-Dissolved	mg/L
Bicarbonate HCO_3 as $CaCO_3$	mg/L	Lead-Dissolved	mg/L
Carbonate CO_3^{2-} as $CaCO_3$	mg/L	Manganese-Dissolved	mg/L
Hydroxide OH- as $CaCO_3$	mg/L	Mercury-Dissolved	mg/L
Total Alkalinity as $CaCO_3$	mg/L	Molybdenum-Dissolved	mg/L
Chloride	mg/L	Nickel-Dissolved	mg/L
Sulphate	mg/L	Selenium-Dissolved	mg/L
Ionic Balance	%	Strontium-Dissolved	mg/L
Hardness as $CaCO_3$	mg/L	Tin-Dissolved	mg/L
Sum of Anions	meq/L	Zinc-Dissolved	mg/L

Prior to the current monitoring period, routine monitoring was conducted at CO-WS-14 along with a further seven pools in the Project area (Appendix A). Therefore, long-term water quality and quantity data collected at pool CO-WS-14 was compared to data collected at the additional water pools where available (Appendix A) to provide a comparative understanding of the natural variability and factors driving such variation at CO-WS-14. However, a direct comparison could not be completed due to differences in sampling periods.

4.6 Statistical Analysis

4.6.1 Microclimate Variation at CO-CA-01 and CO-CA-03

Summary statistics (generated in excel) considered all temperature and RH readings recorded each sampling day (i.e. between 0000 and 2100). Daily climactic data (i.e. rainfall, minimum and maximum temperatures) were retrieved from Marble Bar Station (weather station 004106) (BoM, 2020). Daily percentage moon illumination data was retrieved from Moongiant (2020).

In a bid to see whether cave microclimate was directly affected by climatic conditions outside the cave we performed three tests. Note: to delineate the daytime microclimate that may influence diurnal roosting by Pilbara leaf-nosed bats, only microclimate data obtained during a typical diurnal roosting period (between 0600 and 1800 each day) was used for this statistical analysis):

1. internal temperature (within each cave) was plotted against ambient temperature to determine the degree to which the two variables were correlated;
2. as temperature influences the amount of water vapor held in air (Perry, 2012), maximum cave RH (within each cave) was plotted against ambient temperature (daily maxima) to determine the degree to which the two variables were correlated; and
3. cumulative two-weekly rainfall was plotted against maximum cave RH.

Modelling was then used to test for a cave effect, a nonlinear monthly trend, and a nonlinear interaction of ambient temperature and two-week rainfall on cave RH. The mixed GAM computation vehicle (mgcv) package in R with the beta regression family of data distributions and a logit link function was used. It is appropriate where the response (cave RH) is a proportion (0,1). A cubic regression spline was fitted to the nonlinear month effect and a tensor spline was fitted to the nonlinear interaction effect of ambient temperature and two-week rainfall. All analyses were performed in R (R Core Team, 2017). The R package "mgcViz" (Fasiolo *et al.*, 2018) was used to plot the effects and check the model fit the data appropriately. P values were used to define significant results.

4.6.2 Ultrasonic Analysis

Effects on Roosting by Pilbara Leaf-nosed Bats at CO-CA-03

To better delineate the daytime microclimate that may influence diurnal roosting by Pilbara leaf-nosed bats, only microclimate data obtained during a typical diurnal roosting period (between 0600 and 1800 each day) was used for this statistical analysis. As diurnal roosting was demonstrated throughout the monitoring period at CO-CA-01, the following analyses were only conducted for CO-CA-03 in a bid to see what factors influence diurnal roosting at this cave. Two GAM models were generated to investigate:

1. maximum cave temperature, maximum ambient temperature, percentage moon illumination and day of sampling (day 1 equates to 17th April 2019 and day 374 equates to 24th April 2020) versus the binary response variable of roosting (0 = not roosting, 1 = roosting).

2. maximum cave temperature, range of cave RH, percentage moon illumination and day of sampling versus roosting.

The mgcv package in R with the binomial regression family was used. Model fit diagnostics were assessed with the R package mgcViz (Fasiolo *et al.*, 2018). P values were used to define significant results.

Effects on Pilbara Leaf-nosed Bat Activity at CO-CA-01 and CO-CA-03

Only microclimate data between 0600 and 1800 each day was used for this statistical analysis. Through a visual interrogation of microclimate data, average day-time temperature did not fluctuate from average night-time temperature (20.9°C at CO-CA-01 and 30.3°C at CO-CA-03). Moreover, average day-time RH (76.8% at CO-CA-01 and 85% at CO-CA-03) did not fluctuate by more than 0.6% RH from night-time RH (77.4% at CO-CA-01 and 85.6% at CO-CA-03). To determine the factors that influence Pilbara leaf-nosed bat activity the following models were produced:

1. GAM model investigating the effect of maximum cave humidity, percentage moon illumination and day of sampling.
2. GAM model investigating the effect of range in cave humidity, percentage moon illumination and day of sampling.

The mgcv package was used in R with the Tweedie regression family. Cubic regression smoothing splines were fit to cave humidity and day of sampling so their nonlinear effects on activity could be estimated. Additionally, linear effects in the model were cave and percentage moon illumination. Temporal autocorrelation (order=1) was also included in the model. Cave temperature was not included because of problems of model convergence. All analyses were performed in R. The R package “mgcViz” (Fasiolo *et al.*, 2018) was used to check the residuals. P values were used to define significant results.

4.6.3 Water Analysis

To ensure pool CO-WS-14 remains suitable for Pilbara leaf-nosed bat, natural levels were delineated via summary statistics (including minimum, maximum, range, median, mean and standard error). R function 'stat.desc' from the package 'pastecs' was used to obtain the descriptive statistics (Grosjean & Ibanez, 2018).

Supplementary to this, the Australian and New Zealand Guidelines (ANZG) were used to better understand the water quality of the site with regards to its ecological suitability (ANZECC & ARMCANZ, 2019). The primary objective of the ANZG guidelines is “*to provide an authoritative guide for setting water quality objectives required to sustain current, or likely future, environmental values (users) for natural and semi-natural water resources in Australia and New Zealand*” (ANZECC & ARMCANZ, 2019). The guidelines aim to provide industry standard but are not mandatory and have no formal legal status.

ANZECC and ARMCANZ (2019) broadly classify physical and chemical stressors into groups depending on their effects to aquatic ecosystems; whether they are direct or indirect effects, and whether these effects include direct toxicity to biota. The guidelines provide default guideline values (GVs) for a range of water quality analytes designed to protect aquatic ecosystems at a low level of risk but are not designed as pass or fail compliance criteria. Rather, exceedances of default GVs are intended to act as triggers to inform managers and regulators that changes in water quality are occurring and may need to be investigated. In this context, GVs are defined as a “measurable quantity (threshold) or condition of an indicator for a specific community value below or above which we consider to be a low risk of unacceptable effects occurring". The default GVs are inherently conservative assessment levels and are intended to be applied to systems for which there are no baseline data or where baseline data are insufficient to adequately describe the natural or existing seasonal or annual fluctuations in water quality.

Summary statistics (median, average, minimum and maximum) were compared against the 95% and 99% (protection level signifies the percentage of species expected to be protected) GV's. Moreover, long-term water quality data collected at pool CO-WS-14 was compared to data collected during the current monitoring year where available (Appendix E) to provide a better understanding of the natural variability.

All less than values were removed from the data set and less than value was assumed to be the true value (for instance Copper levels were assumed to be 0.001 mg/L). However, if the data sets for each analyte also contained true values, then less than values were halved (i.e. <0.001 mg/L was assumed to be 0.0005 mg/L). An outlier was removed from the Lead-Dissolved (mg/L) data set during the current monitoring year and from the Molybdenum-Dissolved (mg/L) within the long-term data set. Almost all values equated to <0.001 mg/L, with a single value equating to <0.00005 mg/L. As none of the values were true values, it was not possible to estimate a true value below <0.001 mg/L and thus, perform summary statistics on the data. Therefore, the <0.00005 mg/L results were removed. Outliers were removed from the water logger dataset if the water logger was retrieved (for the purpose of downloading data) around the same time as the hourly log, particularly if the resulting log varied greatly in comparison to logs recorded immediately prior and immediately preceding the retrieval.

5 RESULTS

5.1 Temperature

5.1.1 CO-CA-03

During the monitoring period (April 2019 to April 2020), temperatures inside CO-CA-03 were notably stable, with very little daily fluctuation. Overall temperatures ranged from 28.0 to 31.6 °C (3.6 °C difference) inside the roost (Table 5.1, Appendix C), averaging 30.3ºC (*SE* ± 0.02ºC) throughout the monitoring period. Comparatively, ambient temperatures ranged from 7.2 to 47.8ºC (40.6ºC difference). Therefore, ambient temperatures had very little influence on temperatures inside the roost (Figure 5.1). Although, temperature within the cave declined marginally between October and December 2019, there was little temporal variation. Temperatures inside the roost remained within the target range (28-32 °C) for the entire monitoring period (100%).

Table 5.1: Summary of temperature data (April 2019 to April 2020) recorded inside CO-CA-03.

Summary Stats	Temperature (°C)								
	3am	6am	9am	12pm	3pm	6pm	9pm	12am	OVERALL
Average	30.3	30.3	30.4	30.4	30.3	30.3	30.3	30.3	**30.3**
SE	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.04	**0.02**
Minimum	28.5	28.5	29.0	28.5	28.0	28.0	28.0	28.5	**28.0**
Maximum	31.6	31.6	31.6	31.6	31.6	31.6	31.6	31.6	**31.6**
Difference between Minimum and Maximum	3.1	3.1	2.6	3.1	3.6	3.6	3.6	3.1	**3.6**
Number of recordings between 28 - 32ºC									**2,848**
Percentage of recordings within 28 - 32ºC									**100%**

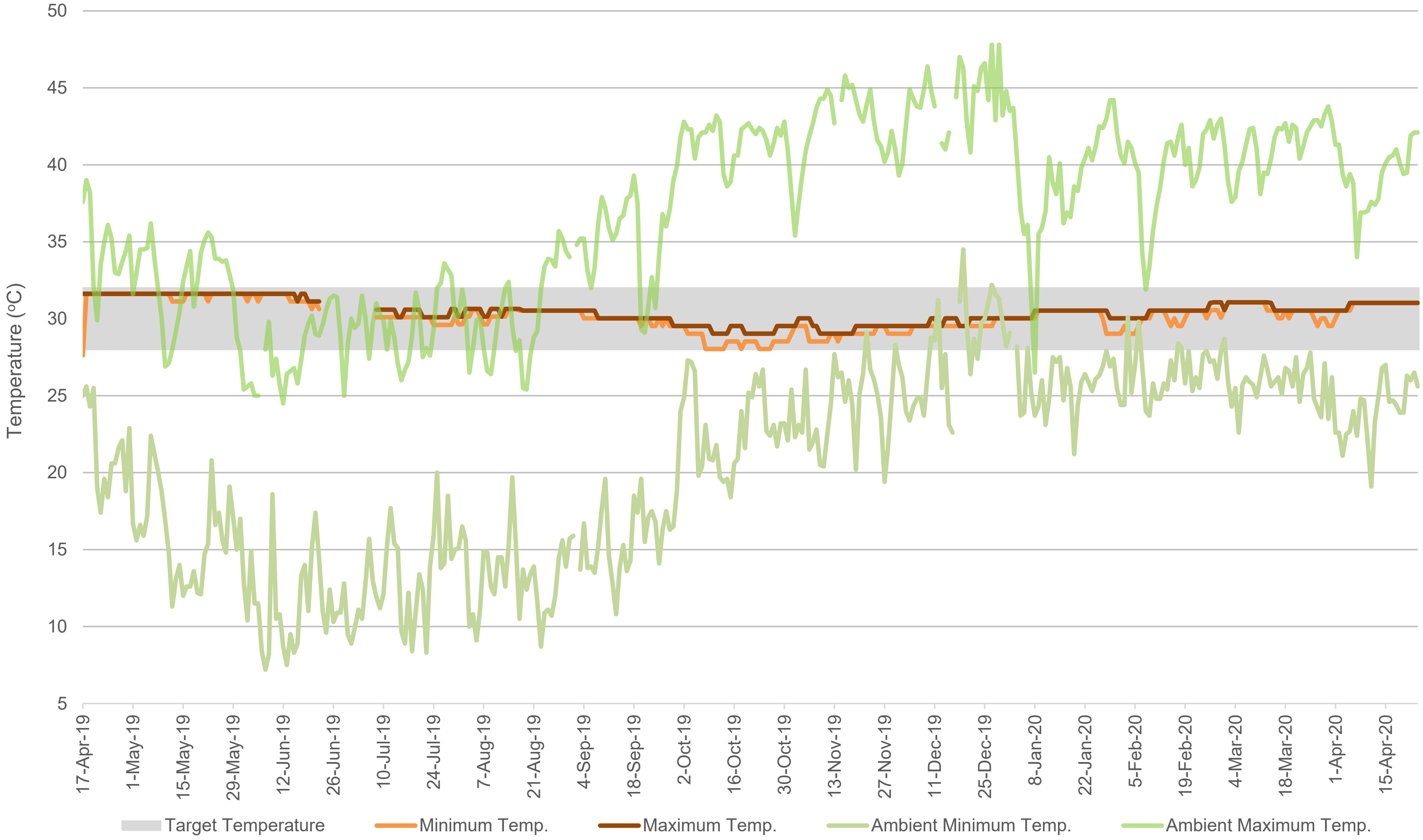


Figure 5.1: Daily temperature (°C) range (minimum and maximum) recorded at CO-CA-03

5.1.2 CO-CA-01

During the monitoring period (April 2019 to April 2020), temperatures inside CO-CA-01 were notably stable, with minimal daily fluctuation. Overall temperatures ranged from 27.6 to 31.1 °C (3.5°C difference) inside the roost (Table 5.2; Appendix D), averaging 29.9°C (*SE* ± 0.01°C) throughout the monitoring period. Comparatively, ambient temperatures ranged from 7.2 to 47.8°C (40.6°C difference). Therefore, ambient temperatures had very little influence on temperatures inside the roost (Figure 5.2). Temperatures within the cave declined marginally between late January and mid-March 2020, approximating minimum ambient temperatures. However, minimum ambient temperatures were toward the upper range recorded during the monitoring period. Therefore, temperature within CO-CA-01 are unlikely to have been influenced by ambient temperature.

Temperatures inside the roost remained within the target range (28-32°C) for almost the entire monitoring period (99.89%). Inside the roost, temperatures were slightly below the target range on three occasions; 27.6°C at 6pm and 9pm on the 18th of February 2020 and 9pm on the 19th of February 2020.

Table 5.2: Summary of temperature data (April 2019 to April 2020) recorded inside CO-CA-01.

Summary Stats	Temperature (°C)								
	3am	6am	9am	12pm	3pm	6pm	9pm	12am	OVERALL
Average	29.9	29.9	29.9	29.9	29.8	29.8	29.9	29.9	**29.9**
SE	0.04	0.03	0.03	0.04	0.04	0.04	0.04	0.04	**0.01**
Minimum	28.1	28.1	28.1	28.1	28.1	27.6	27.6	28.1	**27.6**
Maximum	31.1	31.1	31.1	31.1	31.1	31.1	31.1	31.1	**31.1**
Difference between Minimum and Maximum	3.0	3.0	3.0	3.0	3.0	3.5	3.5	3.0	**3.5**
Number of recordings between 28 - 32°C									**2,850**
Percentage of recordings within 28 - 32°C									**99.89%**

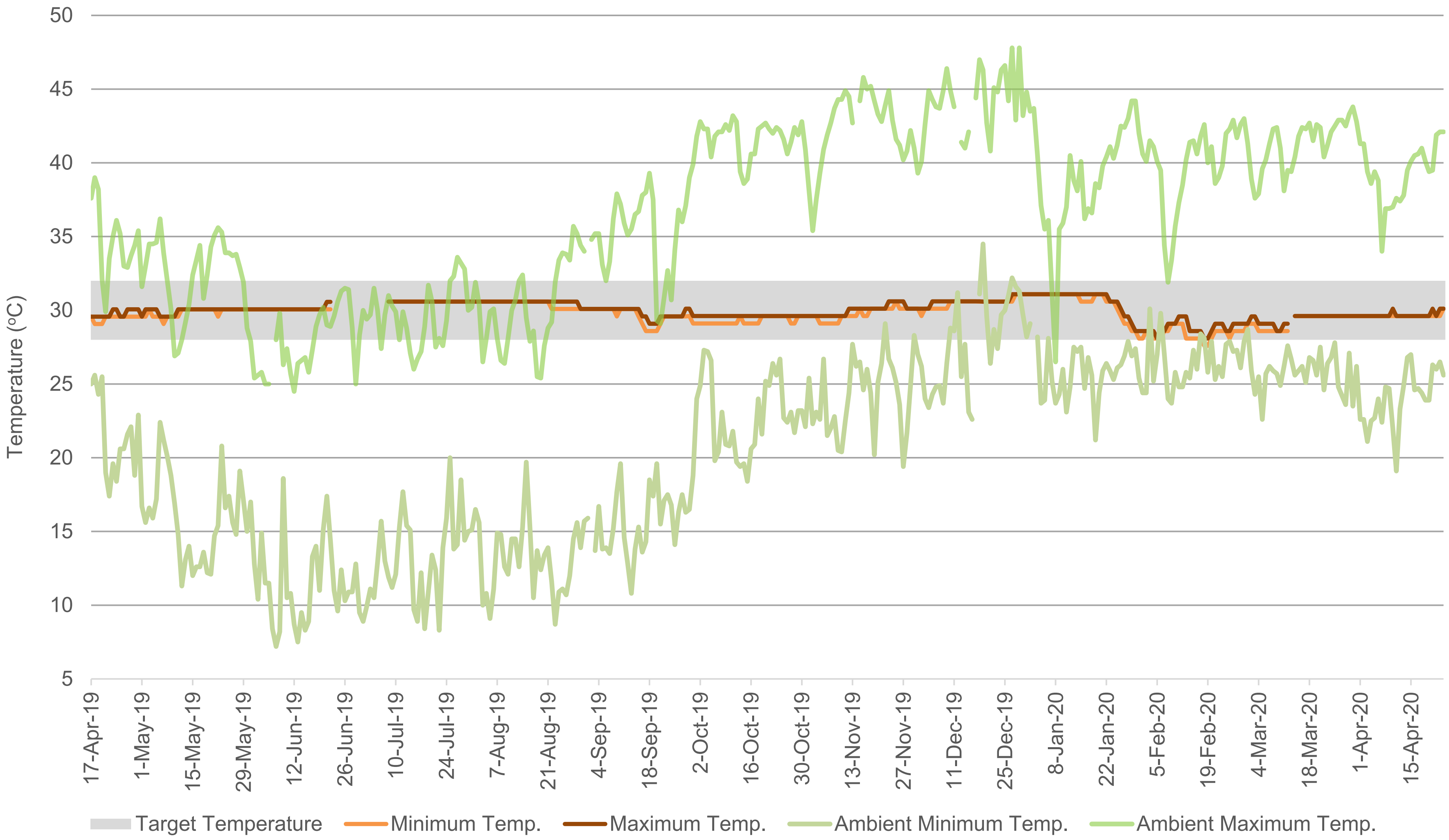


Figure 5.2: Daily temperature (°C) range (minimum and maximum) recorded at CO-CA-01

5.2 Humidity

5.2.1 CO-CA-03

During the monitoring period (April 2019 to April 2020), RH inside CO-CA-03 ranged from 18.1% to 99.5% (81.4% difference), averaging 85.2% (*SE* ± 0.34) (Table 5.3). On average, minimum humidity occurred at 6pm (81.0% [*SE* ± 1.21]) and maximum humidity occurred at 6am (88.3% [*SE* ± 0.63]). A substantial amount of rainfall was received in March 2019 (246.2 mm was received in March compared to the long-term average of 85.5 mm), on account of Cyclone Veronica, with a majority of the rainfall occurring on the 25th of March 2019 (138 mm; Figure 5.3). Following Cyclone Veronica, below average rainfall was then received between April and December 2020 (41.8 mm was received between April and December compared to the long-term average of 117.7 mm). Following Cyclone Veronica, humidity within the cave was notably stable with minimal daily fluctuation between the 18th of April and the 7th of October 2019; humidity ranged from 88.4% to 99.5% (11.2% difference). All recordings during this period fell within the target range (85-100%) whereby RH within the cave was 95.1% (*SE* ± 0.05) on average.

Average humidity decreased between the 8th of October 2019 and the 7th of January 2020, prior to the next substantial rainfall event: a peak in rainfall occurred in January 2020 (311.6 mm was received in January compared to the long-term average of 114.7 mm) on account of Cyclone Blake (144.2 mm; Figure 5.3). Between October 2019 and January 2020 RH decreased to 60.6% (*SE* ± 0.7) on average, ranging from 18.1% to 94.5% (76.4% difference) with 12.1% of recordings falling within the target range. Finally, RH increased within the caves from the 8th of January 2020 (coinciding with Cyclone Blake) until the end of the monitoring period, averaging 91.7% (*SE* ± 0.2). RH was also more stable during this time and ranged from 50.4% to 96.7% (46.3% difference) with 92.9% of recordings falling within the target range.

Table 5.3: Summary of humidity data (April 2019 to April 2020) recorded inside CO-CA-03.

Summary Stats	Humidity (%)								
	3am	6am	9am	12pm	3pm	6pm	9pm	12am	OVERALL
Average	87.5	88.3	88.0	85.2	82.4	81.1	83.5	85.9	**85.2**
SE	0.74	0.63	0.73	0.98	1.15	1.21	1.06	0.88	**0.34**
Min	31.1	36.6	21.5	18.1	20.2	19.5	20.2	25.6	**18.1**
Max	99.0	99.0	99.5	99.0	99.5	99.5	99.5	99.5	**99.5**
Difference between Minimum and Maximum	68.0	62.4	78.0	80.9	79.3	80.0	79.3	73.9	**81.4**
Number of recordings between 85-100%									**2142**
Percentage of recordings within 85-100%									**75.3%**

To determine what factors drive cave RH and to avoid including correlated variables in subsequent analyses, modelling was used to test for a cave effect, a non-linear monthly trend, and a nonlinear interaction of ambient temperature (Figure 5.4) and two-week rainfall on cave RH. There was a significant non-linear monthly effect on humidity (p = <0.0001). There was also a significant non-linear relationship between ambient temperature and two-week rainfall (p = <0.0001). Ambient temperature was found to be negatively correlated with cave RH (after about 35°C), and the relationship was mediated by two-week rainfall (p = <0.0001). Specifically, cave RH is highest when ambient temperature is between 35-40°C and two-week rainfall is ≥250 mm.

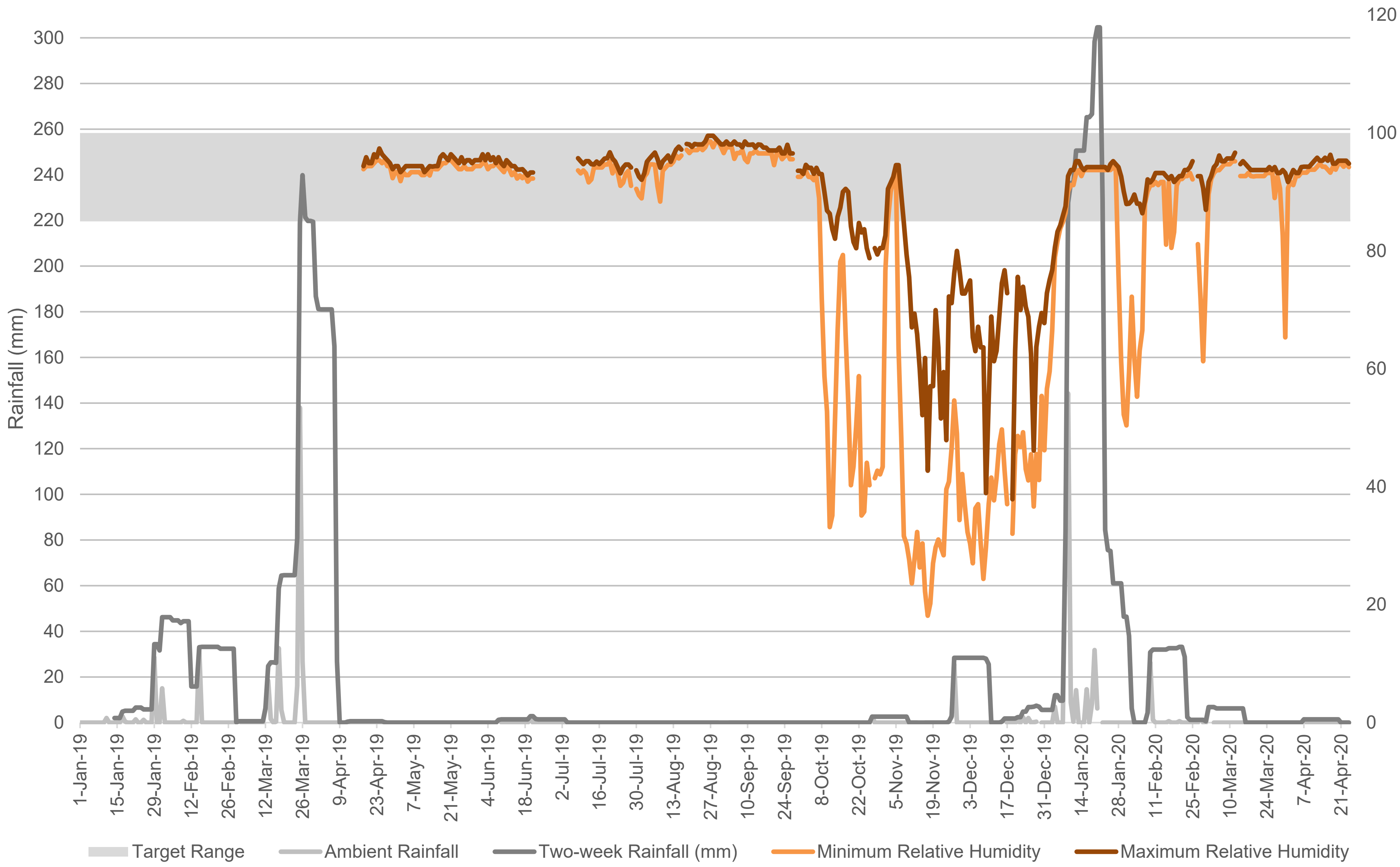


Figure 5.3: Daily humidity (%) range (minimum and maximum) recorded at CO-CA-03 against rainfall

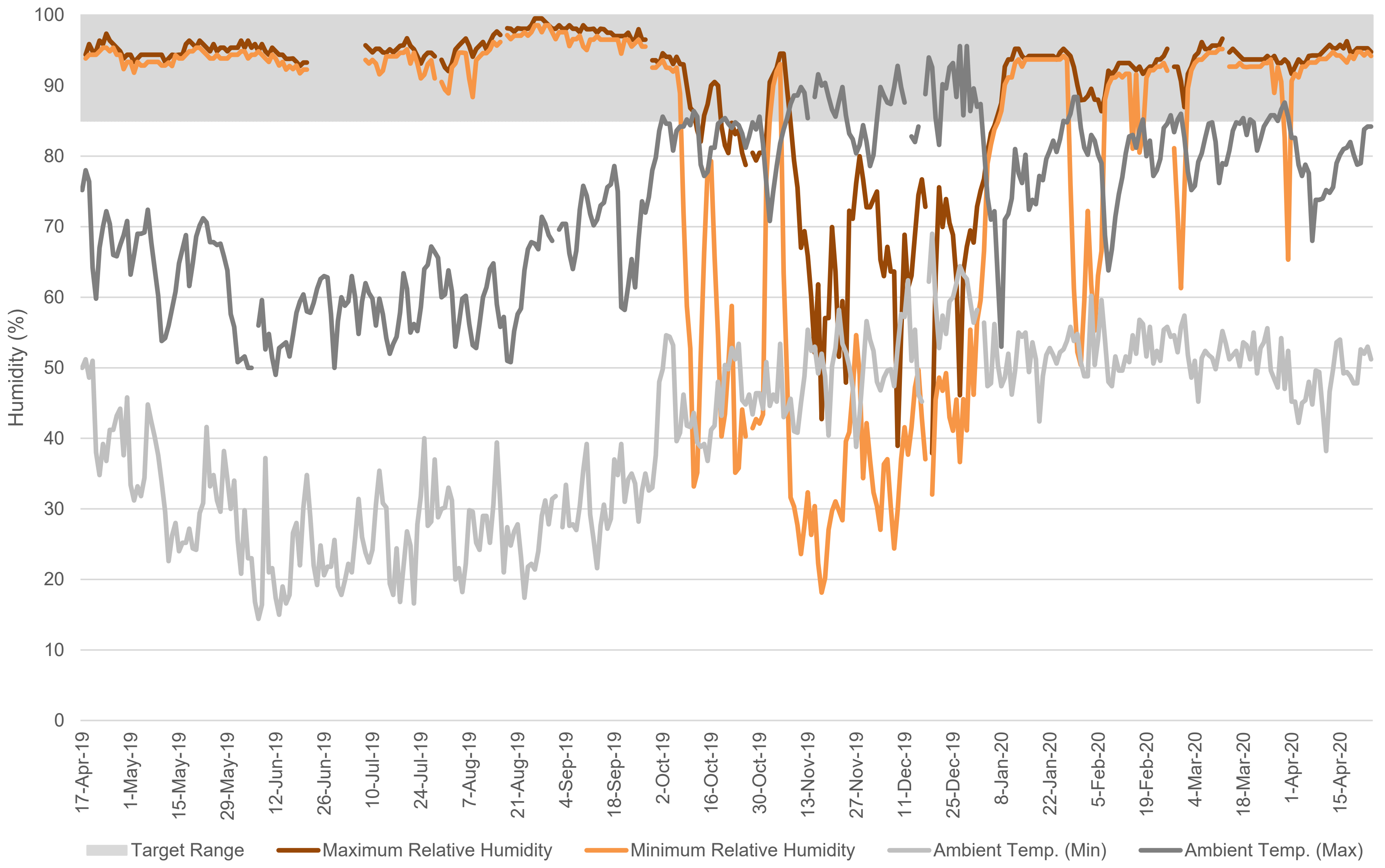


Figure 5.4: Daily humidity (%) range (minimum and maximum) recorded at CO-CA-03 against ambient temperature

5.2.2 CO-CA-01

During the monitoring period (April 2019 to April 2020), RH inside CO-CA-01 ranged from 31.3% to 100% (68.7% difference), averaging 77.01% (*SE* ± 0.35) (Table 5.4). Overall daily fluctuations in humidity were low whereby minimum humidity occurred at 6pm (73.9% [*SE* ± 1.13]) and maximum humidity occurred at 6am (80.0% [*SE* ± 0.84]).

During a routine monitoring visit to cave CO-CA-01 (16th April 2019), Arnold Slabber noted that a substantial amount of water had come through the roosting chamber, at the back of the cave. Moreover, a yellow lid previously housing an iButton was buried approximately 2 m away from its' deployment location. On the 22nd of June 2019, the iButton previously deployed within this yellow lid was retrieved and the data log indicated that it had suddenly recorded 100% humidity on the 13th of March 2019 at 6am (having recorded 63% on average since the beginning of March 2019) and continued to record >99.5% humidity until it was retrieved. Given the stability and sudden onset of 100% humidity it is thought that the iButton became inundated within the water that seeped through the cave. This is supported by the fact that a second iButton, which was deployed within the cave at the same time, only recorded 66-96% humidity. For this reason, this iButton was eliminated from the analysis.

A substantial amount of rainfall was received in March 2019 (on account of Cyclone Veronica) followed by below average rainfall between April and December 2020. Following Cyclone Veronica, humidity within the cave was notably stable with minimal daily fluctuation, ranging from 65.9% to 95.2% (29.4% difference) between April 2019 to 22 May 2019. Moreover, 80.2% of recordings fell within the target range (85-100%) during this period whereby RH averaged 87.9% (*SE* ± 0.3). From the 22nd of May 2019 until 15th of September 2019, RH further stabilised (ranged from 87.6% to 98.4% [10.7% difference]) with 100% of recordings falling within the target range (averaging 93.5% [*SE* ± 0.03]).

Changes in internal cave humidity were only later observed toward the end of the dry season (from the 16th of September 2019 until the 7th of January 2020). During this time, RH decreased to 55.7% (*SE* ± 0.46) on average. During this period, RH was also more variable, ranging from 31.3% to 90.7% (59.5% difference) with only 6.5% of recordings falling within the target range.

Finally, RH steeply increased on the 8th of January 2020, with a peak in rainfall in January 2020, on account of Cyclone Blake, to an average of 90.9% (*SE* ± 0.4). RH was also more stable during this time and ranged from 67.9% to 100% (32.2% difference) with 76.7% of recordings falling within the target range. However, this increase and stabilisation was not maintained; humidity declined to 67.1% (*SE* ± 0.3) until the end of the monitoring period whereby no recordings fell within the target range from the 8th of March 2020.

Modelling was used to test for a cave effect, a nonlinear monthly trend, and a nonlinear interaction of ambient temperature (Figure 5.6) and two week rainfall on cave RH. There was a significant non-linear monthly effect on humidity (p = <0.0001). There was also a significant non-linear relationship between ambient temperature and two-week rainfall (p = <0.0001). Ambient temperature was found to be negatively correlated with cave RH (after about 35°C), and the relationship was mediated by two-week rainfall (p = <0.0001). Specifically, cave RH is highest when ambient temperature is between 35-40°C two-week rainfall is ≥250 mm.

Table 5.4: Summary of humidity data (April 2019 to April 2020) recorded inside CO-CA-01.

Summary Stats	Humidity (%)								
	3am	6am	9am	12pm	3pm	6pm	9pm	12am	OVERALL
Average	78.7	80.0	78.9	76.7	74.6	73.9	75.9	77.7	**77.01**
SE	0.92	0.84	0.91	1.02	1.10	1.13	1.05	0.97	**0.35**
Min	37.1	41.5	39.6	34.5	32.6	31.3	31.9	33.2	**31.3**
Max	100	100	100	100	100	100	100	100	**100**
Difference between Minimum and Maximum	62.9	58.5	60.4	65.5	67.4	68.7	68.1	66.8	**68.7**
Number of recordings between 85-100%									**1,459**
Percentage of recordings within 85-100%									**51.3%**

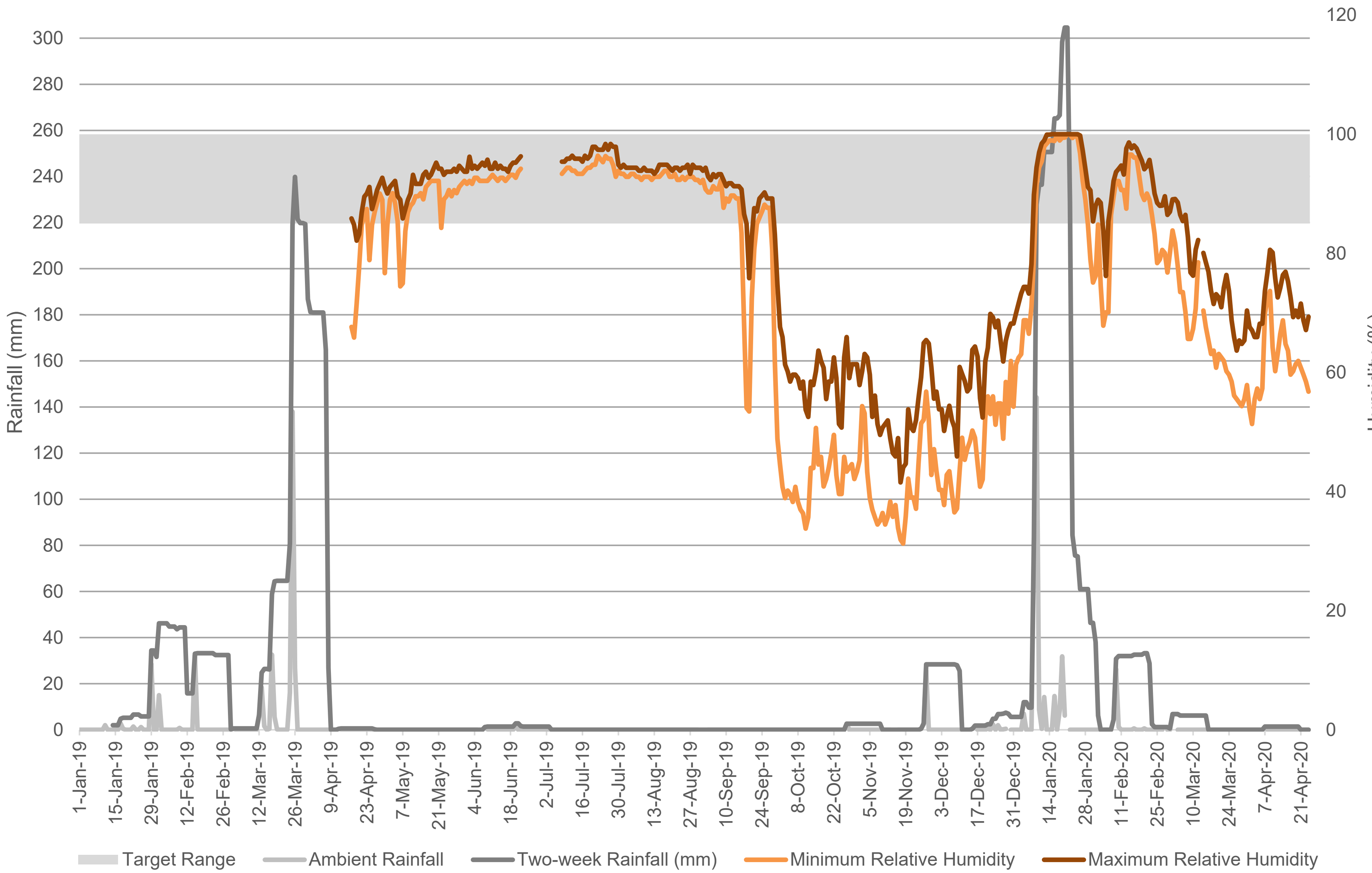


Figure 5.5: Daily humidity (%) range (minimum and maximum) recorded at CO-CA-01 against rainfall

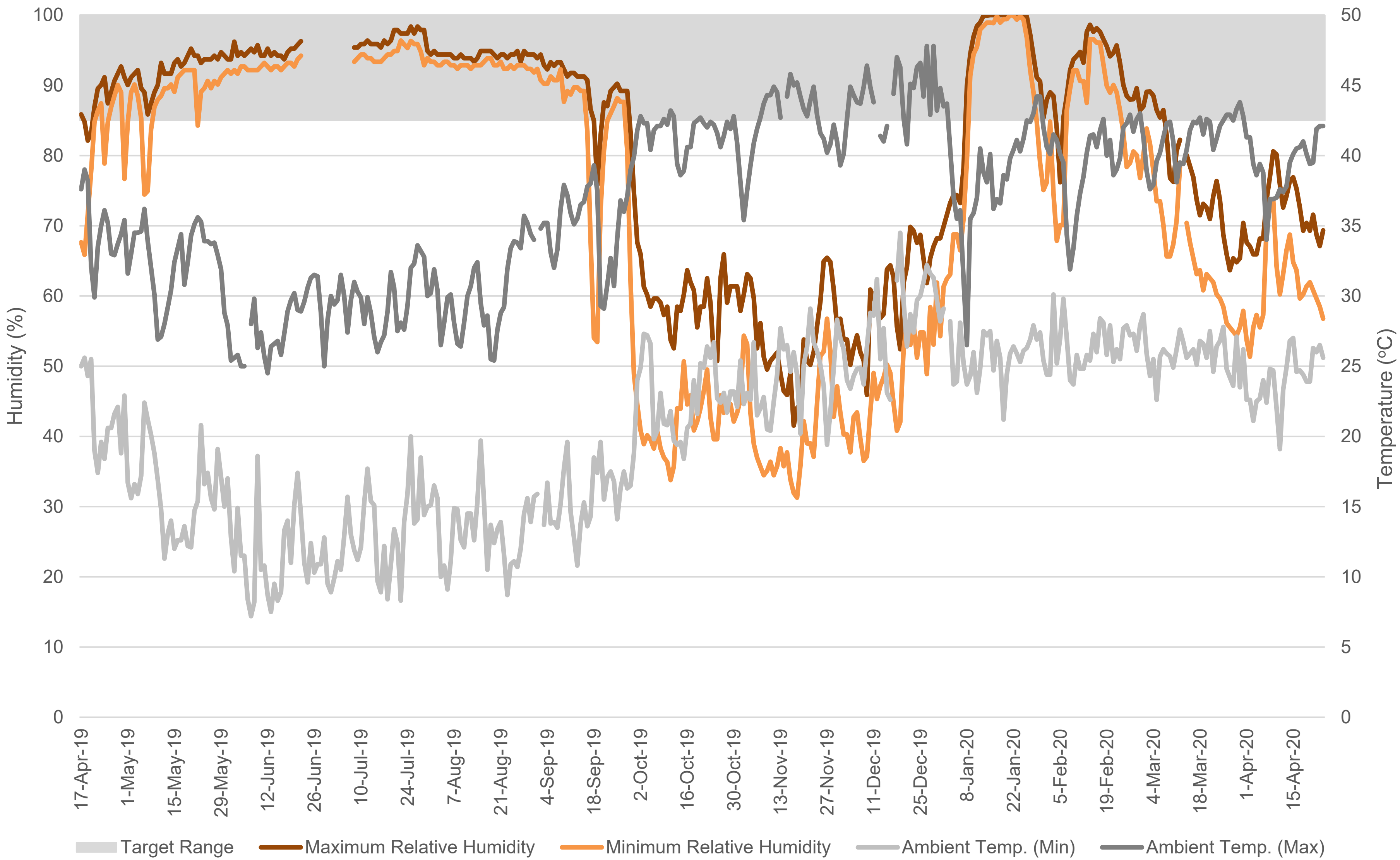


Figure 5.6: Daily humidity (%) range (minimum and maximum) recorded at CO-CA-01 against ambient temperature

5.3 Ultrasonic Analysis

5.3.1 CO-CA-03

Pilbara Leaf-nosed Bats were recorded on every night during the monitoring period, except for the 8th of January 2020. Activity ranged from 64 calls (on the 18th of January 2020) to 56,699 calls (12th of July 2019), averaging 7,033 (*SE* ± 619) calls per night (Appendix C).

Roosting was indicated on 47% of recording nights during the monitoring period, of which 91.3% of roosting events occurred between the 17th of April 2019 and the 25th of October 2019 (Figure 5.7, Figure 5.8). When the species was roosting, 13,440 calls were detected per recording night on average. Pilbara leaf-nosed bats were encountered on three of five visitations in high numbers during routine visits to the cave between April and October 2019 (Table 5.5).

Between the 26th of October 2019 and the 24th of April 2020, roosting was only indicated on 8.4% of recording nights (Figure 5.7, Figure 5.8). When roosting was not indicated, the timing of most calls suggested that individuals were in flight, possibly foraging, and roosting at another location. During this period 1,346 calls were detected per recording night on average. Pilbara leaf-nosed bats were encountered on one of five visitations in low numbers during routine visits Between October 2019 and April 2020 (Table 5.5).

Table 5.5: Pilbara leaf-nosed bat observations at CO-CA-03

Date	Pilbara leaf-nosed bats observed
01/05/2019	-
22/06/2019	Second chamber full of bats
29/07/2019	250-500
17/08/2019	None
28/09/2019	Large Number
27/10/2019	None
18/12/2019	-
26/02/2020	None
13/03/2020	None
25/04/2020	One

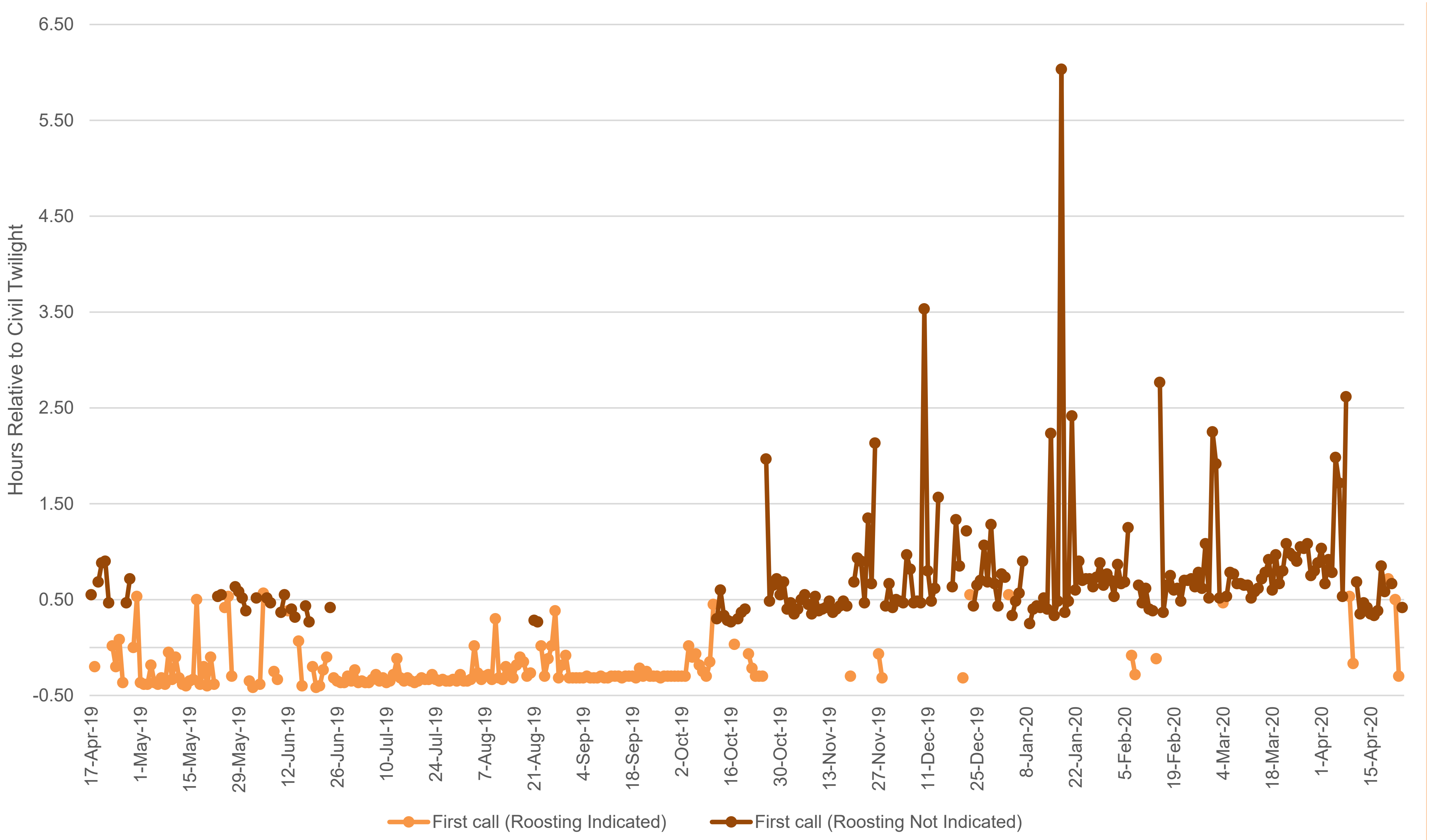


Figure 5.7: Timing of first call (relative to Civil Dusk) when the species was and was not roosting per day at CO-CA-03 during the monitoring period (April 2019 – April 2020)

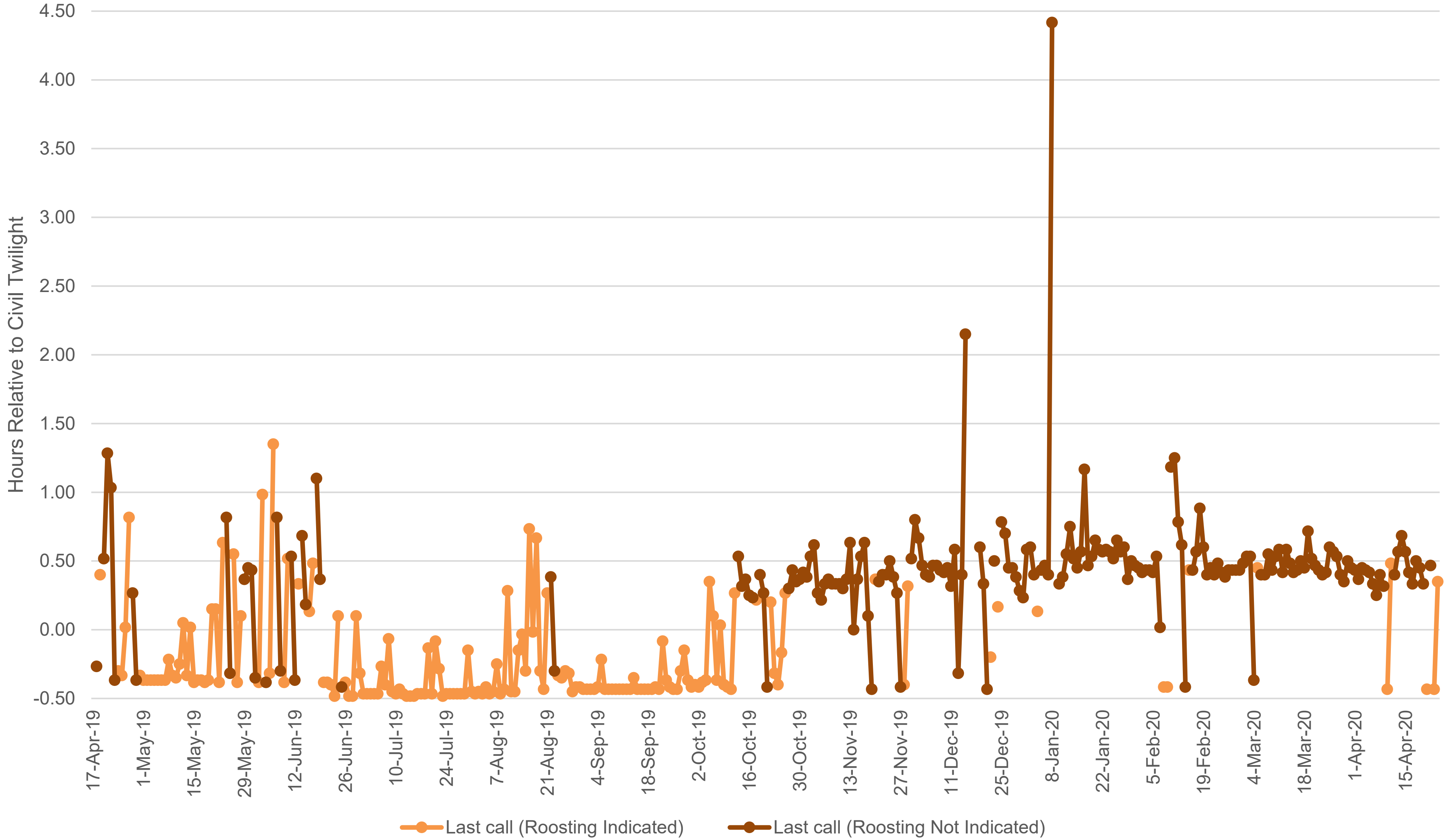


Figure 5.8: Timing of last call (relative to Civil Dawn) when the species was and was not roosting per day at CO-CA-03 during the monitoring period (April 2019 – April 2020)

The decline in roosting observed from October 2019 coincided with a decline and increased variability in cave RH as well as decline in internal temperature although marginal (approximately ~1.5°C) (Figure 5.10, Figure 5.11). However, roosting did not increase relative to temperature and cave RH from January 2020. GAM model 1 (See 4.6.2 Effects on Roosting by Pilbara Leaf-nosed Bats at CO-CA-03) showed that maximum ambient temperature, maximum cave temperature, percentage moon illumination did not significantly affect the roosting status of the species at the cave. The model was able to explain 66.3% of the variation recorded. GAM model 2 showed that maximum cave temperature, range in cave RH and percentage moon illumination did not significantly affect the roosting status of the species at the cave. The model was able to explain 60.9% of the variation recorded. However, day of sampling significantly affected roosting in both models (*p* = <0.0001). This indicates that untested variables likely influence whether bats roost at the cave.

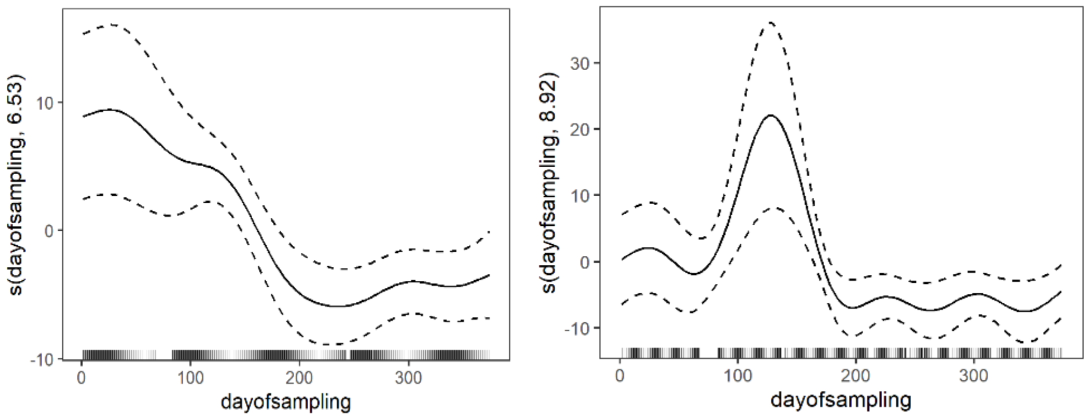


Figure 5.9: Effects on Day of Sampling on Roosting at CO-CA-03 (model including range cave RH and cave temperature left, model including ambient temperature and cave temperature right).

Patterns in Pilbara leaf-nosed bat activity followed a similar trend to roosting. Activity was high on average prior to October 2019 with a peak of activity occurring from approximately mid-June to early August 2019. Activity then declined from October 2019 relative to the marginal decline in internal temperature (Figure 5.10) and decline and increased variability in cave RH (Figure 5.11). However, activity did not increase relative to increase in temperature and humidity from January 2020. Model 1 (outlined in 4.6.2 Effects on Pilbara Leaf-nosed Bat Activity at CO-CA-01 and CO-CA-03) demonstrated that Pilbara leaf-nosed bat activity was significantly affected by day of sampling (*p* = <0.0001) (Figure 5.12). However, maximum cave RH did not significantly affect activity after accounting for seasonality. Moreover, percentage moon illumination did not significantly affect activity at the caves. The model explains 69.2% of the variation recorded. Model 2 (outlined in 4.6.2 Effects on Pilbara Leaf-nosed Bat Activity at CO-CA-01 and CO-CA-03) demonstrated that Pilbara leaf-nosed bat activity was significantly affected by day of sampling (*p* = <0.0001) (Figure 5.12). Additionally, range in cave RH (difference between maximum and minimum) significantly affected activity at CO-CA-03 after accounting for seasonality (*p* = <0.05). However, percentage moon illumination did not significantly affect activity at the caves. The model explains 68.7% of the variation recorded.

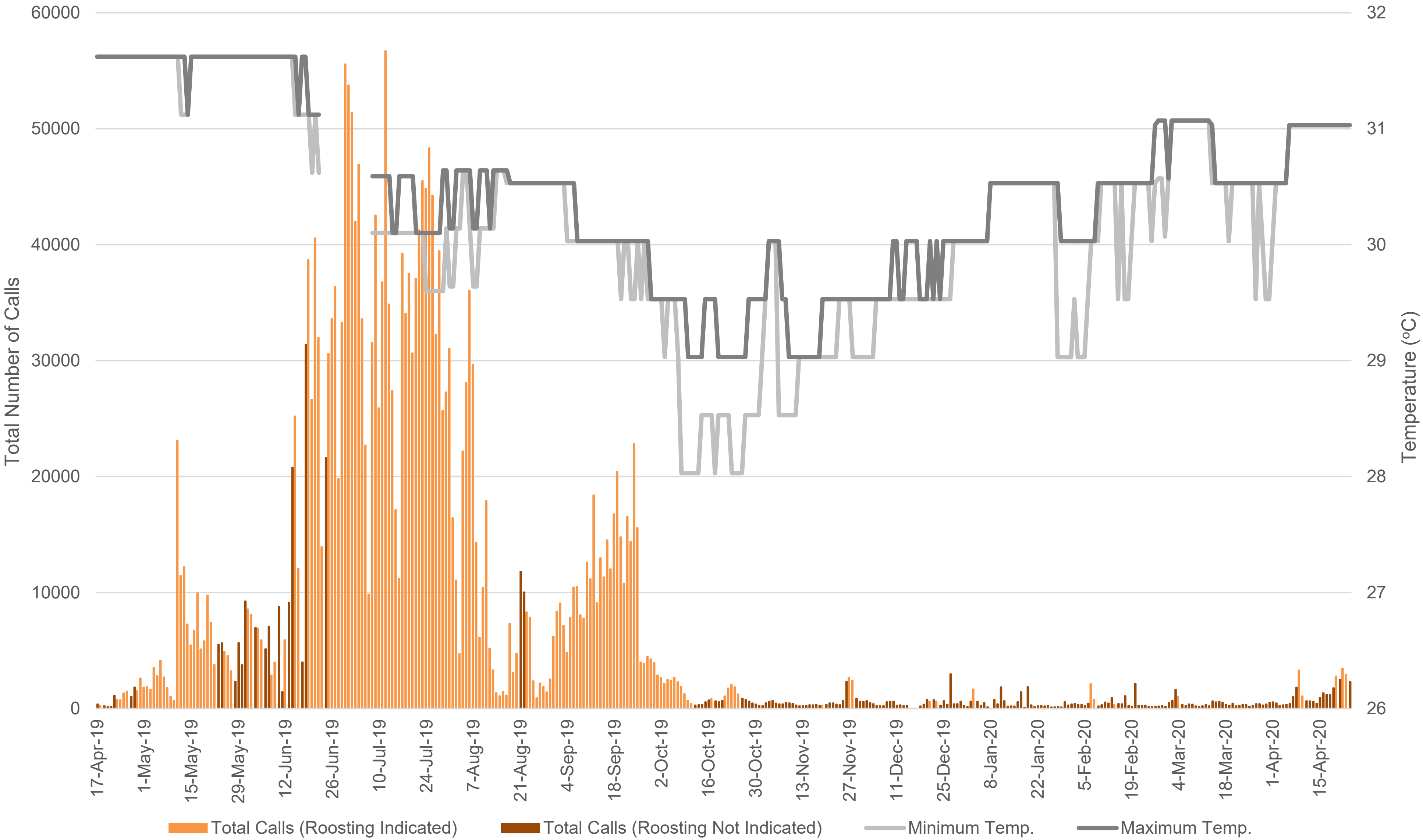


Figure 5.10: Number of calls per day plotted against internal temperature at CO-CA-03 during the monitoring period (April 2019 – April 2020)

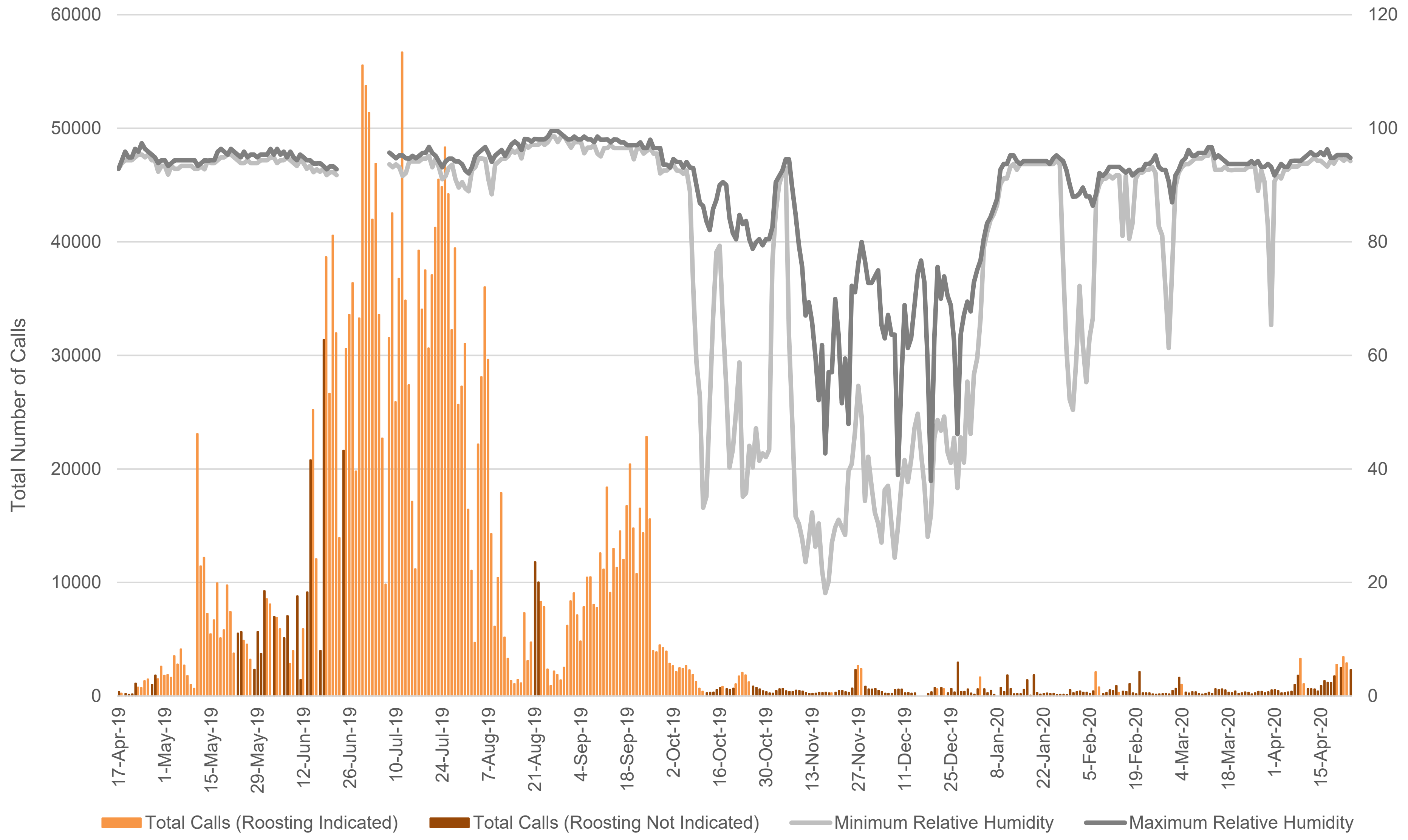


Figure 5.11: Number of calls per day plotted against cave RH at CO-CA-03 during the monitoring period (April 2019 – April 2020)

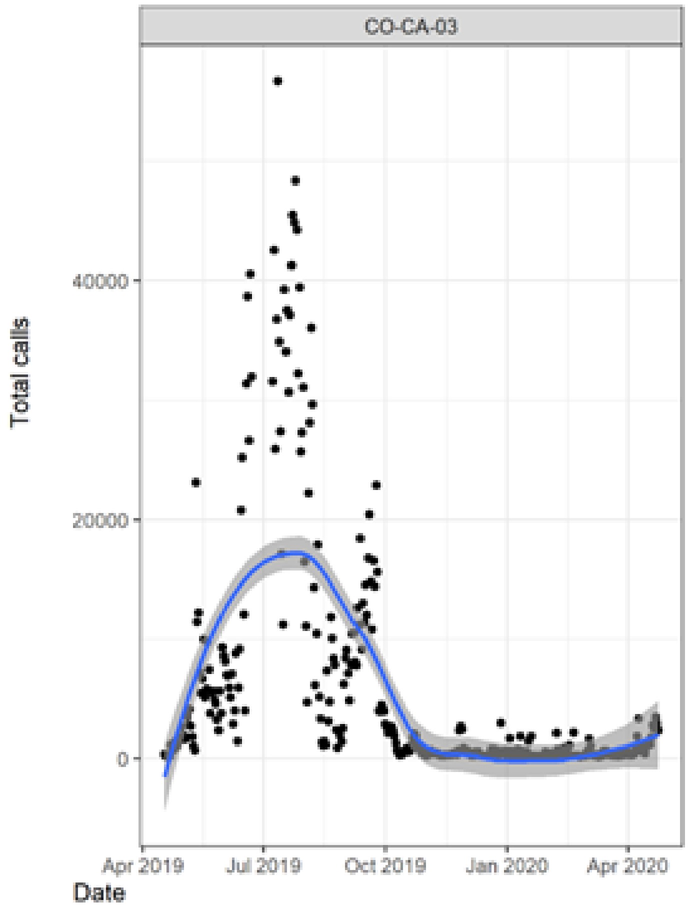


Figure 5.12: Pilbara Leaf-nosed Bat Activity at CO-CA-03

5.3.2 CO-CA-01

Due to technical issues, no ultrasonic data was captured between the 20th of April and the 20th of July 2019. Pilbara Leaf-nosed Bats were recorded on every night during the monitoring period for which data was available. Moreover, roosting was indicated on all recording nights during the monitoring period (Figure 5.13, Figure 5.14). Pilbara leaf-nosed bat activity ranged from 470 calls (on the 5th of January 2020) to 30,452 calls (7th of January 2020), averaging 4,726 (*SE* ± 229) calls per night.

Table 5.6: Pilbara leaf-nosed bat observations at CO-CA-01

Date	Pilbara leaf-nosed bats observed
16/04/2019	-
22/06/2019	Could not hear any bats
29/07/2019	Bats observed roosting
28/09/2019	Large number
18/12/2019	-
13/03/2020	-

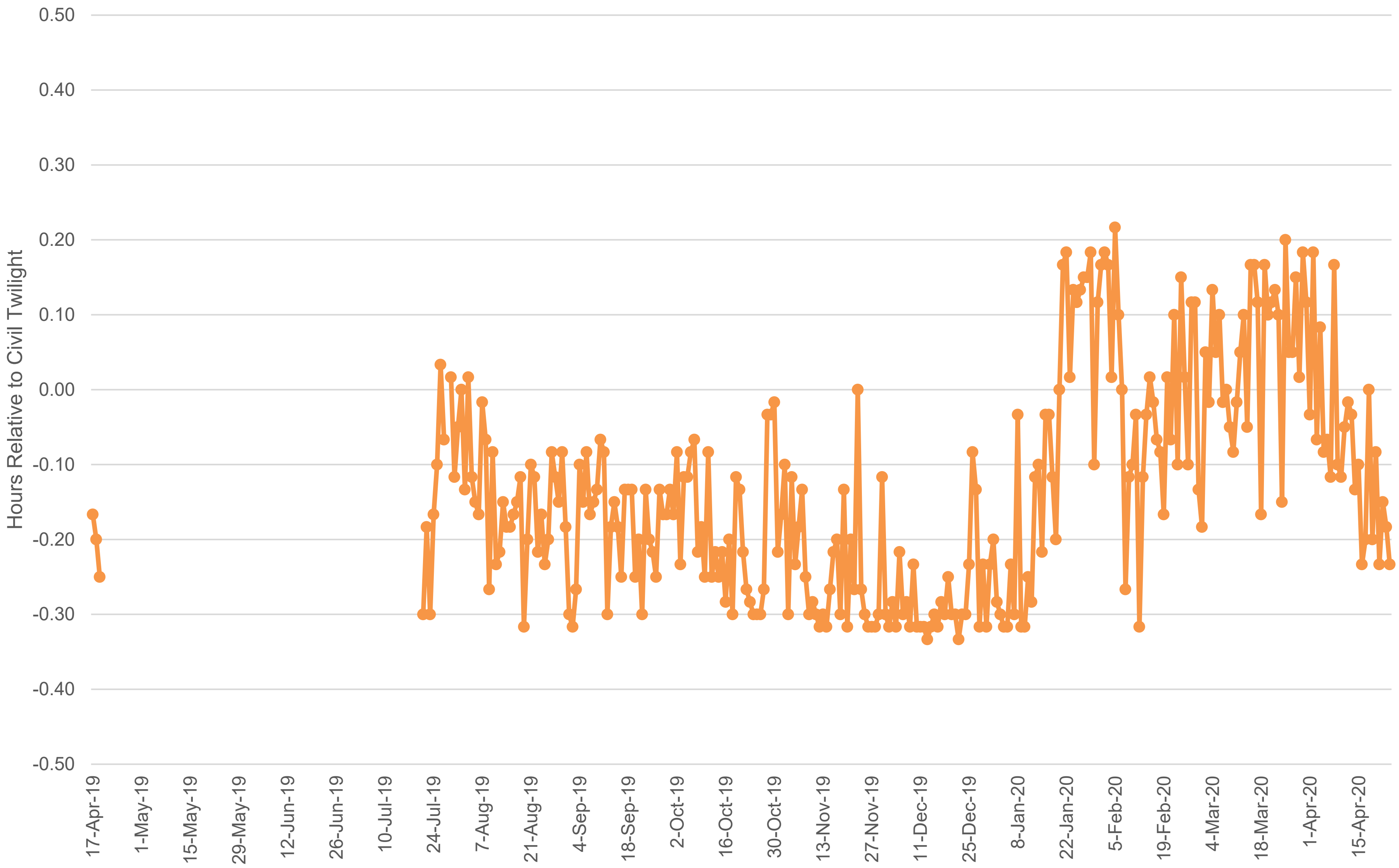


Figure 5.13: Timing of first call (relative to Civil Dusk) per day at CO-CA-01 during the monitoring period (April 2019 – April 2020)

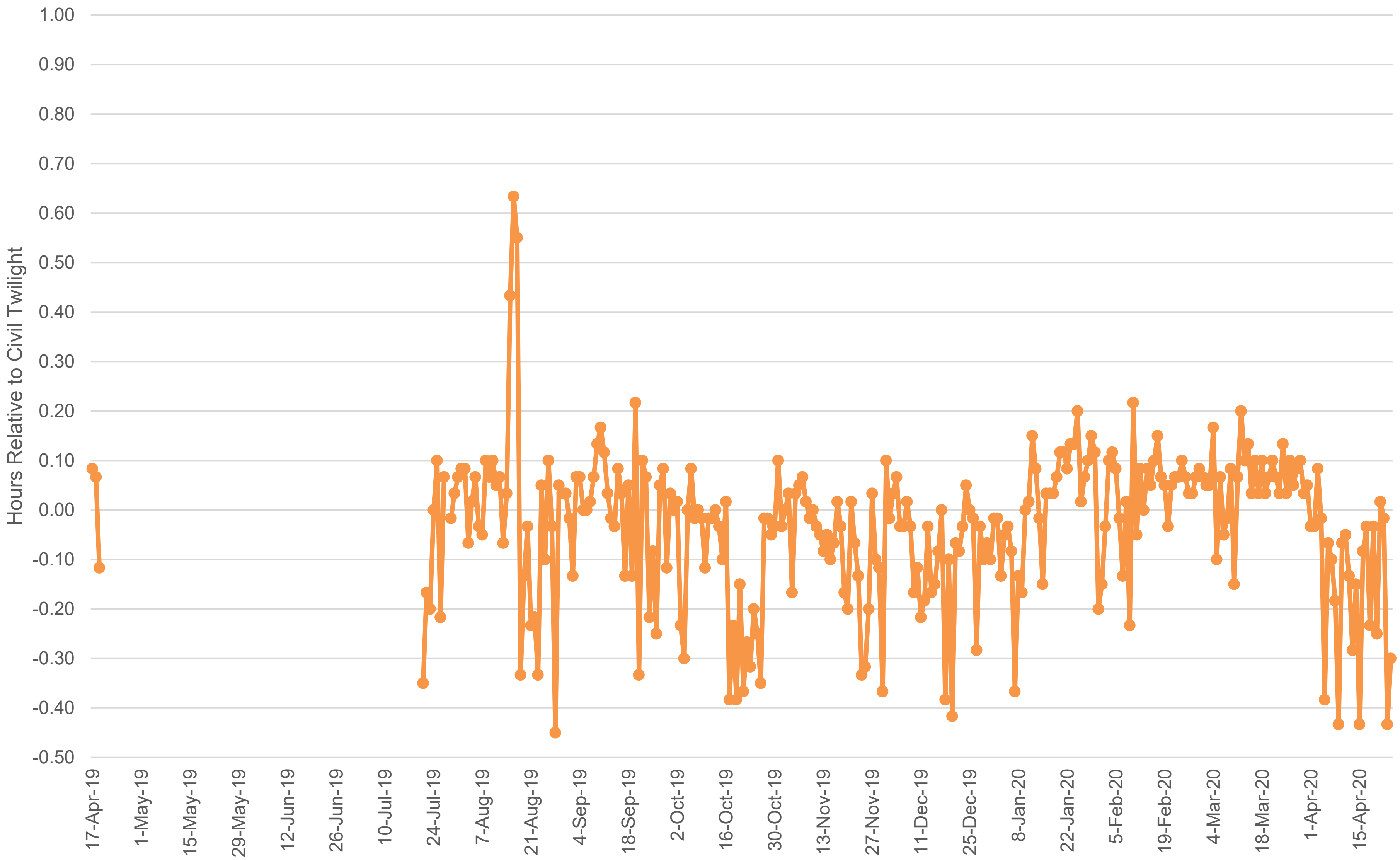


Figure 5.14: Timing of last call (relative to Civil Dawn) per day at CO-CA-01 during the monitoring period (April 2019 – April 2020)

There was little variation in temperature during the monitoring period (Figure 5.16). However, temperature within the cave declined slightly between late January and mid-March 2020 (approximately ~1.3°C). Conversely, cave RH varied throughout the monitoring period (Figure 5.17). Cave RH was relatively high and stable until mid-September 2019 when humidity declined and became more variable. RH steeply increased again in early January 2020. This increase was not maintained, declining again in early March 2020 until the end of the monitoring period. However, Pilbara leaf-nosed bat activity remained relatively constant throughout the monitoring period (Figure 5.17). Model 1 and 2 (outlined in 4.6.2 Effects on Pilbara Leaf-nosed Bat Activity at CO-CA-01 and CO-CA-03) demonstrated that Pilbara leaf-nosed bat activity was significantly affected by day of sampling (p = <0.05) (Figure 5.15). However, maximum cave RH as well as range in cave RH did not significantly affect activity at CO-CA-01 after accounting for seasonality. Moreover, percentage moon illumination did not significantly affect activity at the caves. The model explains 68.7% of the variation recorded.

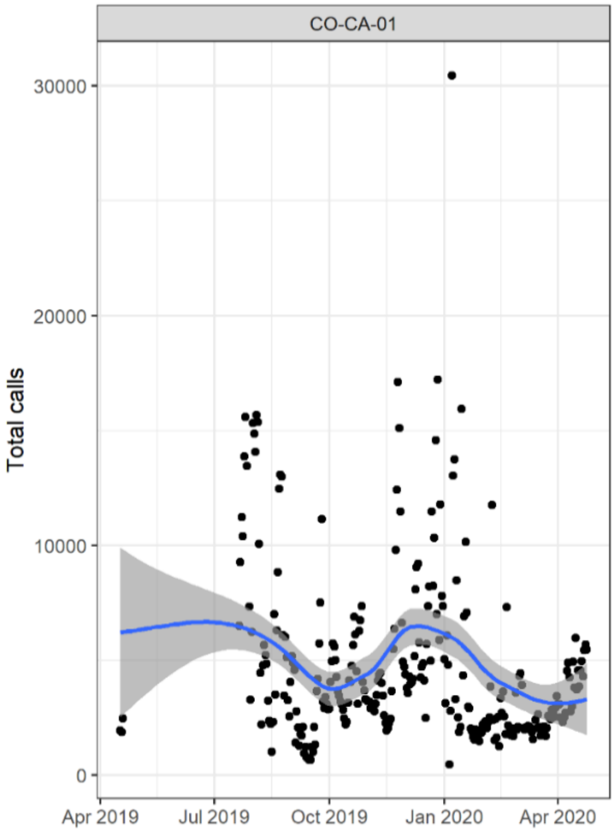


Figure 5.15: Pilbara Leaf-nosed Bat Activity at CO-CA-01

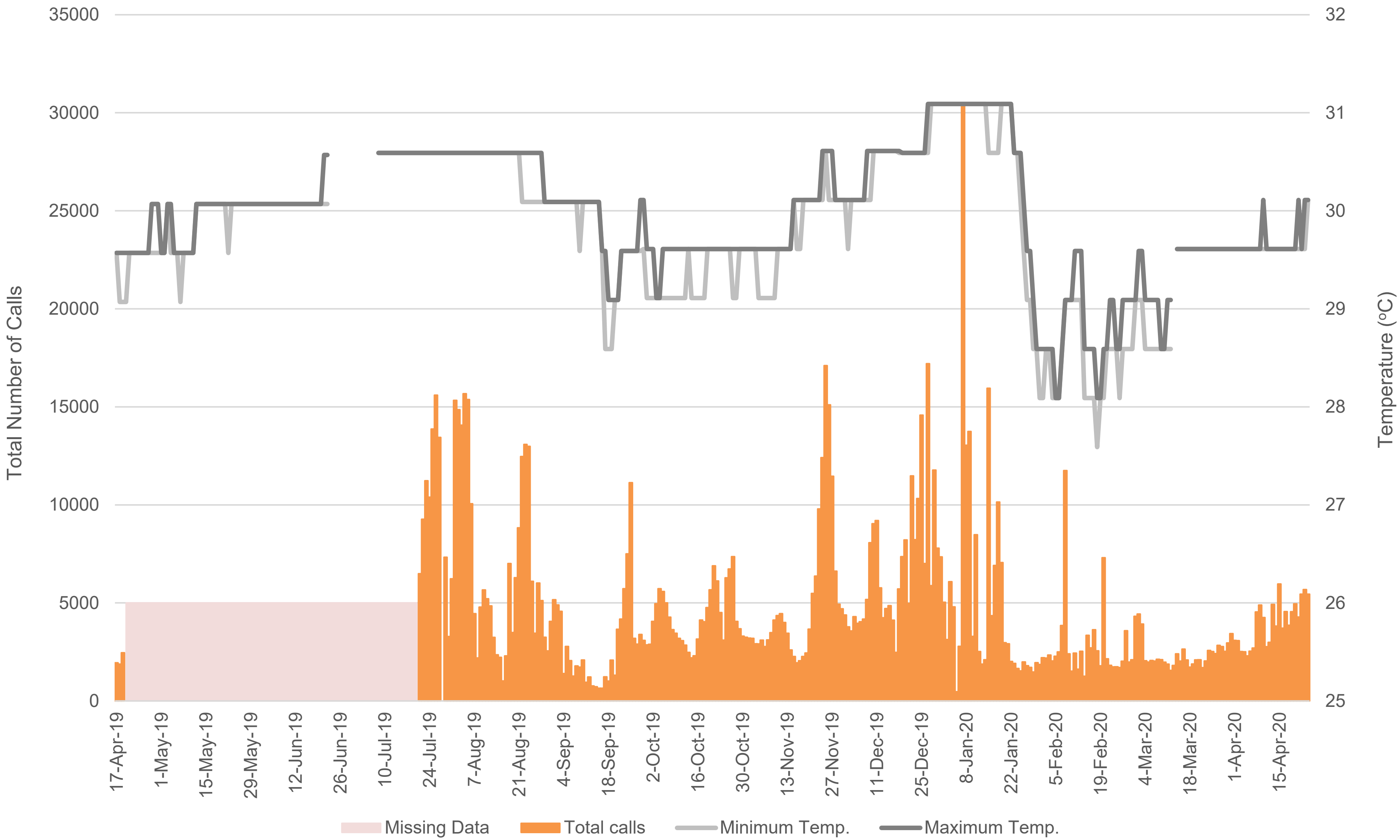


Figure 5.16: Number of calls per day plotted against internal temperature at CO-CA-01 during the monitoring period (April 2019 – April 2020)

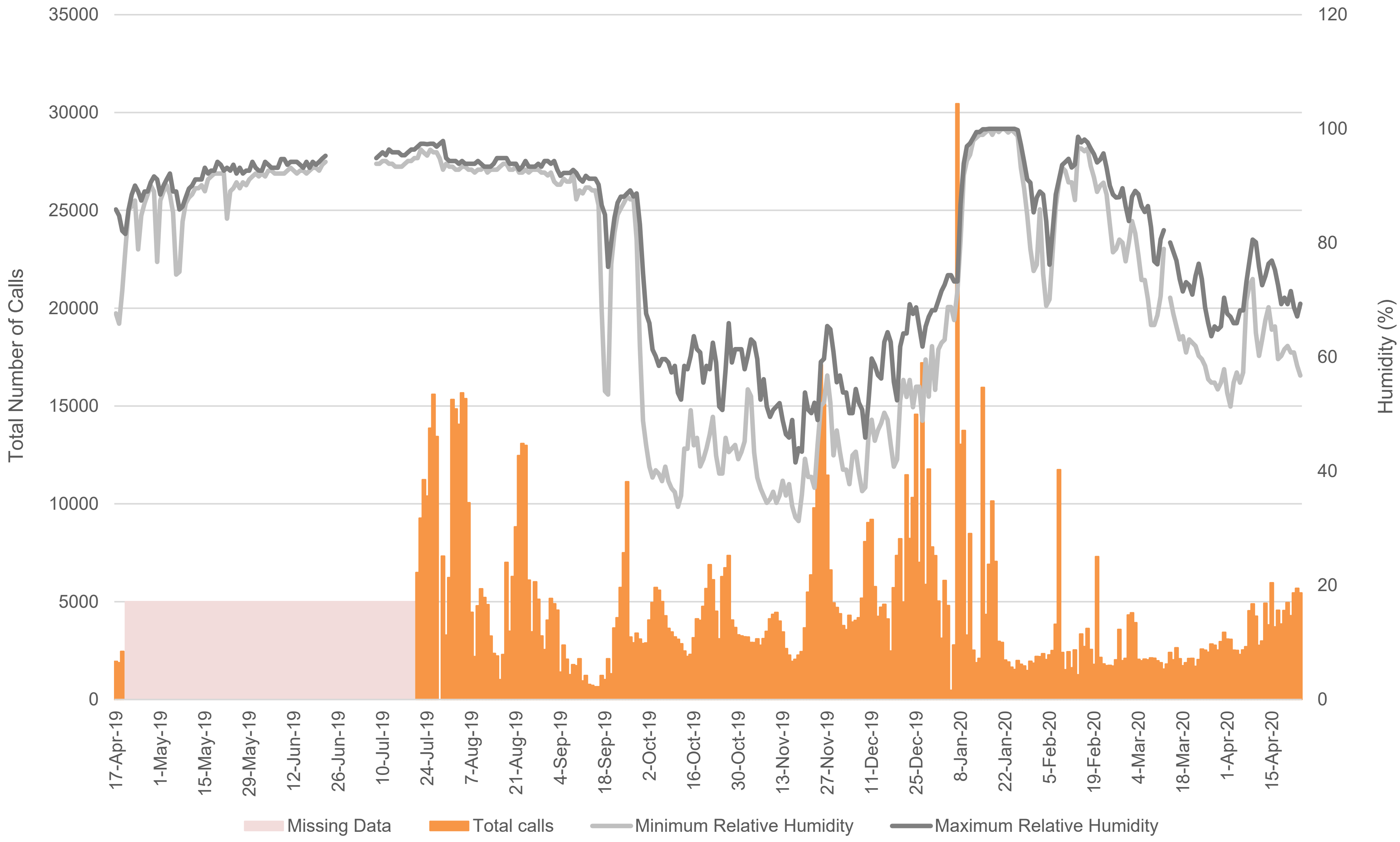


Figure 5.17: Number of calls per day plotted against cave RH at CO-CA-01 during the monitoring period (April 2019 – April 2020)-

5.4 CO-WS-14

5.4.1 Water Quantity

Water was observed at CO-WS-14 during the entire monitoring period and has been observed at the pool since monitoring began in October 2017.

The pool base level equates to 320.09 metres reduced level (mRL). During the monitoring period (April 2019 to April 2020), water depth at CO-WS-14 was relatively stable. Field observations of water depth ranged from 320.98 mRL to 321.04 mRL (0.06 m difference), averaging ~1.1 meters (m) relative to a staff gauge or 321.00 (std = 0.02) mRL (Table 5.7, Figure 5.18). Results were emulated in supplementary water logger data (available from the 1st April 2019 until the 30th July 2019) as well as long-term field observations and long-term water logger data (from October 2017 until April 2020; ~2.5 years) recorded at the site (Table 5.7).

Table 5.7: Water Depth (mRL) at CO-WS-14

Summary Stats	Field Observations		Water Logger Data	
	April 2019 – April 2020	Long-Term	April – July 2019	Long-Term
Average	321.00	320.99	320.96	320.98
Std	0.02	0.02	0.03	0.03
Min	320.98	320.94	320.90	320.90
Max	321.04	321.04	321.03	321.57
Difference	0.06	0.95	0.1	0.7

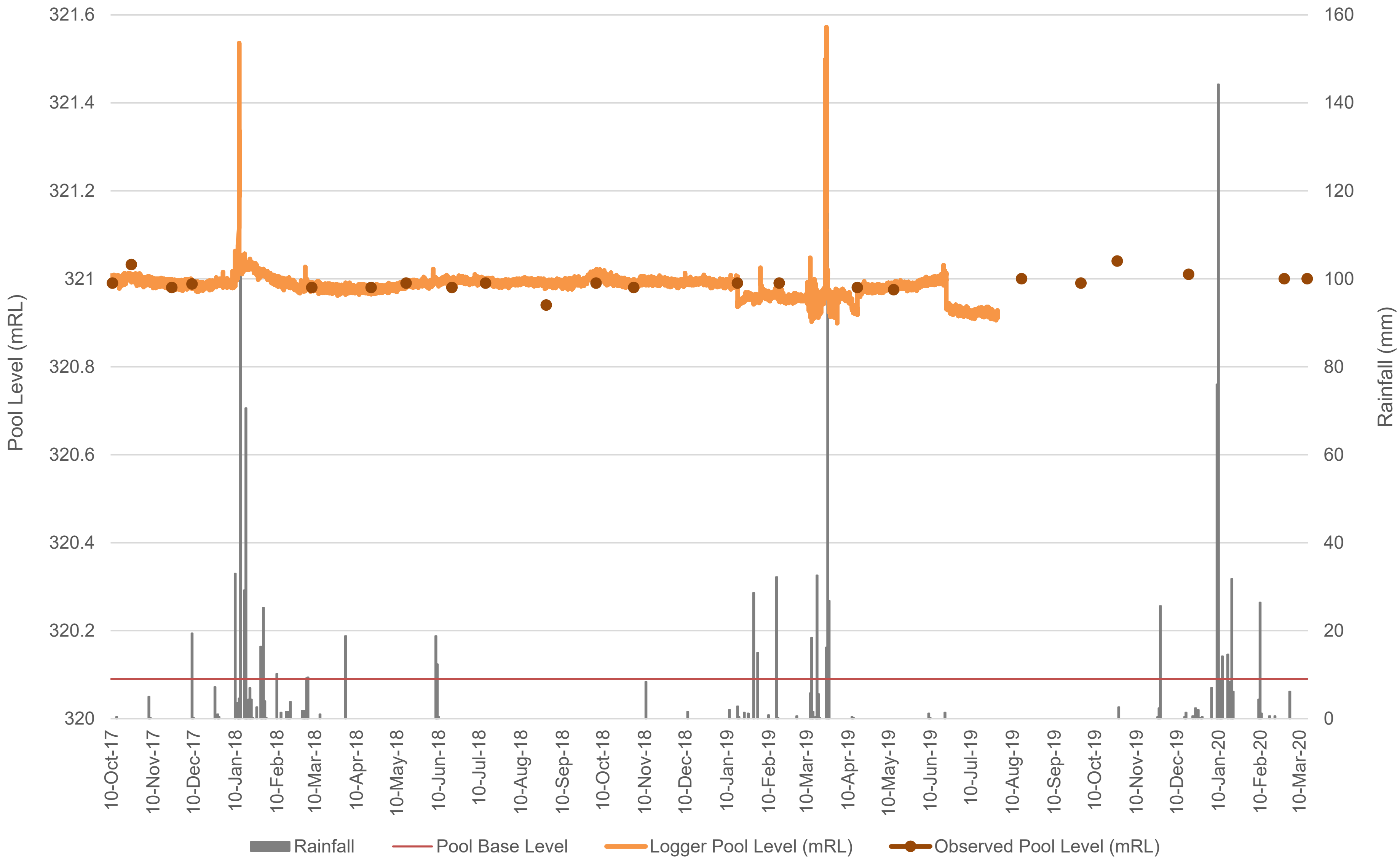


Figure 5.18: Water depth recorded during field observations at CO-WS-14

Prior to the current monitoring period, routine monitoring was conducted at CO-WS-14 along with a further seven pools in the Project Area. CO-WS-11 showed the greatest degree of differentiation in depth (1.64 m based on field observations and 2.6 m based on water logger results) and variability (averaged 399.23 [std = 0.55] mRL based on field observations and 399.3 [std = 0.64] mRL based on water logger results; Table 5.8). CO-WS-14 showed the lowest degree of differentiation in depth (0.1 m based on field observations and 0.7 m based on water logger results) and variability (averaged 320.99 [std = 0.02] mRL based on field observations and 321.0 [std = 0.03] mRL based on water logger results; Table 5.8). Similarly, CO-CA-05 showed the lowest degree of differentiation in depth (0.09 m) and variability (averaged 313.19 [std = 0.03] mRL) based on field observations (Table 5.8). Water was continuously observed at CO-WS-14 since monitoring began in October 2017 (Table 5.8). The water logger at CO-WS-01 is located downstream, in a potentially unsuitable location. Therefore, water logger data should be treated with caution at this pool. This is supported by the fact that water was collected for the purpose of water quality monitoring the day prior to an apparent drop in water depth that was sustained for approximately one month.

Table 5.8: Water Depth (mRL) based at multiple Corunna Downs pools

Summary Stats	CO-WS-01	CO-WS-05	CO-WS-08	CO-WS-10	CO-WS-11	CO-WS-12	CO-WS-13	CO-WS-14
Permanency (SRK, 2019)	Perennial	Perennial	Ephemeral	Perennial	Ephemeral	Perennial	Ephemeral	Perennial
Field Observations								
Average	N/A	313.19	321.86	297.14	399.23	373.94	327.02	320.99
SE	N/A	0.03	0.27	0.21	0.55	0.17	0.29	0.02
Min	N/A	313.17	321.71	296.81	398.53	373.67	326.68	320.94
Max	N/A	313.26	322.26	297.32	400.17	374.14	327.44	321.04
Difference	N/A	0.09	0.54	0.51	1.64	0.46	0.76	0.1
Dry Observations (%)	N/A	20%	36%	22%	25%	8.3%	50%	0%
Water Logger Data								
Average	255.61	N/A	321.74	297.10	399.27	374.00	326.86	320.98
Std	0.10	N/A	0.58	0.27	0.64	0.12	0.35	0.03
Min	254.92	N/A	321.30	296.63	398.44	373.74	326.44	320.90
Max	256.08	N/A	323.54	297.87	401.08	374.80	328.61	321.57
Difference	1.2	N/A	2.2	1.2	2.6	1.1	2.2	0.7
Base Level	255.013	Unknown	321.31	296.65	398.52	373.81	326.59	320.09
Logs < Base Level (#/ %)	*0.06%**		0.7%	7.0%	0.4%	6.7%	36.6%	0.0%

** =The water logger at CO-WS-01 may not be in a representative location for the pool and so this data should be treated with caution as field observations to date confirm permanency of this pool.*

5.4.2 Water Quality

Natural levels and fluctuations in physical stressors (i.e. temperature, conductivity, turbidity, suspended particulate matter, flow and organic matter decay processes) and chemical stressors (i.e. dissolved oxygen (DO), alkalinity, hardness, major ions, total dissolved solids, pH, nutrients, metals, pesticides *etc*.) during the monitoring period are summarised in Table 5.9. Average levels of 11 analytes were comparable with long-term data (Appendix E) including Carbonate (CO_3^{2-} as $CaCO_3$), Hydroxide (OH as $CaCO_3$), Antimony, Arsenic, Cadmium, Chromium, Cobalt, Copper, Lead, Nickel and Selenium. Average levels between the current monitoring year and long-term data were marginal. The largest relative differences in average mg/L were recorded in Mercury (current year was 0.6mg/L higher than the long term average), Iron (current year was 0.25mg/L lower than the long term average) and NOx as N (current year was 0.18mg/L higher than the long term average).

Four of the analytes exceeded the 99% GV by ANZECC and ARMCANZ (2019). Median Boron levels conductivity exceeded the GV on 5 occasions (Table 5.9) during the current monitoring year (and on nine occasions when considering long-term data). Mercury, Zinc and Nitrate (as NO_3) exceeded the GV on one occasion during the monitoring year. Considering long-term data, Zinc exceeded the GV on a further three occasions. Two of the analytes exceeded the 95% GV stipulated by ANZECC and ARMCANZ (2019). The median electrical conductivity exceeded the GV on 10 occasions (Table 5.9) during the current monitoring year (and on 20 occasions when considering long-term data). NOx as N exceeded the GV on five occasions (and on seven occasions when considering long-term data). Iron did not exceed the 95% or 99% GV during the current monitoring period. However, Iron exceeded 95% GV on one occasion in December 2017.

Table 5.9: Summary Statistics of Chemical Analytes at CO-WS-14 (April 2019 to April 2020)

Analyte	Unit	Min	Max	Range	Median	Mean	SE	ANZECC and ARMCANZ (2019) Default GV		Number of exceedances	
								99%	95%	99%	95%
pH		7.3	7.9	0.6	7.75	7.7	0.1	-	6-8	-	-
Electrical Conductivity	µS/cm	330	360	30	340	342	2.5	-	250	-	10
Total Dissolved Solids	mg/L	180	250	70	190	197	7.2	-	-	-	-
Total Suspended Solids	mg/L	2.5	9	6.5	2.5	3.75	0.71	-	-	-	-
Fluoride	mg/L	0.1	0.4	0.3	0.3	0.3	0.03	-	-	-	-
Nitrate as NO_3	mg/L	0.025	1.1	1.1	0.3	0.3	0.09	1	2.4	1	-
Nitrite as NO_2	mg/L	0.025	0.25	0.225	0.25	0.182	0.034	-	-	-	-
NOx as N	mg/L	0.002	0.3	0.3	0.02	0.04	0.03	-	0.01	-	5
Calcium Dissolved	mg/L	11	13	2	12	11.9	0.2	-	-	-	-
Potassium Dissolved	mg/L	1	3	2	1.3	1.4	0.2	-	-	-	-
Magnesium Dissolved	mg/L	19	22	3	20.5	20.7	0.3	-	-	-	-
Sodium Dissolved	mg/L	19	24	5	21.5	21.4	0.4	-	-	-	-
Bicarbonate HCO_3 as CaCO3	mg/L	72	100	28	89	89.1	2.5	-	-	-	-
Carbonate CO_3^{2-} as $CaCO_3$	mg/L	<5	<5	0	<5	<5	0	-	-	-	-
Hydroxide OH as $CaCO_3$	mg/L	<5	<5	0	<5	<5	0	-	-	-	-
Total Alkalinity as $CaCO_3$	mg/L	72	100	28	89	89.1	2.5	-	-	-	-
Chloride	mg/L	29	40	11	32	32.6	1.04	-	-	-	-
Sulphate	mg/L	27	34	7	29.5	29.4	0.7	-	-	-	-
Ionic Balance	%	-2	3	5	0.004	0.4	0.7	-	-	-	-
Hardness as $CaCO_3$	mg/L	110	120	10	115	115	1.7	-	-	-	-
Sum of Anions	meq/L	2.9	3.1	0.2	3.0	3.0	0.03	-	-	-	-
Sum of Cations	meq/L	3.2	3.4	0.2	3.4	3.3	0.03	-	-	-	-
Silica	mg/L	14	18	4	17	16.8	0.4	-	-	-	-
Aluminium Dissolved	mg/L	0.005	0.02	0.02	0.005	0.007	0.001	0.027	0.055	-	-
Antimony Dissolved	mg/L	<0.001	<0.001	0	<0.001	<0.001	0	-	-	-	-
Arsenic Dissolved	mg/L	<0.001	<0.001	0	<0.001	<0.001	0	0.001	0.024	-	-
Barium Dissolved	mg/L	0.005	0.1	0.095	0.005	0.02	0.009	-	-	-	-
Boron Dissolved	mg/L	0.005	0.1	0.095	0.095	0.08	0.01	0.09	0.37	5	-
Cadmium Dissolved	mg/L	<0.0001	<0.0001	0	<0.0001	<0.0001	0	0.00006	0.0002	-	-
Chromium Dissolved	mg/L	<0.001	<0.001	0	<0.001	<0.001	0	0.00001	0.001	-	-
Cobalt Dissolved	mg/L	<0.001	<0.001	0	<0.001	<0.001	0	-	-	-	-
Copper Dissolved	mg/L	<0.001	<0.001	0	<0.001	<0.001	0	0.001	0.0014	-	-
Iron Dissolved	mg/L	0.005	0.05	0.05	0.02	0.02	0.005	-	0.3	-	-
Lead Dissolved	mg/L	<0.001	<0.001	0	<0.001	<0.001	0	0.001	0.0034	-	-
Manganese Dissolved	mg/L	<0.001	0.3	0.3	0.2	0.2	0.03	1.2	1.9	-	-
Mercury Dissolved	mg/L	<0.00005	0.1	0.13	0	0.01	0.01	0.00006	0.0006	1	-
Molybdenum Dissolved	mg/L	<0.001	<0.001	0	<0.001	<0.001	0	-	-	-	-
Nickel Dissolved	mg/L	<0.001	0.001	0	0	0.001	0	0.008	0.011	-	-
Selenium Dissolved	mg/L	<0.001	<0.001	0	<0.001	<0.001	0	0.005	0.011	-	-
Strontium Dissolved	mg/L	0.04	0.056	0.016	0.048	0.047	0.001	-	-	-	-
Tin Dissolved	mg/L	<0.001	0.01	0.01	0	0.002	0.001	-	-	-	-
Zinc Dissolved	mg/L	<0.001	0.003	0.002	0.002	0.002	0	0.0024	0.008	1	-

Note: orange cells exceed 99% GV, yellow cells exceed 95% GV

6 DISCUSSION

6.1 Cave Microclimate

During the monitoring period (April 2019 to April 2020), temperatures inside both CO-CA-01 and CO-CA-03 were notably stable, with minimal daily fluctuation. Overall temperatures were slightly higher, on average, in CO-CA-03 compared with CO-CA-01 (30.3°C [*SE* ± 0.02°C] and 29.9°C [*SE* ± 0.01°C], respectively). Temperatures inside CO-CA-03 remained within the target range (28-32°C) for the entire monitoring period (100%), while temperatures inside CO-CA-01 remained within the target range for 99.89% of the monitoring period. Ambient temperatures appeared to have very little influence on temperatures inside the roost. Although there was little temporal variation, temperatures within CO-CA-03 declined marginally between October and December 2019 while temperatures within CO-CA-01 declined marginally between late January and mid-March 2020. Therefore, while both caves exhibited temperatures within the same range, they did not follow the same pattern, suggesting that the factor/s controlling temperate are different at the caves such as cave morphology (Perry, 2012). Though both are upward sloping caves and readily trap upward rising air, as is a common trend of such caves (Perry, 2012), they are very different with respect to entrance size, shape and position in the landscape.

During the monitoring period, RH in CO-CA-03 occurred over a greater range and was significantly higher (p = <0.0001), on average, than in CO-CA-01 (Figure 6.1). Both caves exhibited similar temporal trends in cave RH levels, except for between March and April 2020 whereby CO-CA-01 exhibited a decline in RH outside of the target range. There was a significant non-linear monthly trend in caver RH. Moreover, variation in RH was negatively correlated with ambient temperature (after 35°C Figure 6.1), and the relationship was mediated by two- week rainfall (p = <0.0001). Specifically, cave RH was highest when ambient temperature was between 35-40°C and two-week rainfall was ≥250 mm. In addition, water seeps have been noted in both caves. It is likely these seeps are supplemented by rainfall emanating through the rock strata and likely contribute to humid internal conditions.

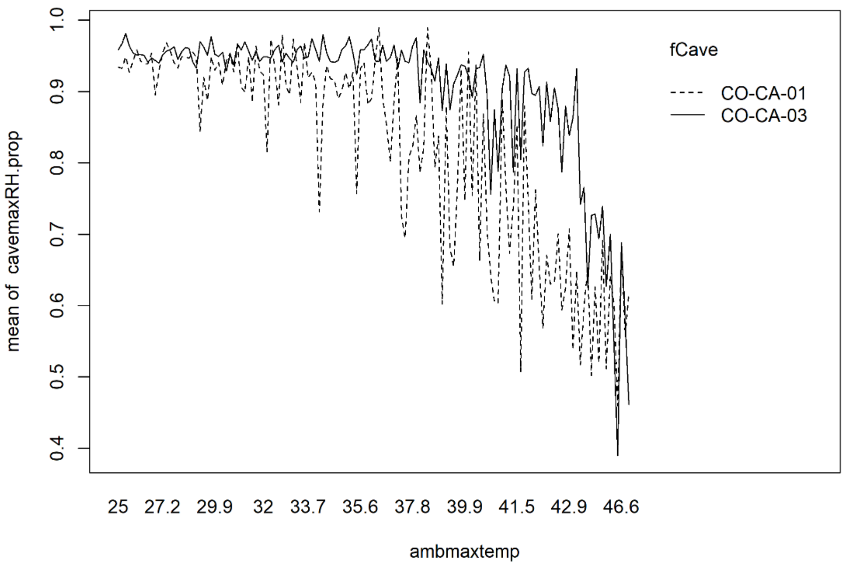


Figure 6.1: Relationship between RH at CO-CA-01 and CO-CA-03 and ambient temperature during the monitoring period

RH fell within the target range (85-100%) between April to late-September 2019 and from April to early-October 2019 at CO-CA-01 and CO-CA-03, respectively. During this period, 94.8% of recordings fell within the target range at CO-CA-01 and 100% fell within the target range at CO-CA-03. Following, RH at both caves declined outside the target range until January 2020. These results highlight the fact that caves naturally fluctuate outside of the target range. Moreover, it would be assumed that CO-CA-03 offers a more suitable environment for the species, in consideration of microclimate data only. However, low humidity levels recorded at CO-CA-03 in November 2017 was suggested to be on account of an outward flowing draft likely emanating from a crack in the strata of the second chamber that may open to the top of the ridge and periodically close on account of ground water contained within the strata or some other process that blocks the airflow (Bat Call, 2018). Moreover, it could be that the iButton within CO-CA-01 was not in the most representative roosting location for the species, given lack of access to rear chamber.

6.2 Cave Utilisation

Pilbara leaf-nosed bats were recorded at both CO-CA-01 and CO-CA-03 on every night during the monitoring period except for a single night at CO-CA-03; on the 8th January 2020 when Cyclone Blake hit Marble Bar. Interestingly, activity by the species peaked at CO-CA-01 on the 7th of January. Overall, activity occurred over a greater range at CO-CA-03 (64 to 56,699 calls) compared to CO-CA-01 (470 to 30,452 calls). Moreover, average activity was significantly greater at CO-CA-03 (7,033 [*SE* ± 619] calls per night) in comparison to CO-CA-01 (4,726 [*SE* ± 229] calls per night). During previous baseline monitoring event, average activity was also greater at CO-CA-03 than at CO-CA-01 in July 2017 (MWH, 2018), but marginally lower in 2018 (Biologic, 2019c).

Pilbara leaf-nosed bat activity at CO-CA-01 was significantly affected by day of sampling (p = <0.05). This indicates that activity is driven by an untested variable related to timing and/or a behavioural response. Roosting was indicated on all recording nights during the monitoring period at CO-CA-01. This pattern of usage is consistent with a Permanent Diurnal Roosts (Priority 1) defined by TSSC (2016) as a roost "*occupied year-round and are likely to be the focus for some part of the 9-month breeding cycle*". Roosting remained relatively constant throughout the monitoring period regardless of the apparent temporal variation in cave RH.

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. Therefore, humid microclimates help to reduce the consequence of dehydration (Baudinette *et al.*, 2000). Moreover, at temperatures lower than 30°C, the Pilbara leaf-nosed bat cannot maintain a body temperature of 36°C as such conditions require energy consumption rates of at least double that within thermoneutrality (Baudinette *et al.*, 2000). Therefore, the species is dependent on warm and humid roosting sites, especially during the dry Pilbara winter months (Baudinette *et al.*, 2000). This supports the theory that the iButton at CO-CA-01 may not be in the most representative roosting location of the species. As such cave RH at CO-CA-01 may be more consistent than that recorded during the monitoring period, given the Pilbara leaf-nosed bat roosted on all recording nights during the monitoring period, and have consistently been recorded roosting within the cave during previous monitoring surveys (Biologic, 2019a, 2019c).

Conversely, roosting at CO-CA-03 was indicated on 47% of recording nights during the monitoring period, of which 91.3% of roosting events occurred between the 17th of April 2019 and the 25th of October 2019. In the Pilbara, mating by the species is thought to commence in July, and parturition is thought to commence in December after a long gestation period (Armstrong, 2001; Churchill, 1995). The level of activity and the consistency of roosting observed at CO-CA-03 over this period coincides with the species mating period and therefore may indicate such activities at the cave. Moreover, this pattern of usage is consistent with a Non-Permanent Breeding Roosts (Priority 2), defined by TSSC (2016) as roosts containing "*evidence of usage during some part of the 9-month breeding cycle (July–March), but not occupied year-round; considered as critical habitat that is essential for both the daily and long-term survival of the Pilbara leaf-nose bat*". Between the 26th of October and the 24th of April 2020, roosting was only indicated on 8.4% of recording nights. When roosting was not indicated, the timing of most of these calls suggested that individuals were in flight, possibly foraging, and roosting at another location.

Maximum ambient temperature, maximum cave temperature, range in cave RH and percentage moon illumination were not significant variables influencing roosting status at CO-CA-03. However, roosting typically occurred when conditions were more favourable (i.e. temperature and RH within the target ranges) suggesting that these conditions are still a prerequisite for roosting. Roosting was however correlated with day of sampling, indicating fluctuations in roosting activity at certain times of the year, exclusive to the other variables tested. This indicates that roosting was driven by untested variables related to timing and/or a behavioural response (e.g. reproductive cues).

Modelling also demonstrated that Pilbara leaf-nosed bat activity was significantly affected by day of sampling (p = <0.0001). This indicates that activity is also driven by an untested variable related to timing and/or a behavioural response (i.e. a behavioural preference for roosting at CO-CA-03). Although maximum cave RH and percentage moon illumination were not significant variables influencing activity at CO-CA-03, activity was significantly influence by range in cave RH (after accounting for seasonality; p = <0.05). Peaks in activity typically occurred when conditions were more favourable (i.e. temperature and RH within the target ranges). Therefore, it can be inferred that Pilbara leaf-nosed bats utilise CO-CA-03 during the mating and gestation period prior to parturition when cave RH is high and stable. Furthermore, during the mating and gestation period, it may be that Pilbara leaf-nosed bats are preferentially roosting within CO-CA-03 given the greater levels of activity observed in comparison to CO-CA-01 (although this is based on limited data at CO-CA-01, for which no ultrasonic recordings were available between April and July 2019). The species may have also preferentially used CO-CA-03 in July 2017 (MWH, 2018). However, average activity was marginally lower in 2018 at CO-CA-03 compared to CO-CA-01 (Biologic, 2019c).

6.3 Water Quality and Quantity

Foraging sites surrounding known or suspected roosts can be critical to the survival of the Pilbara leaf-nosed bat. The species forages within the vicinity of roost caves and more broadly along waterbodies with suitable fringing vegetation supporting prey species (TSSC, 2016). Riparian zones are preferentially used by the species likely on account of their high productivity and water availability (Cramer *et al.*, 2016). As such gorges with pools are considered Priority 1 foraging habitat for the species (TSSC, 2016). Therefore, CO-WS-14 is considered foraging habitat critical to Pilbara leaf-nosed bat survival.

Pilbara leaf-nosed bats were recorded at CO-CA-03 on every night during the monitoring period except for a single night (8th January 2020). Roosting at the cave was recorded on 47% of recording nights during the monitoring period. However, on 53% of recording nights, the timing of calls suggested that individuals were in flight and possibly foraging at the site and by virtue CO-WS-14 (activity at CO-WS-14 cannot be directly recorded due to its proximity to CO-CA-03). The consistency at which the species uses the site as a forging location suggests CO-WS-14 is currently suitable habitat for the species. Therefore, the water quantity (tabulated in Sections 5.4.1) can be inferred as suitable for Pilbara leaf-nosed bats. CO-WS-14 contained water for the entire monitoring period and since monitoring began in October 2017. The pool is unlikely to dry out without interference in consideration of this and in consideration of the depth of CO-WS-14. Moreover, the quality (tabulated in Section 5.4.2) of the water can be inferred as suitable for Pilbara leaf-nosed bats. Some exceedances in six of the analytes relative to 95% and 99% GV stipulated in the ANZG Guidelines were observed (ANZG, 2019).

6.4 Evaluation of EPBC Approval Decision Condition 4

Condition 3 and 4 of the EPBC Approval Decision relate to potential impacts and management of the Pilbara leaf-nosed bat, specifically at cave CO-CA-03 and pool CO-WS-14. Currently, a monitoring strategy must be designed to demonstrate the maintenance of Condition 4, unless otherwise justified and approved by the Minister. The analysis, review and assessment of baseline monitoring data collected between April 2019 and April 2020 was used to help inform the adequacy and achievability of these objectives (Table 6.1).

Table 6.1: Conditions stipulated in EPBC Approval Decision 2017/7861

Condition	Assessment Against Baseline Data
4a) without anthropogenic supplementation of its water level, pool CO-WS-14 has water in it during and continuously for three consecutive years following the cessation of mining of Razor Back Pit	Water was continually present during the entire monitoring period (April 2019 to April 2020) as well as over the long-term (October 2017 to April 2020). Based on field observation, pool water level averaged 321.00 mRL [Std ± 0.02] during the monitoring period and 320.99 mRL [Std ± 0.02] over the long term.
4b) the water quality of pool CO-WS-14 remains suitable for Pilbara leaf-nosed bat during and continuously for three consecutive years following the cessation of mining of Razor Back Pit	Given the consistency at which the species uses the site as a foraging location (i.e. CO-CA-03 and by virtue CO-WS-14) suggests CO-WS-14 is currently suitable for the species. Therefore, the current quality documented over the monitoring period can be inferred as suitable for Pilbara leaf-nosed bats.
4c-i) cave CO-CA-03 maintains humidity between 85-100 per cent relative humidity during and continuously for five years following cessation of the mining of Razor Back Pit	Overall, humidity ranged from 18.1% to 99.5%, averaging 85.2% (*SE* ± 0.34). There was cyclic variation in RH; RH was highest between April to October 2019 (100% fell within the target range) and January to April 2020 (92.7% of recordings falling within the target range) and lowest between October 2019 and January 2020 (12.1% of recordings fell within the target range). Over a 12-month period, 75.3% of humidity recordings were within the target range (85-100%). Between April and October, RH within the cave was 95.1% (*SE* ± 0.05) on average. This coincided with roosting by the species on 91.3% of recording nights over this period and days of sampling was found to significantly influence the probability of roosting. Pilbara leaf-nosed bat activity was also significantly affected by day of sampling as well as range in cave RH. Therefore, it can be inferred that Pilbara leaf-nosed bats utilise CO-CA-03 during the mating and gestation period prior to parturition when cave RH is high and more stable. Overall, RH was not maintained within the target range for the entire monitoring period, rendering this condition unachievable.
4c-ii) cave CO-CA-03 maintains temperature between 28 and 32 degrees Celsius during and continuously for five years following cessation of the mining of Razor Back Pit	Temperature ranged from 28.0 to 31.6°C, averaging 30.3°C (*SE* ± 0.02°C) over the monitoring period. Overall, temperatures inside the roost were maintained within the target range for the entire monitoring period (within the target range (28-32°C) for 100% of the 12-month monitoring period), rendering this condition achievable

7 CONCLUSIONS

7.1 Cave Microclimate and Cave Utilisation

Roosting was indicated on all recording nights during the monitoring period at CO-CA-01. This pattern of usage is consistent with a Permanent Diurnal Roost (Priority 1) defined by TSSC (2016) as a roost "*occupied year-round and are likely to be the focus for some part of the 9-month breeding cycle*". Pilbara leaf-nosed bat roosting events remained relatively constant throughout the monitoring period regardless of the temporal variation in internal temperature and RH. However, given the species dependence on warm and humid microclimates it is possible that the iButton at CO-CA-01 may not have been placed in the most representative roosting location within the cave.

Roosting at CO-CA-03 was indicated on 47% of recording nights during the monitoring period, of which 91.3% of roosting events occurred between April and October 2019. The level of activity and the consistency of roosting observed over this period suggests individuals potentially congregate at the cave for the purposes of mating. Moreover, this pattern of usage is consistent with a Non-Permanent Breeding Roost (Priority 2), defined by TSSC (2016) as roosts containing "*evidence of usage during some part of the 9-month breeding cycle (July–March), but not occupied year-round; considered as critical habitat that is essential for both the daily and long-term survival of the Pilbara leaf-nose bat*".

Conditions 4c-i in EPBC Approval Decision 2017/7861, stipulated that cave CO-CA-03 should maintain humidity between 85-100%. However, there is a significant non-linear trend in cave RH. Moreover, ambient temperature was found to be negatively correlated with cave RH (above 35^{o}C), and the relationship was mediated by two-week rainfall. At CO-CA-03, RH was highest (100% of recordings fell within the target range) between April to October 2019 (coinciding with the mating period for the species) and January to April 2020 (92.7% of recordings fell within the target range). In comparison, RH was lowest between October 2019 and January 2020 over which only 12.1% of recordings were within the target range. Similarly, RH was not maintained within the target range for the entire monitoring period at CO-CA-01, although the iButton may not have been in the most representative roosting location for the species.

At CO-CA-03, Pilbara leaf-nosed bat activity and roosting was significantly affected by day of sampling. This suggests that an untested variable and/or a behavioural response may be driving roosting and activity at the cave. Additionally, range in cave RH significantly influenced activity. Roosting and peaks in activity typically occurred when conditions were more favourable (i.e. temperature and RH within the target ranges) suggesting that these conditions are still a prerequisite for roosting. Therefore, in summary Pilbara leaf-nosed bats utilise CO-CA-03 during the mating season prior to parturition when cave RH is high and relatively stable. Consequently, it is recommended that Condition 4c-i be altered to consider that RH remains in the target range (85%-100%) for part of the year only, perhaps during the mating season in order to avoid disruption of breeding by the species that may have a significant impact on the species (TSSC, 2016). Some consideration should also be provided to the effect of rainfall given its correlation with changes in RH; RH may vary according to year to year rainfall variability.

Conditions 4c-ii in EPBC Approval Decision 2017/7861, stipulated that cave CO-CA-03 should maintain temperature between 28-32°C. Temperatures inside both roosts remained within the target range (28-32°C) for the monitoring period (100%) and did not appear to be influenced by ambient temperatures. Although there was little cyclic and seasonal variation, temperatures within CO-CA-03 declined marginally between October and December 2019 while temperatures within CO-CA-01 declined marginally between late January and mid-March 2020. Therefore, while both caves exhibited temperatures within the same range, they did not follow the same pattern, suggesting that the factor/s controlling temperate are different at the caves. Neither ambient temperature or cave temperature significantly affected activity or roosting by the species. However, ambient temperature was found to be negatively correlated with cave RH, and the relationship was mediated by two-week rainfall. Consequently, Condition 4c-ii does not require alteration.

The results of this analysis are based on 12-month monitoring period. However, trends maybe more or less apparent over a longer sampling period.

7.2 Water Quality and Quantity

Condition 4a in EPBC Approval Decision 2017/7861, stipulated that without anthropogenic supplementation of its water level, pool CO-WS-14 has water in it during and continuously for three consecutive years following the cessation of mining of Razorback Pit. During the entire monitoring period (April 2019 to April 2020) as well as over the long-term (October 2017 to April 2020) water was present at the site; pool water level averaged 321.00 mRL [Std ± 0.02] and 320.99 mRL [Std ± 0.02] respectively. No drawdown is anticipated from the Project (SRK, 2019).

Additionally, Condition 4b stipulates that the water quality of pool CO-WS-14 remains suitable for Pilbara leaf-nosed bat during and continuously for three consecutive years following the cessation of mining of Razor Back Pit. Pilbara leaf-nosed bats were recorded at CO-CA-03 on every night during the monitoring period except for a single night (8th January 2020 likely due to Cyclone Blake). On 53% of recording nights, the timing calls suggested that individuals were in flight and possibly foraging at the site and by virtue CO-WS-14. Given the consistency at which the species uses the site as a forging location suggests CO-WS-14 is currently suitable for the species. Therefore, the quality of the water can be inferred as suitable for Pilbara leaf-nosed bats. Suitable parameters for the species are not known.

8 REFERENCES

ACG, Australian Centre for Geomechanics. (2017). *Corunna cave project: CO-CA-03 cave stability assessment*. Unpublished report prepared for Atlas Iron Limited.

ANZECC, Australian and New Zealand Environment and Conservation Council, & ARMCANZ, Agriculture and Resource Management Council of Australia and New Zealand. (2019). Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Retrieved from https://www.waterquality.gov.au/anz-guidelines

ANZG, Australian and New Zealand Guidelines for Fresh and Marine Water Quality. (2019). Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Retrieved from https://www.waterquality.gov.au/anz-guidelines

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

Atlas Iron, Pty Ltd. (2019). *Corunna Downs project supplementary report - EPA referral*. Unpublished report for the Environmental Protection Authority (EPA).

Bat Call, WA. (2018). *Corunna Downs cave CO-CA-03 Pilbara leaf-nosed bat roost census, November 2017*. Unpublished report prepared for Atlas Iron Limited.

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, Environmental Survey. (2019a). *Corunna Downs project Pilbara Leaf-nosed Bat and Ghost Bat monitoring survey 2019*. Unpublished report prepared for Atlas Iron Limited.

Biologic, Environmental Survey. (2019b). *Corunna Downs project, northern quoll monitoring survey 2018*. Unpublished report prepared for Atlas Iron Limited.

Biologic, Environmental Survey. (2019c). *Corunna Downs project, Pilbara Leaf-nosed Bat and ghost bat monitoring survey 2018*. Unpublished report prepared for Atlas Iron Limited.

BoM, Bureau of Meteorology. (2020). Climate Data Online. Retrieved 2020 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.

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. (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

Fasiolo, M., Nedellec, R., Goude, Y., & Wood, S. N. (2018). Scalable visualisation methods for modern Generalized Additive Models.: ArXiv preprint Retrieved from https://arxiv.org/abs/1809.10632

Grosjean, P., & Ibanez, F. (2018). pastecs: Package for Analysis of Space-Time Ecological Series. R package (Version 1.3.21). Retrieved from https://CRAN.R-project.org/package=pastecs'

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.

Moongiant. (2020). Moon Phase. Retrieved from https://www.moongiant.com/phase/today/

MWH, Australia. (2016). *Corunna Downs project: Terrestrial vertebrate fauna survey*. Unpublished report prepared for Atlas Iron Limited.

MWH, Australia. (2017). *Current understanding of the importance of CO-CA-03 for the pilbara leaf-nosed bat*. Unpublished report prepared for Atlas Iron Limited.

MWH, Australia. (2018). *Corunna Downs project: Pilbara leaf-nosed bat and ghost bat baseline monitoring survey*. Prepared For Atlas Iron Limited:

Perry, R. W. (2012). A review of factors affecting cave climates for hibernating bats in temperate North America. *Environmental Reviews, 21*(1), 28-39. doi:https://doi.org/10.1139/er-2012-0042

R Core Team. (2017). R: A language and environment for statistical computing.: R Foundation for Statistical Computing, Vienna, Austria. Retrieved from https://www.R-project.org/.

SRK, Consulting. (2019). *Corunna Downs mine water supply: H3 hydrogeological assessment*. Unpublished report prepared for Atlas Iron Limited.

Stantec, Australia. (2018). *Corunna Downs Project Hydrogeological Investigation*. Unpublished report prepared for Atlas Iron.

Terra Rosa. (2017). *CO-CA-03 Laser Scan*. Unpublished dataset prepared for Atlas Iron Limited.

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*. Canberra, Australian Capital Territory:

Wildlife Acoustics, Inc. (2017). *Song Meter SM4BAT FS Bioacoustics Recorder User Guide*. Massachusetts, United States of America:

9 APPENDICES

Appendix A: Sample Water Quality Report from ENVIROLAB

Envirolab Services (WA) Pty Ltd trading as MPL Laboratories
ABN 53 140 099 207
16-18 Hayden Court Myaree WA 6154
ph 08 9317 2505 fax 08 9317 4163
lab@mpl.com.au
www.mpl.com.au

CERTIFICATE OF ANALYSIS 218256

Client Details

Client	Atlas Iron Limited
Attention	David Nyquest
Address	Level 18, 300 Murray Street, PERTH, WA, 6000

Sample Details

Your Reference	**Atlas Iron / Corunna / Surface Water**
Number of Samples	4 Waters
Date samples received	05/11/2018
Date completed instructions received	05/11/2018

Analysis Details

Please refer to the following pages for results, methodology summary and quality control data.

Samples were analysed as received from the client. Results relate specifically to the samples as received.

Results are reported on a dry weight basis for solids and on an as received basis for other matrices.

Report Details

Date results requested by	09/11/2018
Date of Issue	09/11/2018

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Results Approved By
Todd Lee, Laboratory Manager, Perth

Authorised By

Todd Lee, Laboratory Manager

Miscellaneous Inorganics						
Our Reference	UNITS	PQL	218256-1	218256-2	218256-3	218256-4
Your Reference			CO-WS-01	CO-WS-14	CO-WS-12	CO-WS-10
Date Sampled			03/11/2018	02/11/2018	01/11/2018	01/11/2018
Type of sample			Water	Water	Water	Water
Date prepared	-		05/11/2018	05/11/2018	05/11/2018	05/11/2018
Date analysed	-		05/11/2018	05/11/2018	05/11/2018	05/11/2018
pH	pH Units		7.9	7.6	6.3	8.0
Electrical Conductivity (EC)	µS/cm	1	380	340	140	910
Total Dissolved Solids (grav)	mg/L	5	230	200	85	540
Total Suspended Solids	mg/L	5	<5	<5	17	<5
Fluoride	mg/L	0.1	<0.1	0.3	0.2	0.3
Nitrate as NO_3	mg/L	0.5	<0.5	<0.5	<0.5	<0.5
Nitrite as NO_2	mg/L	0.5	<0.5	<0.5	<0.5	<0.5
NOx as N	mg/L	0.005	0.017	<0.005	<0.005	<0.005

Ionic Balance						
Our Reference			218256-1	218256-2	218256-3	218256-4
Your Reference	UNITS	PQL	CO-WS-01	CO-WS-14	CO-WS-12	CO-WS-10
Date Sampled			03/11/2018	02/11/2018	01/11/2018	01/11/2018
Type of sample			Water	Water	Water	Water
Date prepared	-		08/11/2018	08/11/2018	08/11/2018	08/11/2018
Date analysed	-		08/11/2018	08/11/2018	08/11/2018	08/11/2018
Calcium - Dissolved	mg/L	0.5	12	12	3.3	13
Potassium - Dissolved	mg/L	0.5	1.0	1.2	<0.5	2.2
Magnesium - Dissolved	mg/L	0.5	27	21	6.4	36
Sodium - Dissolved	mg/L	0.5	24	20	13	110
Bicarbonate HCO_3 as $CaCO_3$	mg/L	5	130	92	39	170
Carbonate CO_3^{2-} as $CaCO_3$	mg/L	5	<5	<5	<5	<5
Hydroxide OH^- as $CaCO_3$	mg/L	5	<5	<5	<5	<5
Total Alkalinity as $CaCO_3$	mg/L	5	130	92	39	170
Chloride	mg/L	1	32	29	18	170
Sulphate	mg/L	1	13	26	<1	28
Ionic Balance	%		0.37	0.053	-0.97	-2.1
Hardness as $CaCO_3$	mg/L	3	140	110	35	180
Sum of Anions	meq/L	0	3.39	2.87	1.14	8.13
Sum of Cations	meq/L	0	3.91	3.20	1.26	8.39

Dissolved Metals in Water						
Our Reference			218256-1	218256-2	218256-3	218256-4
Your Reference	UNITS	PQL	CO-WS-01	CO-WS-14	CO-WS-12	CO-WS-10
Date Sampled			03/11/2018	02/11/2018	01/11/2018	01/11/2018
Type of sample			Water	Water	Water	Water
Date prepared	-		06/11/2018	06/11/2018	06/11/2018	06/11/2018
Date analysed	-		06/11/2018	06/11/2018	06/11/2018	06/11/2018
Silica	mg/L	0.2	17	19	26	32
Aluminium-Dissolved	mg/L	0.01	<0.01	<0.01	<0.01	<0.01
Antimony-Dissolved	mg/L	0.001	<0.001	<0.001	0.002	<0.001
Arsenic-Dissolved	mg/L	0.001	<0.001	<0.001	<0.001	<0.001
Barium-Dissolved	mg/L	0.001	0.016	0.007	0.030	0.029
Boron-Dissolved	mg/L	0.02	0.09	0.1	0.07	0.34
Cadmium-Dissolved	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium-Dissolved	mg/L	0.001	<0.001	<0.001	<0.001	<0.001
Copper-Dissolved	mg/L	0.001	<0.001	<0.001	<0.001	<0.001
Cobalt-Dissolved	mg/L	0.001	<0.001	<0.001	0.001	<0.001
Iron-Dissolved	mg/L	0.01	0.03	0.01	0.07	<0.01
Lead-Dissolved	mg/L	0.001	<0.001	<0.001	<0.001	<0.001
Manganese-Dissolved	mg/L	0.005	0.033	0.26	0.46	0.026
Mercury-Dissolved	mg/L	0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Molybdenum-Dissolved	mg/L	0.001	<0.001	<0.001	<0.001	<0.001
Nickel-Dissolved	mg/L	0.001	<0.001	<0.001	0.002	<0.001
Selenium-Dissolved	mg/L	0.001	<0.001	<0.001	<0.001	<0.001
Strontium-Dissolved	mg/L	0.001	0.071	0.050	0.055	0.15
Tin-Dissolved	mg/L	0.001	<0.001	<0.001	<0.001	<0.001
Zinc-Dissolved	mg/L	0.001	0.002	0.001	<0.001	<0.001

Method ID	Methodology Summary
INORG-001	pH - Measured using pH meter and electrode base on APHA latest edition, Method 4500-H+. Please note that the results for water analyses may be indicative only, as analysis can be completed outside of the APHA recommended holding times. Soils are reported from a 1:5 water extract unless otherwise specified.
INORG-002	Conductivity and Salinity - measured using a conductivity cell at 25°C based on APHA latest edition Method 2510. Soils reported from a 1:5 water extract unless otherwise specified.
INORG-006	Alkalinity - determined titrimetrically based on APHA latest edition, Method 2320-B. Soils reported from a 1:5 water extract unless otherwise specified.
INORG-018	Total Dissolved Solids - determined gravimetrically. The solids are dried at 180±5°C
INORG-019	Suspended Solids - determined gravimetrically by filtration of the sample. The samples are dried at 104+/-5oC.
INORG-040	Ion Balance Calculation: Cations in water by ICP-OES; Anions in water by IC; Alkalinity in water by Titration using APHA methods.
INORG-055	NOx - determined colourimetrically. Soils are analysed from a water extract.
INORG-081	Anions - a range of anions are determined by Ion Chromatography based on APHA latest edition Method 4110-B. Soils and other sample types reported from a water extract unless otherwise specified (standard soil extract ratio 1:5).
METALS-008	Hardness calculated from Calcium and Magnesium as per APHA latest edition 2340B.
METALS-020	Metals in soil and water by ICP-OES.
METALS-021	Determination of Mercury by Cold Vapour AAS.
	For urine samples total Mercury is determined, however, mercury in urine is almost entirely in the inorganic form (CDC).
METALS-022	Determination of various metals by ICP-MS.

QUALITY CONTROL: Miscellaneous Inorganics					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	218256-2
Date prepared	-			05/11/2018	1	05/11/2018	05/11/2018		05/11/2018	05/11/2018
Date analysed	-			05/11/2018	1	05/11/2018	05/11/2018		05/11/2018	05/11/2018
pH	pH Units		INORG-001	[NT]	1	7.9	[NT]		101	[NT]
Electrical Conductivity (EC)	µS/cm	1	INORG-002	<1	1	380	[NT]		104	[NT]
Total Dissolved Solids (grav)	mg/L	5	INORG-018	<5	1	230	[NT]		104	[NT]
Total Suspended Solids	mg/L	5	INORG-019	<5	1	<5	<5	0	103	[NT]
Fluoride	mg/L	0.1	INORG-081	<0.1	1	<0.1	<0.1	0	93	92
Nitrate as NO_3	mg/L	0.5	INORG-081	<0.5	1	<0.5	<0.5	0	100	77
Nitrite as NO_2	mg/L	0.5	INORG-081	<0.5	1	<0.5	<0.5	0	98	93
NOx as N	mg/L	0.005	INORG-055	<0.005	1	0.017	0.017	0	103	77

QUALITY CONTROL: Ionic Balance					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	218256-2
Date prepared	-			08/11/2018	1	08/11/2018	08/11/2018		08/11/2018	08/11/2018
Date analysed	-			08/11/2018	1	08/11/2018	08/11/2018		08/11/2018	08/11/2018
Calcium - Dissolved	mg/L	0.5	METALS-020	<0.5	1	12	[NT]		96	[NT]
Potassium - Dissolved	mg/L	0.5	METALS-020	<0.5	1	1.0	[NT]		97	[NT]
Magnesium - Dissolved	mg/L	0.5	METALS-020	<0.5	1	27	[NT]		98	[NT]
Sodium - Dissolved	mg/L	0.5	METALS-020	<0.5	1	24	[NT]		98	[NT]
Bicarbonate HCO_3 as $CaCO_3$	mg/L	5	INORG-006	<5	1	130	[NT]		100	[NT]
Carbonate CO_3^{2-} as $CaCO_3$	mg/L	5	INORG-006	<5	1	<5	[NT]		100	[NT]
Total Alkalinity as $CaCO_3$	mg/L	5	INORG-006	<5	1	130	[NT]		100	[NT]
Chloride	mg/L	1	INORG-081	<1	1	32	32	0	99	93
Sulphate	mg/L	1	INORG-081	<1	1	13	13	0	97	94
Hardness as $CaCO_3$	mg/L	3	METALS-008	<3	1	140	[NT]		[NT]	[NT]

QUALITY CONTROL: Dissolved Metals in Water					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	LCS-1	218256-2
Date prepared	-			06/11/2018	1	06/11/2018	06/11/2018		06/11/2018	06/11/2018
Date analysed	-			06/11/2018	1	06/11/2018	06/11/2018		06/11/2018	06/11/2018
Silica	mg/L	0.2	METALS-020	<0.2	1	17	[NT]		104	[NT]
Aluminium-Dissolved	mg/L	0.01	METALS-022	<0.01	1	<0.01	<0.01	0	93	95
Antimony-Dissolved	mg/L	0.001	METALS-022	<0.001	1	<0.001	<0.001	0	90	85
Arsenic-Dissolved	mg/L	0.001	METALS-022	<0.001	1	<0.001	<0.001	0	106	108
Barium-Dissolved	mg/L	0.001	METALS-022	<0.001	1	0.016	0.016	0	107	103
Boron-Dissolved	mg/L	0.02	METALS-022	<0.02	1	0.09	0.09	0	118	128
Cadmium-Dissolved	mg/L	0.0001	METALS-022	<0.0001	1	<0.0001	<0.0001	0	108	109
Chromium-Dissolved	mg/L	0.001	METALS-022	<0.001	1	<0.001	<0.001	0	95	93
Copper-Dissolved	mg/L	0.001	METALS-022	<0.001	1	<0.001	<0.001	0	94	91
Cobalt-Dissolved	mg/L	0.001	METALS-022	<0.001	1	<0.001	<0.001	0	97	93
Iron-Dissolved	mg/L	0.01	METALS-022	<0.01	1	0.03	0.03	0	94	92
Lead-Dissolved	mg/L	0.001	METALS-022	<0.001	1	<0.001	<0.001	0	102	99
Manganese-Dissolved	mg/L	0.005	METALS-022	<0.005	1	0.033	0.032	3	98	107
Mercury-Dissolved	mg/L	0.00005	METALS-021	<0.00005	1	<0.00005	[NT]		109	[NT]
Molybdenum-Dissolved	mg/L	0.001	METALS-022	<0.001	1	<0.001	<0.001	0	106	107
Nickel-Dissolved	mg/L	0.001	METALS-022	<0.001	1	<0.001	<0.001	0	94	91
Selenium-Dissolved	mg/L	0.001	METALS-022	<0.001	1	<0.001	<0.001	0	103	105
Strontium-Dissolved	mg/L	0.001	METALS-022	<0.001	1	0.071	0.068	4	101	102
Tin-Dissolved	mg/L	0.001	METALS-022	<0.001	1	<0.001	<0.001	0	107	106
Zinc-Dissolved	mg/L	0.001	METALS-022	<0.001	1	0.002	0.001	67	99	99

QUALITY CONTROL: Dissolved Metals in Water					Duplicate				Spike Recovery %	
Test Description	Units	PQL	Method	Blank	#	Base	Dup.	RPD	[NT]	218256-4
Date prepared	-			[NT]	3	06/11/2018	06/11/2018		[NT]	06/11/2018
Date analysed	-			[NT]	3	06/11/2018	06/11/2018		[NT]	06/11/2018
Silica	mg/L	0.2	METALS-020	[NT]	3	26	[NT]		[NT]	[NT]
Aluminium-Dissolved	mg/L	0.01	METALS-022	[NT]	3	<0.01	[NT]		[NT]	[NT]
Antimony-Dissolved	mg/L	0.001	METALS-022	[NT]	3	0.002	[NT]		[NT]	[NT]
Arsenic-Dissolved	mg/L	0.001	METALS-022	[NT]	3	<0.001	[NT]		[NT]	[NT]
Barium-Dissolved	mg/L	0.001	METALS-022	[NT]	3	0.030	[NT]		[NT]	[NT]
Boron-Dissolved	mg/L	0.02	METALS-022	[NT]	3	0.07	[NT]		[NT]	[NT]
Cadmium-Dissolved	mg/L	0.0001	METALS-022	[NT]	3	<0.0001	[NT]		[NT]	[NT]
Chromium-Dissolved	mg/L	0.001	METALS-022	[NT]	3	<0.001	[NT]		[NT]	[NT]
Copper-Dissolved	mg/L	0.001	METALS-022	[NT]	3	<0.001	[NT]		[NT]	[NT]
Cobalt-Dissolved	mg/L	0.001	METALS-022	[NT]	3	0.001	[NT]		[NT]	[NT]
Iron-Dissolved	mg/L	0.01	METALS-022	[NT]	3	0.07	[NT]		[NT]	[NT]
Lead-Dissolved	mg/L	0.001	METALS-022	[NT]	3	<0.001	[NT]		[NT]	[NT]
Manganese-Dissolved	mg/L	0.005	METALS-022	[NT]	3	0.46	[NT]		[NT]	[NT]
Mercury-Dissolved	mg/L	0.00005	METALS-021	[NT]	3	<0.00005	<0.00005	0	[NT]	126
Molybdenum-Dissolved	mg/L	0.001	METALS-022	[NT]	3	<0.001	[NT]		[NT]	[NT]
Nickel-Dissolved	mg/L	0.001	METALS-022	[NT]	3	0.002	[NT]		[NT]	[NT]
Selenium-Dissolved	mg/L	0.001	METALS-022	[NT]	3	<0.001	[NT]		[NT]	[NT]
Strontium-Dissolved	mg/L	0.001	METALS-022	[NT]	3	0.055	[NT]		[NT]	[NT]
Tin-Dissolved	mg/L	0.001	METALS-022	[NT]	3	<0.001	[NT]		[NT]	[NT]
Zinc-Dissolved	mg/L	0.001	METALS-022	[NT]	3	<0.001	[NT]		[NT]	[NT]

Result Definitions

NT	Not tested
NA	Test not required
INS	Insufficient sample for this test
PQL	Practical Quantitation Limit
<	Less than
>	Greater than
RPD	Relative Percent Difference
LCS	Laboratory Control Sample
NS	Not specified
NEPM	National Environmental Protection Measure
NR	Not Reported

Quality Control Definitions

Blank	This is the component of the analytical signal which is not derived from the sample but from reagents, glassware etc, can be determined by processing solvents and reagents in exactly the same manner as for samples.
Duplicate	This is the complete duplicate analysis of a sample from the process batch. If possible, the sample selected should be one where the analyte concentration is easily measurable.
Matrix Spike	A portion of the sample is spiked with a known concentration of target analyte. The purpose of the matrix spike is to monitor the performance of the analytical method used and to determine whether matrix interferences exist.
LCS (Laboratory Control Sample)	This comprises either a standard reference material or a control matrix (such as a blank sand or water) fortified with analytes representative of the analyte class. It is simply a check sample.
Surrogate Spike	Surrogates are known additions to each sample, blank, matrix spike and LCS in a batch, of compounds which are similar to the analyte of interest, however are not expected to be found in real samples.

Australian Drinking Water Guidelines recommend that Thermotolerant Coliform, Faecal Enterococci, & E.Coli levels are less than 1cfu/100mL. The recommended maximums are taken from "Australian Drinking Water Guidelines", published by NHMRC & ARMC 2011.

The recommended maximums for analytes in urine are taken from “2018 TLVs and BEIs”, as published by ACGIH (where available).

Laboratory Acceptance Criteria

Duplicate sample and matrix spike recoveries may not be reported on smaller jobs, however, were analysed at a frequency to meet or exceed NEPM requirements. All samples are tested in batches of 20. The duplicate sample RPD and matrix spike recoveries for the batch were within the laboratory acceptance criteria.

Filters, swabs, wipes, tubes and badges will not have duplicate data as the whole sample is generally extracted during sample extraction.

Spikes for Physical and Aggregate Tests are not applicable.

For VOCs in water samples, three vials are required for duplicate or spike analysis.

Duplicates: >10xPQL - RPD acceptance criteria will vary depending on the analytes and the analytical techniques but is typically in the range 20%-50% – see ELN-P05 QA/QC tables for details; <10xPQL - RPD are higher as the results approach PQL and the estimated measurement uncertainty will statistically increase.

Matrix Spikes, LCS and Surrogate recoveries: Generally 70-130% for inorganics/metals; 60-140% for organics (+/-50% surrogates) a

In circumstances where no duplicate and/or sample spike has been reported at 1 in 10 and/or 1 in 20 samples respectively, the sample volume submitted was insufficient in order to satisfy laboratory QA/QC protocols.

When samples are received where certain analytes are outside of recommended technical holding times (THTs), the analysis has proceeded. Where analytes are on the verge of breaching THTs, every effort will be made to analyse within the THT or as soon as practicable.

Where sampling dates are not provided, Envirolab are not in a position to comment on the validity of the analysis where recommended technical holding times may have been breached.

Measurement Uncertainty estimates are available for most tests upon request.

Appendix B: Pools Monitored within the Corunna Project Area

Pool ID	Latitude	Longitude	Permanency/ ground water dependency (SRK, 2019)	Monthly field observations and chemical data	Hourly water logger data	Photo
CO-WS-01	-21.411	119.687	Perennial/ Likely	20/12/2017 - 29/07/2019	11/10/2017 - 24/04/2020	
CO-WS-05	-21.467	119.639	Perennial/ Likely	24/11/2017 - 15/05/2019	N/A	

Pool ID	Latitude	Longitude	Permanency/ ground water dependency (SRK, 2019)	Monthly field observations and chemical data	Hourly water logger data	Photo
CO-WS-08	-21.452	119.651	Ephemeral/ Likely	25/10/2017 - 15/05/2019	25/10/2017 - 17/04/2019	
CO-WS-10	-21.416	119.676	Perennial/ Likely	24/11/2017 - 14/05/2019	25/10/2017 - 19/01/2019	

Pool ID	Latitude	Longitude	Permanency/ ground water dependency (SRK, 2019)	Monthly field observations and chemical data	Hourly water logger data	Photo
CO-WS-11	-21.439	119.678	Ephemeral/ Unlikely	20/12/2017 - 14/05/2019	11/10/2017 - 16/04/2019	
CO-WS-12	-21.420	119.673	Perennial/ Likely	25/10/2017 - 30/07/2019	11/10/2017 - 24/04/2020	
CO-WS-13	-21.466	119.650	Ephemeral/ Likely	25/10/2017 - 15/05/2019	13/10/2017 - 17/04/2019	

Pool ID	Latitude	Longitude	Permanency/ ground water dependency (SRK, 2019)	Monthly field observations and chemical data	Hourly water logger data	Photo
CO-WS-14	-21.468	119.671	Perennial/ Likely	25/10/2017 - 25/04/2020	10/10/2017 - 30/07/2019	

Appendix C: Raw Ultrasonic and Microclimate Data at CO-CA-03

Date	First Call	Last Call	Number of Calls	Temperature								Humidity							
				3am	6am	9am	12pm	3pm	6pm	9pm	12am	3am	6am	9am	12pm	3pm	6pm	9pm	12am
17-Apr-19	18:44	6:08	371						31.62	31.62	31.16						92.85	94.87	93.32
18-Apr-19	17:58	5:28	239	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	94.37	94.37	94.37	94.37	93.86	94.37	94.37	93.86
19-Apr-19	18:50	5:21	215	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	94.87	95.88	94.37	95.88	94.37	94.37	94.87	94.37
20-Apr-19	19:02	4:36	134	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	95.38	94.37	94.37	94.87	94.37	94.87	94.37	94.87
21-Apr-19	19:02	4:51	168	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	94.87	94.87	94.87	94.37	94.87	94.87	94.87	94.87
22-Apr-19	18:35	6:15	1114	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	94.37	95.38	94.87	95.38	95.88	96.38	95.38	94.87
23-Apr-19	18:07	6:12	769	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	94.87	95.38	95.88	95.38	95.88	95.38	95.38	95.38
24-Apr-19	17:54	6:14	724	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	94.87	95.38	95.88	95.88	95.38	97.37	95.38	96.38
25-Apr-19	18:10	5:53	1330	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	95.38	94.87	95.88	95.88	96.38	95.38	95.38	95.38
26-Apr-19	17:42	5:06	1476	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	95.88	95.88	95.88	95.88	95.88	95.38	96.38	95.88
27-Apr-19	18:32	5:39	1009	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	95.38	94.87	95.38	94.37	94.37	94.37	94.87	94.87
28-Apr-19	18:46	6:17	1834	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	94.37	94.37	94.37	94.37	94.87	94.87	94.37	94.87
29-Apr-19	18:02	6:16	1502	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	94.37	93.86	92.34	93.36	93.36	92.85	92.85	94.37
30-Apr-19	18:34	6:18	2607	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	94.37	93.36	93.86	93.86	93.86	94.37	94.37	93.86
1-May-19	17:39	6:18	1810	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	94.37	93.86	94.37	93.86	93.36	93.36	93.36	94.37
2-May-19	17:38	6:19	1879	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	93.86	92.85	92.85	92.85	91.83	93.36	93.86	93.36
3-May-19	17:37	6:19	1633	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	93.36	93.36	93.86	93.36	93.36	93.86	93.86	92.85
4-May-19	17:48	6:19	3535	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	93.36	93.86	93.86	92.85	93.36	94.37	93.86	94.37
5-May-19	17:37	6:20	2804	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	94.37	93.86	94.37	92.85	93.86	93.86	93.36	93.86
6-May-19	17:35	6:20	4135	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	93.36	93.86	93.36	94.37	93.86	93.86	92.34	94.37
7-May-19	17:39	6:12	2700	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	94.37	93.86	93.86	94.37	93.36	93.86	93.86	92.34
8-May-19	17:34	6:19	1784	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	93.86	93.36	93.36	93.86	94.37	93.86	93.36	93.36
9-May-19	17:54	6:20	1015	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	92.85	94.37	93.36	93.36	93.36	93.36	93.86	93.86
10-May-19	17:36	6:15	660	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	93.86	93.86	93.86	93.36	92.85	94.37	93.36	93.86
11-May-19	17:50	5:57	23095	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	93.36	93.36	92.85	93.36	93.36	93.36	92.85	93.86
12-May-19	17:37	6:20	11445	31.12	31.12	31.12	31.62	31.62	31.62	31.62	31.62	94.3	93.79	93.28	93.36	93.86	93.86	93.86	94.37
13-May-19	17:32	6:00	12197	31.62	31.12	31.12	31.12	31.12	31.62	31.12	31.12	93.86	92.78	92.78	93.79	94.3	94.37	94.3	94.3
14-May-19	17:31	6:24	7267	31.12	31.12	31.12	31.12	31.12	31.12	31.62	31.12	93.28	94.3	94.3	94.3	94.3	94.3	94.37	94.3
15-May-19	17:33	6:24	5463	31.12	31.62	31.62	31.62	31.62	31.62	31.62	31.62	94.8	94.37	94.37	94.37	94.37	93.86	93.86	94.87
16-May-19	17:34	6:24	6694	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	94.37	93.86	94.37	94.37	94.37	93.86	94.37	94.37
17-May-19	18:24	6:25	9953	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	95.38	94.37	95.38	94.37	95.88	94.37	94.87	94.37
18-May-19	17:30	6:25	5114	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	95.38	96.38	95.38	95.38	94.87	94.87	94.87	94.87
19-May-19	17:41	5:54	5814	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	95.38	95.88	94.87	94.87	95.38	94.87	95.38	95.38
20-May-19	17:29	5:54	9763	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	95.38	95.38	95.38	95.38	95.38	95.38	96.38	95.38
21-May-19	17:46	6:27	7422	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	95.88	95.38	95.88	96.38	95.38	95.38	95.88	95.38
22-May-19	17:29	5:26	3764	31.12	31.62	31.62	31.62	31.62	31.62	31.62	31.62	96.3	94.87	95.38	95.88	95.88	95.38	95.88	94.87
23-May-19	18:24	5:16	5523	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	94.87	94.87	94.87	94.37	95.38	94.87	94.37	94.87
24-May-19	18:25	6:24	5655	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	94.87	94.37	94.87	94.87	94.87	93.86	94.37	94.37
25-May-19	18:17	5:32	4885	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	94.37	94.87	95.38	93.86	95.88	94.87	94.87	94.87
26-May-19	18:23	6:29	4555	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	94.37	94.37	94.37	94.37	94.87	94.87	95.38	94.87
27-May-19	17:33	6:00	3230	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	94.37	94.37	94.87	95.38	93.86	94.87	95.38	94.37
28-May-19	18:29	5:45	2328	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	94.37	94.87	94.87	95.38	93.86	94.37	93.36	94.37
29-May-19	18:26	5:40	5663	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	94.37	93.86	94.87	94.37	94.37	94.87	94.37	94.37
30-May-19	18:22	5:41	3749	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	94.37	94.37	94.37	95.38	94.37	95.38	95.38	94.87
31-May-19	18:14	6:29	9256	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	95.38	94.37	94.87	95.38	94.87	95.38	95.38	95.38

Date	First Call	Last Call	Number of Calls	Temperature								Humidity							
				3am	6am	9am	12pm	3pm	6pm	9pm	12am	3am	6am	9am	12pm	3pm	6pm	9pm	12am
1-Jun-19	17:30	6:31	8562	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	95.38	94.37	95.38	94.87	94.87	94.87	95.38	94.87
2-Jun-19	17:26	5:09	8091	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.12	95.88	95.88	96.38	94.87	95.38	94.87	95.88	94.8
3-Jun-19	18:22	6:32	6978	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	94.87	94.87	95.38	94.87	95.38	95.38	95.88	95.38
4-Jun-19	17:27	6:28	6910	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	96.38	96.38	95.38	94.87	93.86	94.87	94.87	95.38
5-Jun-19	18:24	4:49	5908	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.12	95.88	94.37	95.38	94.87	95.38	94.87	95.38	95.3
6-Jun-19	18:21	5:21	5118	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	95.38	95.38	94.37	94.87	95.38	95.88	95.38	94.87
7-Jun-19	18:18	6:28	7061	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	94.87	94.87	94.87	94.87	94.87	94.87	94.87	94.87
8-Jun-19	17:36	6:34	2858	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	95.38	95.38	95.88	95.38	94.37	94.87	95.38	94.87
9-Jun-19	17:31	5:40	3981	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	94.87	94.87	94.87	94.37	93.86	94.37	94.87	95.38
10-Jun-19	18:13	5:39	8799	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	94.87	93.86	94.37	93.36	94.37	94.37	95.88	94.87
11-Jun-19	18:24	6:34	1435	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	95.88	94.37	95.38	94.37	94.37	94.37	94.87	94.87
12-Jun-19	18:14	5:52	5908	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	93.36	94.37	93.86	94.37	94.87	94.37	94.37	93.86
13-Jun-19	18:15	5:31	9150	31.62	31.62	31.62	31.62	31.62	31.62	31.62	31.62	93.36	93.86	94.37	93.86	92.85	93.86	93.86	95.88
14-Jun-19	18:10	6:01	20787	31.62	31.62	31.62	31.62	31.62	31.62	31.12	31.12	93.86	93.86	93.86	93.86	94.37	93.36	93.28	93.79
15-Jun-19	17:55	6:05	25205	31.12	31.12	31.12	31.12	31.62	31.62	31.12	31.12	92.27	92.27	93.28	93.79	93.36	93.36	92.78	92.27
16-Jun-19	17:27	5:44	12064	31.12	31.12	31.12	31.12	31.12	31.12	31.12	31.12	93.28	92.78	93.79	92.78	92.78	92.78	92.78	93.28
17-Jun-19	18:17	5:07	3992	31.12	31.12	31.12	31.62	31.62	31.62	31.12	31.12	92.78	92.78	93.28	93.36	93.86	92.34	93.28	92.78
18-Jun-19	18:08	5:52	31386	31.12	31.12	31.12	31.62	31.62	31.62	31.12	31.12	93.79	93.28	93.28	93.36	92.85	92.85	93.28	93.28
19-Jun-19	17:40	6:37	38673	31.12	31.12	31.12	31.12	31.12	31.12	31.12	31.12	93.79	92.78	92.27	92.27	91.75	91.75	92.27	93.28
20-Jun-19	17:27	6:37	26633	31.12	30.62	30.62	31.12	31.12	31.12	31.12	31.12	93.28	92.71	93.21	92.27	92.78	93.28	92.78	93.79
21-Jun-19	17:28	6:38	40561	31.12	31.12	31.12	31.12	31.12	31.12	31.12	31.12	93.28	93.28	92.27	92.78	92.27	92.27	91.75	92.27
22-Jun-19	17:38	6:43	31966	31.12	30.62	31.12	31.12					92.27	92.71	91.75	92.78				
23-Jun-19	17:47	6:09	13934																
24-Jun-19	18:18	6:40	21630																
25-Jun-19	17:34	6:38	30590																
26-Jun-19	17:32	6:44	33591																
27-Jun-19	17:32	6:44	36382																
28-Jun-19	17:32	6:09	19798																
29-Jun-19	17:36	6:34	33278																
30-Jun-19	17:33	6:44	55563																
1-Jul-19	17:41	6:44	53748																
2-Jul-19	17:33	6:44	51380																
3-Jul-19	17:34	6:44	41977																
4-Jul-19	17:34	6:44	46900																
5-Jul-19	17:34	6:32	33591																
6-Jul-19	17:36	6:40	22696																
7-Jul-19	17:40	6:20	9844																
8-Jul-19	17:36	6:43	31538	30.59	30.1	30.59	30.59	30.59	30.59	30.59	30.59	95.72	93.64	95.22	94.21	95.72	95.72	95.22	94.72
9-Jul-19	17:38	6:44	42529	30.59	30.1	30.1	30.59	30.59	30.59	30.59	30.59	95.22	93.14	94.65	94.72	95.22	95.22	94.72	94.72
10-Jul-19	17:36	6:42	25900	30.59	30.1	30.1	30.59	30.59	30.59	30.59	30.59	95.22	94.15	93.64	94.72	94.72	94.72	94.72	95.22
11-Jul-19	17:37	6:44	36764	30.59	30.1	30.59	30.59	30.59	30.59	30.59	30.59	94.72	93.14	94.72	95.22	95.22	94.72	95.72	95.22
12-Jul-19	17:41	6:44	56699	30.59	30.1	30.1	30.1	30.59	30.59	30.1	30.1	94.72	91.61	93.64	94.15	95.22	93.71	93.64	92.63
13-Jul-19	17:52	6:44	34850	30.1	30.1	30.1	30.1	30.59	30.59	30.59	30.1	93.14	92.12	93.64	94.15	94.21	94.72	94.72	94.65
14-Jul-19	17:40	6:44	27395	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1	93.64	94.65	94.15	94.65	94.15	94.65	94.15	94.15
15-Jul-19	17:38	6:43	17132	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1	94.15	94.15	94.15	94.15	94.15	95.15	94.65	93.64

Date	First Call	Last Call	Number of Calls	Temperature								Humidity							
				3am	6am	9am	12pm	3pm	6pm	9pm	12am	3am	6am	9am	12pm	3pm	6pm	9pm	12am
16-Jul-19	17:41	6:43	11181	30.1	30.1	30.1	30.59	30.59	30.59	30.59	30.1	94.15	94.15	94.15	94.21	94.72	94.72	95.22	94.65
17-Jul-19	17:39	6:43	39249	30.1	30.1	30.1	30.1	30.1	30.59	30.59	30.1	94.65	94.15	95.15	94.65	94.15	94.21	95.22	94.15
18-Jul-19	17:39	6:22	34054	30.1	30.1	30.1	30.1	30.1	30.59	30.59	30.1	94.65	95.15	95.65	94.65	95.15	95.22	94.72	95.15
19-Jul-19	17:40	6:42	37513	30.1	30.1	30.1	30.59	30.59	30.59	30.59	30.1	95.15	94.65	95.65	95.22	95.72	95.22	94.72	95.15
20-Jul-19	17:42	6:19	30640	30.1	30.1	30.1	30.1	30.1	30.59	30.1	30.1	95.15	95.65	95.15	96.65	96.15	96.71	96.15	95.65
21-Jul-19	17:42	6:31	37083	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1	95.15	93.14	95.65	95.65	95.15	94.65	94.65	95.15
22-Jul-19	17:42	6:42	41255	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1	94.65	95.15	94.65	94.65	94.65	95.15	94.65	93.64
23-Jul-19	17:45	6:41	45501	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1	93.64	93.14	94.15	94.15	94.15	94.15	94.65	93.64
24-Jul-19	17:43	6:41	44845	30.1	29.6	29.6	29.6	30.1	30.1	30.1	30.1	93.14	91.03	92.56	92.06	93.14	93.14	94.15	93.64
25-Jul-19	17:42	6:40	48333	30.1	29.6	29.6	30.1	30.1	30.1	30.1	30.1	94.15	91.55	92.56	93.64	94.15	94.15	94.15	93.64
26-Jul-19	17:43	6:40	44218	30.1	29.6	30.1	30.1	30.1	30.1	30.1	30.1	93.64	93.07	93.64	94.15	94.15	94.65	94.65	94.65
27-Jul-19	17:43	6:40	32242	30.1	29.6	30.1	30.1	30.1	30.1	30.1	30.1	94.15	93.58	94.15	94.15	94.15	94.65	94.65	94.65
28-Jul-19	17:43	6:39	39453	30.1	29.6	29.6	30.1	30.1	30.1	30.1	30.1	95.15	91.03	94.08	94.15	93.64	94.15	94.65	94.15
29-Jul-19	17:44	6:20	25670	30.1	29.6	30.1	30.1	30.64	30.64	30.64	30.64	93.64	93.07	93.64	94.15	89.55	91.62	91.62	92.64
30-Jul-19	17:44	6:38	27272	30.64	30.14	30.14	30.64	30.64	30.64	30.64	30.14	92.13	90.52	92.57	93.15	93.66	93.15	93.66	92.57
31-Jul-19	17:48	6:38	31042	30.14	29.64	30.14	30.14	30.14	30.14	30.14	30.14	94.1	89.42	91.55	91.55	92.57	92.06	92.57	92.06
1-Aug-19	17:45	6:37	16433	30.14	29.64	29.64	30.14	30.14	30.14	30.14	30.14	92.06	88.9	90.45	92.06	92.06	92.06	92.57	91.55
2-Aug-19	17:45	6:37	11065	30.14	30.14	30.14	30.14	30.64	30.14	30.14	30.14	93.59	92.57	92.57	93.08	93.15	93.08	93.59	93.59
3-Aug-19	17:46	6:34	4719	30.14	30.14	30.14	30.14	30.14	30.64	30.64	30.64	93.08	93.59	93.59	93.59	95.11	93.15	94.17	93.15
4-Aug-19	18:08	6:36	22181	30.64	30.64	30.64	30.64	30.64	30.64	30.64	30.64	93.66	95.68	94.67	94.67	95.18	94.67	96.18	95.18
5-Aug-19	17:51	6:35	28101	30.64	30.64	30.64	30.64	30.64	30.64	30.64	30.64	95.18	94.67	94.67	95.68	96.18	96.18	95.18	95.68
6-Aug-19	17:47	6:22	36023	30.64	30.14	30.14	30.14	30.64	30.64	30.64	30.64	96.18	94.6	95.61	96.11	96.68	96.18	94.67	95.18
7-Aug-19	17:49	6:34	29637	30.14	29.64	30.14	30.14	30.14	30.14	30.14	30.14	94.6	90.97	94.1	94.1	94.6	95.61	93.59	94.1
8-Aug-19	17:51	6:32	14296	30.14	29.64	29.64	30.14	30.14	30.14	30.14	30.14	93.08	88.37	91.49	93.59	93.59	94.1	93.59	93.59
9-Aug-19	17:48	5:48	6130	30.14	30.14	30.14	30.14	30.14	30.64	30.14	30.14	93.59	94.1	93.59	94.1	94.6	95.18	94.1	94.1
10-Aug-19	18:26	6:32	10431	30.64	30.14	30.64	30.64	30.64	30.64	30.64	30.14	94.67	94.1	95.68	94.17	95.18	95.18	95.18	95.11
11-Aug-19	17:50	6:31	17900	30.14	30.14	30.14	30.64	30.64	30.64	30.14	30.14	95.61	94.6	95.61	95.68	96.18	95.68	94.6	95.11
12-Aug-19	17:49	6:12	5168	30.14	30.14	30.14	30.14	30.14	30.14	30.14	30.14	94.6	94.6	94.6	94.6	95.11	95.11	95.11	95.11
13-Aug-19	17:57	6:05	3309	30.14	30.14	30.14	30.64	30.64	30.64	30.64	30.64	96.11	95.61	95.11	96.18	95.18	95.68	96.18	95.68
14-Aug-19	17:55	6:20	1341	30.64	30.64	30.64	30.64	30.64	30.64	30.64	30.64	96.68	96.18	97.18	96.68	96.18	96.18	95.68	96.18
15-Aug-19	17:51	5:17	1074	30.64	30.64	30.64	30.64	30.64	30.64	30.64	30.64	96.18	97.67	96.68	96.68	95.68	97.67	96.18	95.18
16-Aug-19	17:59	6:02	1438	30.64	30.64	30.64	30.64	30.64	30.64	30.64	30.64	96.68	96.18	96.68	97.18	97.18	97.18	96.18	96.68
17-Aug-19	18:04	5:20	1136	30.64	30.64		30.53	30.53	30.53	30.53	30.53	96.68	96.18		94.68	95.67	94.68	95.67	96.66
18-Aug-19	18:02	6:17	7327	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	97.15	97.15	97.64	97.64	97.64	98.13	98.13	96.1
19-Aug-19	17:53	6:25	3096	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	96.59	96.59	97.57	97.08	98.06	98.06	96.59	97.57
20-Aug-19	17:55	5:42	4739	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	97.57	97.57	97.08	97.57	97.08	97.64	98.55	97.57
21-Aug-19	18:29	5:34	11812	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	97.57	97.08	98.06	97.57	98.13	98.13	98.06	97.08
22-Aug-19	18:28	6:14	10028	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	97.08	97.57	97.08	97.57	98.06	98.06	97.57	97.57
23-Aug-19	18:13	6:16	8312	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	97.57	97.57	98.06	97.57	98.06	98.06	98.06	97.57
24-Aug-19	17:54	6:16	7853	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	97.57	97.08	97.57	97.57	97.57	98.06	98.06	98.06
25-Aug-19	18:06	6:12	2366	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	97.57	98.06	98.06	97.57	98.06	98.55	98.06	98.06
26-Aug-19	18:14	6:12	901	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	98.06	98.55	99.03	99.03	99.03	99.52	99.52	98.55
27-Aug-19	18:36	6:19	2184	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	99.03	98.55	99.52	99.03	99.52	99.52	99.03	98.55
28-Aug-19	17:54	6:16	1879	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	98.06	99.03	99.52	97.57	99.03	99.03	99.03	98.06
29-Aug-19	18:03	6:16	1409	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	99.03	98.55	98.55	98.55	99.03	98.55	99.03	99.52

Date	First Call	Last Call	Number of Calls	Temperature								Humidity							
				3am	6am	9am	12pm	3pm	6pm	9pm	12am	3am	6am	9am	12pm	3pm	6pm	9pm	12am
30-Aug-19	18:09	6:16	2522	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	97.57	98.55	98.55	98.55	98.55	98.55	98.55	98.55
31-Aug-19	17:55	6:15	6212	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	98.55	97.57	98.06	97.57	98.06	98.06	97.57	97.57
1-Sep-19	17:55	6:14	8370	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	98.06	97.57	96.59	97.57	98.06	98.06	98.55	99.03
2-Sep-19	17:56	6:13	9068	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	97.57	98.55	98.06	98.06	97.57	97.57	96.59	98.06
3-Sep-19	17:56	6:11	7134	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	97.08	98.06	98.06	98.06	98.06	97.57	98.06	98.55
4-Sep-19	17:56	5:58	4832	30.53	30.03	30.53	30.53	30.53	30.53	30.03	30.03	97.57	97.57	97.57	98.06	97.57	97.57	97.08	97.08
5-Sep-19	17:57	6:10	7853	30.53	30.03	30.03	30.53	30.53	30.53	30.03	30.53	97.57	95.6	98.06	96.59	97.08	98.55	97.08	97.08
6-Sep-19	17:57	6:09	10455	30.53	30.03	30.03	30.53	30.53	30.53	30.03	30.53	97.57	96.59	97.57	97.08	98.06	97.08	98.06	97.57
7-Sep-19	17:57	6:09	10478	30.53	30.03	30.03	30.03	30.03	30.03	30.03	30.03	97.57	96.59	98.06	97.57	97.08	96.59	97.08	98.06
8-Sep-19	17:57	6:08	8055	30.03	30.03	30.03	30.03	30.03	30.03	30.03	30.03	98.06	97.08	97.08	97.08	97.57	97.57	97.99	98.06
9-Sep-19	17:58	6:07	7776	30.03	30.03	30.03	30.03	30.03	30.03	30.03	30.03	96.59	97.08	98.55	97.51	95.54	97.99	96.03	97.51
10-Sep-19	17:58	6:06	12595	30.03	30.03	30.03	30.03	30.03	30.03	30.03	30.03	96.1	97.99	96.52	96.03	95.04	95.54	97.02	96.03
11-Sep-19	17:58	6:05	11163	30.03	30.03	30.03	30.03	30.03	30.03	30.03	30.03	96.52	97.99	97.02	96.52	97.02	96.52	96.03	97.02
12-Sep-19	17:59	6:04	18395	30.03	30.03	30.03	30.03	30.03	30.03	30.03	30.03	97.51	96.52	97.51	97.08	97.08	98.06	96.52	96.1
13-Sep-19	17:59	5:58	9106	30.03	30.03	30.03	30.03	30.03	30.03	30.03	30.03	97.02	97.02	97.51	97.08	97.02	97.51	96.52	97.51
14-Sep-19	17:59	6:02	12979	30.03	30.03	30.03	30.03	30.03	30.03	30.03	30.03	96.03	96.52	97.51	98.06	97.51	97.02	96.52	97.02
15-Sep-19	17:59	6:01	11328	30.03	30.03	30.03	30.03	30.03	30.03	30.03	30.03	96.52	97.02	96.52	97.99	97.51	96.52	96.52	96.52
16-Sep-19	18:00	6:00	14524	30.03	30.03	30.03	30.03	30.03	30.03	30.03	30.03	97.02	97.02	96.52	97.02	96.52	97.51	97.02	97.02
17-Sep-19	18:00	5:59	12026	30.03	30.03	30.03	30.03	30.03	30.03	30.03	30.03	97.51	97.02	96.52	97.51	97.51	97.02	96.52	96.52
18-Sep-19	18:00	5:58	16751	30.03	30.03	30.03	30.03	30.03	30.03	30.03	30.03	96.52	97.02	96.52	97.02	96.52	97.02	96.03	96.52
19-Sep-19	18:00	5:56	20424	30.03	30.03	30.03	30.03	30.03	30.03	30.03	30.03	96.03	96.52	96.52	96.52	97.02	97.02	96.52	96.52
20-Sep-19	18:06	5:56	14782	30.03	29.53	30.03	30.03	30.03	30.03	30.03	30.03	96.52	94.54	96.52	97.02	97.02	96.03	97.02	96.52
21-Sep-19	18:01	5:34	10776	30.03	30.03	30.03	30.03	30.03	30.03	30.03	30.03	96.52	97.02	96.52	97.02	97.02	96.52	97.02	96.03
22-Sep-19	18:04	5:50	16529	30.03	30.03	30.03	30.03	30.03	30.03	30.03	30.03	96.52	97.02	97.51	97.51	96.52	97.02	97.02	97.02
23-Sep-19	18:02	5:52	14372	30.03	29.53	30.03	30.03	30.03	30.03	30.03	30.03	96.52	95.54	95.54	96.52	96.52	96.03	95.54	94.54
24-Sep-19	18:02	5:52	22835	30.03	29.53	30.03	30.03	30.03	30.03	30.03	30.03	97.02	96.03	96.52	96.52	96.03	96.03	96.52	97.02
25-Sep-19	18:02	5:51	15582	30.03	30.03	30.03	30.03	30.03	30.03	30.03	30.03	96.52	96.52	97.99	97.02	97.99	97.02	97.02	96.52
26-Sep-19	18:02	5:42	3985	30.03	29.53	30.03	30.03	29.53	30.03	30.03	30.03	96.52	95.54	96.52	96.03	96.03	96.03	96.52	96.52
27-Sep-19	18:03	5:33	3877	30.03	30.03	30.03	30.03	30.03	30.03	30.03	30.03	96.52	96.52	96.52	96.03	95.54	95.54	96.03	97.02
28-Sep-19	18:03	5:45	4492	30.03	30.03	30.03			29.53	29.53	29.53	97.02	96.52				92.06	92.56	92.56
29-Sep-19	18:03	5:47	4252	29.53	29.53	29.53	29.53	29.53	29.53	29.53	29.53	93.07	92.56	92.56	93.07	93.58	93.07	93.58	92.56
30-Sep-19	18:04	5:45	3934	29.53	29.53	29.53	29.53	29.53	29.53	29.53	29.53	93.58	92.56	93.58	93.07	93.07	93.58	93.07	93.07
1-Oct-19	18:04	5:45	2865	29.53	29.53	29.53	29.53	29.53	29.53	29.53	29.53	93.07	93.07	93.07	93.07	93.07	93.07	93.07	93.07
2-Oct-19	18:04	5:42	2657	29.53	29.53	29.53	29.53	29.53	29.53	29.53	29.53	93.58	93.58	93.58	93.58	93.58	94.58	92.56	94.58
3-Oct-19	18:05	5:40	2125	29.53	29.53	29.53	29.53	29.53	29.03	29.03	29.03	94.08	93.58	94.08	93.58	92.56	93.01	91.99	91.99
4-Oct-19	18:24	4:56	2486	29.03	29.53	29.53	29.53	29.53	29.53	29.03	29.03	91.99	93.01	93.07	94.08	92.5	93.01	92.5	91.99
5-Oct-19	18:17	5:10	2416	29.03	29.53	29.53	29.53	29.53	29.53	29.53	29.53	92.5	91.99	92.56	92.56	93.07	93.07	92.06	92.5
6-Oct-19	18:20	5:37	2664	29.53	29.53	29.53	29.53	29.53	29.53	29.53	29.03	93.01	92.56	93.58	93.07	94.08	94.08	92.5	92.5
7-Oct-19	18:13	5:12	2291	29.03	29.53	29.53	29.53	29.53	29.03	29.03	29.03	93.01	92.5	92.06	93.07	92.06	88.91	90.97	91.48
8-Oct-19	18:09	5:37	1876	29.03	29.03	29.53	29.53	29.03	28.03	28.53	29.03	92.5	91.99	93.01	91.48	79.3	72.06	87.81	88.91
9-Oct-19	18:07	5:37	1270	29.03	29.03	29.03	29.53	28.03	28.03	28.03	28.53	89.95	89.95	89.95	89.95	68.09	58.76	72.06	83.07
10-Oct-19	18:16	5:37	676	29.03	29.03	29.03	29.03	28.03	28.03	28.53	28.53	86.31	86.31	86.83	70.48	61.13	52.74	74.91	82.54
11-Oct-19	18:52	4:55	404	29.03	29.03	29.03	29.03	28.03	28.03	28.03	28.53	83.66	86.31	85.78	60.59	54.56	33.17	51.52	73.8
12-Oct-19	18:44	4:38	280	28.53	29.03	29.03	28.53	28.03	28.03	28.03	28.53	77.67	80.98	83.66	61.18	38.35	35.13	45.33	69.86
13-Oct-19	19:02	4:50	315	28.53	29.03	29.03	29.03	28.53	28.03	28.53	29.03	75.46	78.82	81.52	82.06	58.81	51.52	77.12	81.52

Date	First Call	Last Call	Number of Calls	Temperature								Humidity							
				3am	6am	9am	12pm	3pm	6pm	9pm	12am	3am	6am	9am	12pm	3pm	6pm	9pm	12am
14-Oct-19	18:46	4:46	334	29.03	29.03	29.03	29.03	28.53	28.53	29.03	29.03	82.06	84.19	84.72	85.78	66.43	73.74	83.66	85.78
15-Oct-19	18:44	4:52	550	29.03	29.03	29.03	29.53	29.03	28.53	29.03	29.03	85.25	86.83	87.35	86.83	84.72	78.16	84.72	85.78
16-Oct-19	18:43	4:52	722	29.03	29.03	29.53	29.53	29.53	28.53	29.03	29.03	86.31	86.83	87.41	88.97	90.01	79.3	86.31	86.83
17-Oct-19	18:30	4:52	836	29.03	29.03	29.03	29.53	29.53	28.53	29.03	29.03	86.83	87.87	88.39	89.49	90.52	65.79	84.67	85.78
18-Oct-19	18:46	4:41	634	29.03	29.03	29.53	29.53	28.53	28.03	28.03	28.53	86.83	87.87	88.46	90.01	67.52	54.56	58.16	78.76
19-Oct-19	18:50	4:48	564	29.03	29.03	29.03	28.53	28.53	28.53	28.53	28.53	82	83.66	84.19	68.15	45.95	40.27	45.95	69.29
20-Oct-19	18:53	5:28	671	29.03	29.03	29.03	29.03	28.53	28.53	28.53	28.53	77.12	79.36	81.52	68.15	54.01	43.44	48.5	67
21-Oct-19	18:25	4:50	1060	28.53	29.03	29.03	29.03	28.53	28.53	28.53	29.03	75.46	78.27	80.44	68.15	50.35	66.43	75.46	80.98
22-Oct-19	18:17	5:20	1747	29.03	29.03	29.03	29.03	28.53	28.53	28.53	28.53	85.25	84.72	84.72	84.19	63.53	58.76	68.66	78.21
23-Oct-19	18:12	5:25	2069	29.03	29.03	29.03	29.03	28.53	28.03	28.03	28.53	81.52	81.52	83.13	68.21	47.82	35.13	59.94	78.76
24-Oct-19	18:13	5:10	1844	29.03	29.03	29.03	29.03	28.03	28.03	28.03	28.53	80.39	82	83.66	82.6	40.27	35.78	61.71	73.24
25-Oct-19	18:13	4:43	1237	28.53	29.03	29.03	28.53	28.03	28.03	28.03	28.53	77.67	79.84	80.44	67.57	49.06	44.07	46.58	67.57
26-Oct-19	20:30	4:41	865	28.53	28.53	29.03	28.53	28.53	28.03	28.53	28.53	74.35	77.12	78.76	66.43	50.29	40.27	65.85	73.8
27-Oct-19	19:01	4:32	747	29.03	29.03				28.53	28.53	29.03	80.44	79.9				47.16	54.57	73.26
28-Oct-19	19:12	4:36	612	29.03	29.53	29.53	29.03	28.53	28.53	29.03	29.03	77.75	78.84	80.47	60.58	41.45	46.53	53.35	69.88
29-Oct-19	19:16	4:34	450	29.03	29.03	29.53	29.03	29.03	28.53	29.03	29.03	76.1	78.3	79.39	65.92	53.35	42.73	56.39	73.82
30-Oct-19	19:07	4:31	366	29.03	29.53	29.53	29.03	28.53	28.53	29.03	29.03	78.3	78.84	80.47	62.94	47.78	42.09	56.39	71.01
31-Oct-19	19:15	4:32	260	29.03	29.53	29.53	29.53	29.03	28.53	28.53	29.03	76.1	78.3	79.39	80.47	54.57	43.37	49.03	68.17
1-Nov-19	18:59	4:23	235	29.03	29.03	29.03	29.53	29.53	29.53	29.53	29.53	73.82	76.65	78.84	79.93	81.54	82.61	85.26	85.26
2-Nov-19	19:03	4:17	471	29.53	29.53	29.53	29.53	29.53	29.53	29.53	29.53	85.26	85.26	85.85	88.45	89.48	90.51	88.97	88.45
3-Nov-19	18:57	4:37	615	29.53	30.03	30.03	30.03	30.03	30.03	30.03	29.53	88.97	90	90	91.53	90.51	90.51	91.02	90.51
4-Nov-19	19:01	4:40	653	29.53	30.03	30.03	30.03	30.03	30.03	30.03	30.03	90.51	92.03	92.54	92.54	92.03	92.54	92.03	92.54
5-Nov-19	19:07	4:32	447	30.03	30.03	30.03	30.03	30.03	30.03	29.53	30.03	92.54	93.54	93.04	93.54	94.04	94.54	92.54	92.54
6-Nov-19	19:11	4:30	383	30.03	30.03	30.03	30.03	29.03	28.53	29.03	29.53	93.54	94.54	94.54	94.54	65.28	63.47	85.79	87.35
7-Nov-19	19:05	4:31	385	29.53	29.53	29.53	29.53	28.53	28.53	29.03	29.03	89.42	89.42	89.48	78.3	55.73	48.35	74.94	79.39
8-Nov-19	19:00	4:31	502	29.53	29.53	29.53	29.03	28.53	28.53	28.53	28.53	82.61	84.21	84.74	62.94	40.17	31.61	31.67	58.8
9-Nov-19	19:12	4:30	466	29.03	29.03	29.03	28.53	28.53	28.53	28.53	28.53	72.7	77.2	79.39	43.37	32.33	30.33	29	55.79
10-Nov-19	19:03	4:32	416	29.03	29.03	29.03	28.53	28.53	28.53	28.53	28.53	75.49	74.94	75.55	43.37	30.33	27.65	29	42.73
11-Nov-19	19:05	4:27	285	29.03	29.03	29.03	28.53	28.53	29.03	29.03	29.03	59.99	67.02	66.44	32.33	25.63	23.59	40.81	53.35
12-Nov-19	19:07	4:11	211	29.03	29.03	29.03	29.03	29.03	29.03	29.03	29.03	64.11	69.37	69.37	37.58	30.33	27.65	30.33	40.17
13-Nov-19	19:11	4:49	227	29.03	29.03	29.03	29.03	29.03	29.03	29.03	29.03	41.45	58.8	65.86	40.81	34.31	32.33	32.99	33.65
14-Nov-19	19:05	4:26	239	28.53	29.03	29.03	29.03	29.03	29.03	29.03	29.03	39.52	59.99	42.73	32.33	28.33	26.31	31	30.33
15-Nov-19	19:08	4:16	298	29.03	29.03	29.03	29.03	29.03	29.03	29.03	29.03	33.65	52.13	38.88	33.65	30.39	36.33	39.52	50.89
16-Nov-19	19:10	4:10	287	29.03	29.03	29.03	29.03	29.03	29.03	29.03	29.03	57.05	61.82	40.17	25.63	23.64	22.27	22.27	34.97
17-Nov-19	19:14	4:41	325	29.03	29.03	29.03	29.03	29.03	29.03	29.03	29.03	36.93	42.73	21.53	18.13	20.21	19.52	25	32.33
18-Nov-19	19:12	5:13	258	29.03	29.03	29.03	29.03	29.03	29.03	29.03	29.03	47.21	57.05	39.52	22.96	20.9	20.21	20.21	25.63
19-Nov-19	18:28	4:25	272	29.03	29.53	29.03	29.03	29.03	29.53	29.53	29.53	45.33	57.05	44.06	29.05	27.03	27.03	36.98	54.63
20-Nov-19	19:28	4:26	320	29.53	29.53	29.53	29.53	29.03	29.03	29.03	29.03	63	68.8	69.94	50.33	31.72	29.72	35.68	41.51
21-Nov-19	19:44	4:23	463	29.53	29.53	29.53	29.03	29.03	29.03	29.03	29.03	55.84	63.59	54.02	34.36	31.06	32.38	33.05	38.93
22-Nov-19	19:42	4:22	466	29.03	29.53	29.03	29.03	29.03	29.53	29.03	29.03	45.33	51.57	37.63	33.05	32.38	29.72	31.72	36.98
23-Nov-19	19:17	4:16	365	29.53	29.53	29.03	29.03	29.53	29.53	29.53	29.53	49.09	59.45	38.93	31.06	32.38	28.38	33.71	35.02
24-Nov-19	20:11	4:23	305	29.03	29.53	29.53	29.53	29.53	29.53	29.53	29.53	35.02	44.69	41.51	42.79	39.58	47.9	48.47	58.25
25-Nov-19	19:30	4:30	682	29.53	29.53	29.53	29.53	29.53	29.53	29.53	29.53	65.98	69.43	72.26	52.8	46.59	40.87	51.57	64.17
26-Nov-19	20:59	5:11	2314	29.53	29.53	29.53	29.53	29.53	29.53	29.53	29.53	68.22	69.94	71.13	59.45	46.59	49.71	64.17	70.57
27-Nov-19	18:48	5:10	2675	29.53	29.53	29.53	29.53	29.53	29.53	29.53	29.53	73.94	75.61	76.16	58.85	54.63	61.23	70.51	78.9

Date	First Call	Last Call	Number of Calls	Temperature								Humidity							
				3am	6am	9am	12pm	3pm	6pm	9pm	12am	3am	6am	9am	12pm	3pm	6pm	9pm	12am
28-Nov-19	18:34	4:27	2407	29.53	29.53	29.53	29.53	29.03	29.03	29.03	29.53	81.61	79.99	79.99	79.45	55.84	49.03	54.63	67.65
29-Nov-19	19:19	4:15	858	29.53	29.53	29.53	29.03	29.03	29.03	29.03	29.03	72.76	75.55	76.71	50.95	39.58	34.36	36.98	54.63
30-Nov-19	19:34	3:58	606	29.53	29.53	29.53	29.53	29.03	29.03	29.03	29.03	67.07	70.51	72.76	55.24	44.69	42.15	42.79	49.09
1-Dec-19	19:20	4:06	594	29.53	29.53	29.53	29.53	29.53	29.03	29.03	29.03	61.82	68.22	70.51	72.76	47.21	36.93	40.81	60.05
2-Dec-19	19:25	4:18	652	29.53	29.53	29.53	29.53	29.03	29.03	29.03	29.53	67.07	71.07	73.88	73.88	42.73	32.33	53.41	66.5
3-Dec-19	19:25	4:22	482	29.53	29.53	29.53	29.03	29.03	29.03	29.03	29.03	70.51	72.76	74.99	44	33.65	30.39	34.97	40.17
4-Dec-19	19:25	4:23	389	29.03	29.53	29.53	29.03	29.03	29.03	29.53	29.53	60.05	65.34	47.21	31.06	28.38	27.03	35.68	40.22
5-Dec-19	19:55	4:18	235	29.53	29.53	29.53	29.53	29.53	29.53	29.53	29.53	54.63	63	52.8	41.51	36.33	38.99	48.47	49.71
6-Dec-19	19:47	4:19	224	29.53	29.53	29.53	29.53	29.53	29.53	29.53	29.53	62.41	67.13	55.84	40.87	37.63	37.04	36.33	39.58
7-Dec-19	19:27	4:21	226	29.53	29.53	29.53	29.53	29.53	29.53	29.53	29.53	54.02	63.65	48.47	33.05	31.11	30.44	29.05	39.58
8-Dec-19	19:28	4:22	554	29.53	29.53	29.53	29.53	29.53	29.53	29.53	29.53	55.84	63.65	47.84	33.71	28.38	24.38	27.03	30.39
9-Dec-19	19:28	4:20	598	29.53	29.53	29.53	29.53	29.53	29.53	29.53	29.53	31.06	38.93	34.36	33.1	31.11	29.78	33.1	33.1
10-Dec-19	22:33	4:28	602	29.53	29.53	30.03	30.03	30.03	30.03	30.03	30.03	37.69	37.04	54.69	46.64	44.12	47.27	57.71	65.4
11-Dec-19	19:49	4:13	270	30.03	30.03	30.03	29.53	29.53	29.53	29.53	29.53	66.56	68.86	62.47	42.2	41.56	41.56	45.38	47.27
12-Dec-19	19:31	5:07	288	29.53	29.53	29.53	29.53	29.53	29.53	29.53	29.53	46.59	58.91	61.29	41.51	38.99	37.69	41.56	45.33
13-Dec-19	19:40	4:24	233	29.53	29.53	29.53	29.53	29.53	29.53	29.53	29.53	58.31	63.06	60.7	44.12	42.84	41.56	46.01	57.11
14-Dec-19	20:37	2:40	257	30.03	30.03	30.03	29.53	29.53	29.53	29.53	29.53	65.98	68.86	62.47	55.24	47.21	49.09	62.47	65.4
15-Dec-19				30.03	30.03	30.03	29.53	29.53	29.53	29.53	30.03	71.13	73.38	74.5	58.25	49.71	55.24	63.65	70
16-Dec-19				30.03	30.03	30.03	29.53	29.53	29.53	29.53	29.53	73.38	75.06	76.71	61.29	50.95	42.79	50.33	62.47
17-Dec-19				30.03	30.03	30.03	29.53	29.53	29.53	29.53	29.53	70	72.82	72.26	50.33	40.28	37.04	38.34	44.75
18-Dec-19	19:44	4:14	205	29.53	29.53				29.53	29.53	29.53	48.52	58.31				28.06	28.73	37.88
19-Dec-19	20:26	4:31	349	29.53	29.53	29.53	29.53	29.53	29.53	29.53	29.53	39.16	36.59	37.88	37.23	32.03	32.03	41.71	57.14
20-Dec-19	19:58	5:17	748	29.53	29.53	29.53	29.53	29.53	29.53	29.53	29.53	60.71	63.06	58.33	51.69	45.49	62.47	63.06	67.69
21-Dec-19	18:48	5:04	616	29.53	30.03	30.03	29.53	29.53	29.53	29.53	29.53	71.67	73.36	75.58	66.54	58.33	48.61	51.69	62.47
22-Dec-19	20:21	4:22	739	29.53	29.53	29.53	29.53	29.53	29.53	29.53	30.03	68.26	69.97	63.06	49.84	46.74	61.3	68.26	71.11
23-Dec-19	19:41	4:43	626	30.03	30.03	29.53	29.53	29.53	29.53	29.53	29.53	73.91	73.91	65.96	54.12	49.23	55.33	57.74	61.88
24-Dec-19	19:35	4:06	271	29.53	29.53	29.53	29.53	29.53	29.53	30.03	30.03	66.54	70.54	60.12	47.99	44.24	42.98	58.93	65.96
25-Dec-19	19:48	4:12	647	29.53	30.03	29.53	29.53	29.53	29.53	29.53	29.53	65.96	68.84	65.39	55.94	47.37	41.08	38.52	43.61
26-Dec-19	19:52	4:27	339	29.53	30.03	30.03	29.53	29.53	30.03	30.03	30.03	49.23	62.53	59.52	52.3	45.49	45.55	47.42	48.61
27-Dec-19	20:14	4:28	2968	29.53	29.53	29.53	29.53	30.03	30.03	30.03	30.03	46.74	45.49	46.12	40.44	38.58	36.64	36	41.13
28-Dec-19	19:51	4:33	385	30.03	30.03	30.03	30.03	30.03	30.03	30.03	30.03	47.42	45.55	61.94	63.7	54.79	52.36	50.52	51.74
29-Dec-19	20:28	4:39	392	30.03	30.03	30.03	30.03	30.03	30.03	30.03	30.03	60.17	67.18	60.77	42.98	41.13	52.36	49.9	48.05
30-Dec-19	19:51	4:43	607	30.03	30.03	30.03	30.03	30.03	30.03	30.03	30.03	64.28	66.6	69.47	67.18	59.58	55.39	55.39	55.99
31-Dec-19	19:37	4:22	250	30.03	30.03	30.03	30.03	30.03	30.03	30.03	30.03	60.77	67.75	63.12	55.99	48.05	46.18	63.7	66.6
1-Jan-20	19:58	4:22	145	30.03	30.03	30.03	30.03	30.03	30.03	30.03	30.03	69.47	71.17	72.86	64.28	61.36	56.6	68.32	71.17
2-Jan-20	19:56	4:35	614	30.03	30.03	30.03	30.03	30.03	30.03	30.03	30.03	72.3	73.42	75.09	66.02	59.58	59.58	67.75	71.73
3-Jan-20	19:45	4:51	1663	30.03	30.03	30.03	30.03	30.03	30.03	30.03	30.03	75.09	75.64	76.75	66.6	66.54	73.98	75.64	78.39
4-Jan-20	19:33	4:34	617	30.03	30.03	30.03	30.03	30.03	30.03	30.03	30.03	77.85	79.48	80.57	80.03	78.94	79.48	81.65	80.57
5-Jan-20	19:42	4:33	274	30.03	30.03	30.03	30.03	30.03	30.03	30.03	30.03	81.65	81.65	82.72	82.72	82.18	83.25	82.72	83.25
6-Jan-20	19:47	4:37	487	30.03	30.03	30.03	30.03	30.03	30.03	30.03	30.03	82.72	83.79	83.79	84.32	84.32	84.32	84.85	84.32
7-Jan-20	20:07	0:37	133	30.03	30.03	30.03	30.03	30.03	30.03	30.03	30.03	84.85	84.85	84.85	85.9	85.38	85.9	86.43	86.43
8-Jan-20			0	30.03	30.53	30.53	30.53	30.53	30.53	30.53	30.53	86.43	86.43	87.48	86.95	86.43	87.54	88.58	89.62
9-Jan-20	19:28	4:44	745	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	91.16	91.16	90.14	90.14	92.69	90.65	92.19	92.19
10-Jan-20	19:38	4:41	382	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	92.69	91.16	93.71	92.19	92.19	93.2	92.69	93.2
11-Jan-20	19:40	4:32	1844	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	93.2	91.16	91.68	93.71	93.2	92.69	93.2	92.69

Date	First Call	Last Call	Number of Calls	Temperature								Humidity							
				3am	6am	9am	12pm	3pm	6pm	9pm	12am	3am	6am	9am	12pm	3pm	6pm	9pm	12am
12-Jan-20	19:39	4:21	647	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	94.72	93.2	94.72	93.2	94.72	95.22	94.21	93.2
13-Jan-20	19:45	4:35	181	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	95.22	94.72	95.22	94.72	93.71	95.22	95.22	94.72
14-Jan-20	19:38	4:40	205	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	92.69	93.71	92.69	94.21	93.71	93.2	93.71	94.21
15-Jan-20	21:28	4:34	190	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	93.71	93.71	93.71	93.71	93.71	93.71	93.2	93.71
16-Jan-20	19:34	3:59	568	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	94.21	94.21	93.71	93.71	93.71	93.71	94.21	94.21
17-Jan-20	19:43	4:41	1414	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	94.21	94.21	93.71	93.71	93.71	94.21	93.71	94.21
18-Jan-20	1:36	4:38	64	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	94.72	94.21	93.71	94.21	94.21	93.71	94.21	94.21
19-Jan-20	19:36	4:32	1849	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	93.71	93.71	94.21	93.71	93.71	94.21	94.21	94.72
20-Jan-20	19:42	4:37	289	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	93.2	93.71	93.71	94.21	94.21	93.71	94.21	94.21
21-Jan-20	21:38	4:38	146	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	93.71	93.71	94.21	93.71	94.21	93.71	93.71	93.71
22-Jan-20	19:49	4:38	210	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	93.71	94.21	94.21	93.71	93.71	94.21	94.21	94.72
23-Jan-20	20:07	4:40	244	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	93.71	94.21	94.21	93.71	94.21	93.71	94.21	94.21
24-Jan-20	19:55	4:44	205	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	93.71	93.71	93.71	93.71	93.71	93.71	93.71	94.72
25-Jan-20	19:55	4:36	228	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	94.72	94.21	94.21	93.71	94.21	94.72	94.72	94.72
26-Jan-20	19:55	4:42	114	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	94.21	94.21	94.21	94.72	94.72	95.22	95.22	95.22
27-Jan-20	19:50	4:41	133	30.53	30.53	30.53	30.53	30.53	30.53	30.03	30.03	94.21	93.71	93.71	93.71	94.72	94.72	94.65	94.65
28-Jan-20	19:56	4:55	145	30.53	30.53	30.53	30.53	30.03	29.03	29.53	30.03	93.64	93.64	94.21	93.71	92.12	76.07	90.52	92.63
29-Jan-20	20:04	4:48	123	30.03	30.03	30.03	30.03	29.03	29.03	29.03	29.53	92.63	92.63	92.63	76.69	82.6	61.24	71.05	85.84
30-Jan-20	19:50	4:51	556	29.53	30.03	30.03	29.53	29.03	29.03	29.03	29.03	88.46	89.55	90.07	67.12	55.88	52.24	57.08	79.9
31-Jan-20	19:57	4:52	281	29.53	29.53	29.53	30.03	29.03	29.03	29.03	29.53	82.66	86.37	87.94	87.41	68.78	50.4	76.07	81.05
1-Feb-20	19:52	4:55	374	29.53	29.53	30.03	30.03	29.53	29.03	29.03	29.53	84.26	85.84	87.94	88	82.66	59.46	76.63	84.26
2-Feb-20	19:42	4:55	427	29.53	30.03	30.03	30.03	29.53	29.53	29.53	29.53	86.89	87.41	88.52	88.52	77.24	72.23	83.72	85.84
3-Feb-20	20:01	4:55	319	29.53	30.03	30.03	30.03	29.53	29.03	29.03	29.53	86.37	88.52	89.04	89.55	66.54	61.83	64.17	83.19
4-Feb-20	19:49	4:57	323	29.53	29.53	30.03	30.03	30.03	29.03	29.03	29.53	84.79	86.37	87.48	88	88	55.28	74.41	82.66
5-Feb-20	19:49	4:51	227	29.53	30.03	30.03	30.03	29.53	29.03	29.03	29.53	85.31	86.89	88	87.48	63.06	64.17	60.65	79.96
6-Feb-20	20:23	5:22	434	29.53	29.53	30.03	29.53	29.53	29.53	29.53	30.03	83.72	85.84	86.37	75.03	69.97	66.54	82.66	88.52
7-Feb-20	19:02	5:49	2122	30.03	30.03	30.03	30.03	30.03	30.03	30.03	30.03	86.95	88	88.52	88	88	88	89.04	90.59
8-Feb-20	18:50	5:50	778	30.03	30.03	30.03	30.03	30.03	30.03	30.03	30.03	91.61	91.61	92.12	90.07	90.07	90.59	91.1	91.61
9-Feb-20	19:45	4:14	196	30.03	30.03	30.03	30.53	30.53	30.53	30.53	30.53	90.59	91.61	91.1	91.61	91.61	91.61	92.12	92.12
10-Feb-20	19:34	4:11	303	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	91.1	92.12	92.19	92.19	91.16	92.19	92.19	92.19
11-Feb-20	19:42	4:40	536	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	93.2	92.69	92.69	93.2	92.69	91.68	92.69	93.2
12-Feb-20	19:29	4:50	457	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	93.71	93.2	91.68	91.16	91.16	91.16	94.21	93.2
13-Feb-20	19:27	5:53	907	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	93.2	92.19	91.68	93.2	91.68	93.2	91.68	92.19
14-Feb-20	18:56	5:02	305	30.53	30.53	30.53	30.53	30.53	30.53	30.03	30.03	94.21	91.68	92.19	93.2	92.69	93.14	93.14	91.61
15-Feb-20	21:49	5:03	406	30.03	30.53	30.53	30.53	30.03	29.53	30.03	30.03	92.12	91.61	92.69	92.69	85.84	81.05	89.49	90.59
16-Feb-20	19:24	4:55	385	30.03	30.53	30.53	30.53	30.53	30.53	30.03	30.03	91.61	91.61	92.12	91.68	92.19	92.12	91.61	92.12
17-Feb-20	19:40	4:37	1080	30.53	30.53	30.53	30.53	30.03	29.53	30.03	30.03	92.12	92.19	92.19	92.69	81.11	80.51	89.04	90.59
18-Feb-20	19:46	4:54	255	30.03	30.03	30.53	30.53	30.53	29.53	30.03	30.03	91.1	91.61	91.61	91.68	91.1	83.19	90.59	91.1
19-Feb-20	19:36	5:07	182	30.03	30.03	30.53	30.53	30.53	30.53	30.53	30.53	91.1	91.1	91.61	92.19	92.19	91.61	92.12	91.68
20-Feb-20	19:36	5:05	2139	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	92.19	92.19	92.19	92.19	92.69	92.19	93.71	93.2
21-Feb-20	19:28	5:08	265	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	92.19	92.19	92.69	92.69	92.69	92.19	92.69	93.2
22-Feb-20	19:40	5:04	271	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	93.71	93.2	93.2	92.69	93.71	93.71	93.71	94.72
23-Feb-20	19:39	5:08	273	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	94.72	93.71	92.69	92.69	93.2	92.69	94.72	93.71
24-Feb-20	19:39	5:11	168	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	92.69	93.2	93.2	93.71	93.71	94.21	94.72	93.71
25-Feb-20	19:34	5:08	142	30.53	30.53	30.53	30.53	30.53	30.03	30.03	30.03	94.21	94.21	94.21	94.21	95.22	92.12	92.63	93.64

Date	First Call	Last Call	Number of Calls	Temperature								Humidity							
				3am	6am	9am	12pm	3pm	6pm	9pm	12am	3am	6am	9am	12pm	3pm	6pm	9pm	12am
26-Feb-20	19:42	5:08	177	30.53	30.53	30.53			31.03	30.57	30.57	92.12	93.2	82.72				84.73	89.36
27-Feb-20	19:31	5:09	188	31.07	31.07	31.07	31.07	31.07	30.57	30.57	30.57	92.67	91.66	92.67	92.17	92.67	81.13	86.44	90.57
28-Feb-20	19:58	5:09	226	31.07	31.07	31.07	31.07	30.57	30.57	30.57	30.57	91.15	92.17	92.67	90.13	81.13	71.7	78.36	88.52
29-Feb-20	19:23	5:07	169	30.57	31.07	31.07	30.57	30.07	30.07	30.07	30.07	89.04	89.62	90.64	82.74	74.5	61.29	62.47	72.26
1-Mar-20	21:07	5:04	481	30.57	30.57	30.57	30.57	30.57	30.57	30.57	30.57	81.67	84.86	86.96	86.96	75.67	75.12	83.81	88
2-Mar-20	20:46	5:05	667	31.07	31.07	31.07	31.07	31.07	31.07	31.07	31.07	88.07	89.62	90.13	90.64	91.15	91.66	91.15	92.67
3-Mar-20	19:21	5:59	1633	31.07	31.07	31.07	31.07	31.07	31.07	31.07	31.07	93.68	92.17	92.67	92.67	92.67	92.67	94.18	94.18
4-Mar-20	19:17	5:11	1021	31.07	31.07	31.07	31.07	31.07	31.07	31.07	31.07	94.18	94.18	93.18	94.18	94.18	93.68	94.68	94.68
5-Mar-20	19:20	5:14	336	31.07	31.07	31.07	31.07	31.07	31.07	31.07	31.07	93.68	93.68	94.18	93.68	94.68	94.18	94.18	94.68
6-Mar-20	19:34	5:14	243	31.07	31.07	31.07	31.07	31.07	31.07	31.07	31.07	94.18	94.68	95.18	93.68	94.18	96.17	95.18	95.67
7-Mar-20	19:32	5:06	371	31.07	31.07	31.07	31.07	31.07	31.07	31.07	31.07	93.68	94.68	94.68	94.18	95.18	95.18	94.68	95.18
8-Mar-20	19:25	5:13	349	31.07	31.07	31.07	31.07	31.07	31.07	31.07	31.07	95.18	94.68	94.68	95.18	95.18	94.68	96.66	95.18
9-Mar-20	19:25	5:08	205	31.07	31.07	31.07	31.07	31.07	31.07	31.07	31.07	95.18	94.68	95.18	94.68	95.67	95.67	96.17	95.67
10-Mar-20	19:23	5:05	149	31.07	31.07	31.07	31.07	31.07	31.07	31.07	31.07	95.67	95.18	95.18	95.67	94.68	95.67	95.18	95.67
11-Mar-20	19:22	5:15	224	31.07	31.07	31.07	31.07	31.07	31.07	31.07	31.07	95.18	95.67	95.67	95.18	95.67	95.67	95.18	96.17
12-Mar-20	19:13	5:06	326	31.07	31.07	31.07	31.07	31.07	31.07	31.07	31.07	96.17	96.66	96.17	95.18	96.66	96.66	96.66	96.66
13-Mar-20	19:16	5:12	213	31.07	31.07					30.53	30.53	96.66	96.66					92.19	92.69
14-Mar-20	19:17	5:16	631	30.53	30.53	30.53	30.53	31.03	30.53	30.53	30.53	93.71	94.72	93.2	94.21	93.2	92.69	94.72	93.2
15-Mar-20	19:22	5:16	548	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	95.72	95.22	93.71	94.72	94.21	92.69	93.71	92.69
16-Mar-20	19:25	5:12	609	30.53	30.53	30.53	30.53	30.53	30.53	30.03	30.03	94.21	94.72	93.2	92.69	94.21	93.71	93.14	93.64
17-Mar-20	19:32	5:15	518	30.53	30.53	30.53	30.53	30.53	30.53	30.03	30.53	93.2	93.2	93.2	94.21	93.71	93.71	94.15	92.69
18-Mar-20	19:12	5:00	316	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	93.71	93.71	93.71	93.71	92.69	93.2	92.69	93.2
19-Mar-20	19:34	5:12	274	30.53	30.53	30.53	30.53	30.53	30.03	30.03	30.53	93.2	93.2	93.71	93.71	93.2	92.63	92.12	93.64
20-Mar-20	19:15	5:15	431	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	93.2	93.2	93.71	92.69	93.2	93.14	93.14	92.69
21-Mar-20	19:22	5:18	214	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	93.71	92.69	92.69	93.2	93.71	92.69	93.2	93.2
22-Mar-20	19:38	5:20	263	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	93.2	93.2	92.69	93.2	93.71	93.71	93.71	94.21
23-Mar-20	19:31	5:19	344	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	93.2	92.69	93.71	93.71	93.71	93.71	93.2	93.71
24-Mar-20	19:28	5:09	315	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	93.71	93.71	93.2	93.2	93.2	93.71	93.71	93.71
25-Mar-20	19:24	5:11	177	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	93.2	93.71	94.21	93.71	93.2	93.71	93.2	93.2
26-Mar-20	19:32	5:13	267	30.53	30.53	30.53	30.53	30.53	30.53	30.03	30.53	93.2	93.71	93.71	93.71	93.71	93.71	94.15	93.14
27-Mar-20	19:30	5:22	395	30.53	30.53	30.53	30.53	30.53	29.53	30.03	30.03	93.71	93.71	94.21	93.71	93.2	88.97	93.14	92.12
28-Mar-20	19:32	5:25	395	30.03	30.53	30.53	30.53	30.53	30.53	30.53	30.53	92.63	92.63	93.2	93.2	92.69	93.2	93.2	93.2
29-Mar-20	19:11	5:16	280	30.53	30.53	30.53	30.53	30.53	30.03	30.03	30.03	93.2	92.19	93.2	92.69	93.2	90.59	92.12	92.12
30-Mar-20	19:13	5:19	368	30.53	30.53	30.53	30.53	29.53	29.53	30.03	30.03	93.14	92.19	93.71	93.71	82.66	90.01	92.12	92.12
31-Mar-20	19:18	5:21	523	30.03	30.53	30.53	30.53	30.03	29.53	30.03	30.03	91.61	91.61	93.2	93.2	88.52	65.33	87.48	89.55
1-Apr-20	19:26	5:25	548	30.03	30.03	30.53	30.53	30.53	30.53	30.53	30.53	89.55	91.1	90.65	91.68	91.16	90.65	91.16	91.16
2-Apr-20	19:03	5:20	460	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	93.2	91.68	92.69	92.19	91.68	91.68	91.68	92.69
3-Apr-20	19:17	5:22	265	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	92.69	91.16	92.69	91.68	93.71	93.2	93.2	93.2
4-Apr-20	19:08	5:23	288	30.53	30.53	30.53	30.53	30.53	30.53	30.53	30.53	92.69	92.69	92.69	93.2	92.69	93.2	93.2	93.2
5-Apr-20	20:19	5:28	344	30.53	30.53	30.53	30.53	30.53	30.53	31.03	31.03	93.2	92.69	93.2	92.69	92.69	93.2	93.2	93.71
6-Apr-20	20:02	5:34	403	31.03	31.03	31.03	31.03	31.03	31.03	31.03	31.03	93.71	94.21	93.71	93.71	93.71	93.27	93.27	93.27
7-Apr-20	18:50	5:25	1005	31.03	31.03	31.03	31.03	31.03	31.03	31.03	31.03	93.78	94.28	93.27	93.78	93.78	93.78	93.78	94.28
8-Apr-20	20:55	5:30	1823	31.03	31.03	31.03	31.03	31.03	31.03	31.03	31.03	94.28	94.28	93.27	93.78	94.28	94.28	93.78	94.28
9-Apr-20	18:49	6:15	3299	31.03	31.03	31.03	31.03	31.03	31.03	31.03	31.03	94.21	94.28	93.78	94.28	94.28	94.28	94.28	94.28
10-Apr-20	18:06	5:21	1063	31.03	31.03	31.03	31.03	31.03	31.03	31.03	31.03	94.79	93.78	94.79	94.79	93.78	93.78	95.29	94.79

Date	First Call	Last Call	Number of Calls	Temperature								Humidity							
				3am	6am	9am	12pm	3pm	6pm	9pm	12am	3am	6am	9am	12pm	3pm	6pm	9pm	12am
11-Apr-20	18:56	5:26	645	31.03	31.03	31.03	31.03	31.03	31.03	31.03	31.03	95.29	94.28	94.28	93.78	95.29	94.79	95.29	94.79
12-Apr-20	18:35	5:16	631	31.03	31.03	31.03	31.03	31.03	31.03	31.03	31.03	95.29	94.28	95.29	94.28	95.79	94.79	94.79	94.79
13-Apr-20	18:41	5:10	609	31.03	31.03	31.03	31.03	31.03	31.03	31.03	31.03	94.28	95.29	94.79	95.29	94.79	95.29	95.29	94.28
14-Apr-20	18:38	5:17	423	31.03	31.03	31.03	31.03	31.03	31.03	31.03	31.03	95.79	94.28	94.28	95.29	94.28	94.79	95.29	95.29
15-Apr-20	18:33	5:26	919	31.03	31.03	31.03	31.03	31.03	31.03	31.03	31.03	94.79	95.79	94.28	94.28	95.29	94.28	95.79	95.29
16-Apr-20	18:31	5:32	1332	31.03	31.03	31.03	31.03	31.03	31.03	31.03	31.03	94.79	95.29	95.29	94.28	93.78	93.78	93.78	94.28
17-Apr-20	18:33	5:22	1192	31.03	31.03	31.03	31.03	31.03	31.03	31.03	31.03	94.28	95.79	93.78	93.78	93.27	96.29	93.78	95.79
18-Apr-20	19:01	5:25	1179	31.03	31.03	31.03	31.03	31.03	31.03	31.03	31.03	94.28	94.28	94.79	94.28	94.79	94.28	95.29	94.79
19-Apr-20	18:44	5:33	1761	31.03	31.03	31.03	31.03	31.03	31.03	31.03	31.03	94.28	93.78	94.79	94.79	93.78	94.79	95.29	94.79
20-Apr-20	18:51	6:19	2782	31.03	31.03	31.03	31.03	31.03	31.03	31.03	31.03	95.29	95.29	95.29	94.79	94.79	95.29	94.79	95.29
21-Apr-20	18:47	5:25	2498	31.03	31.03	31.03	31.03	31.03	31.03	31.03	31.03	94.79	95.29	95.29	94.79	95.29	95.29	95.29	94.79
22-Apr-20	18:37	6:20	3447	31.03	31.03	31.03	31.03	31.03	31.03	31.03	31.03	94.79	94.28	94.79	94.79	95.29	94.79	94.79	94.79
23-Apr-20	17:48	5:33	2906	31.03	31.03	31.03	31.03	31.03	31.03	31.03	31.03	95.29	94.79	95.29	94.79	94.79	94.79	94.79	94.79
24-Apr-20	18:30	6:13	2311	31.03	31.03	31.03	31.03	31.03	31.03	31.03	31.03	95.22	94.21	94.79	94.79	94.79	94.79	94.79	94.79

Appendix D: Raw Ultrasonic and Microclimate Data at CO-CA-01

Date	First Call	Last Call	Number of Calls	Temperature								Humidity							
				3am	6am	9am	12pm	3pm	6pm	9pm	12am	3am	6am	9am	12pm	3pm	6pm	9pm	12am
17-Apr-19	18:01	5:47	1947	29.57	29.57	29.57	29.57	29.57	29.57	29.57	29.57	85.86	85.86	85.86	76.12	67.65	76.12	75.56	79.96
18-Apr-19	17:58	5:48	1877	29.57	29.57	29.57	29.07	29.07	29.07	29.07	29.57	82.67	84.8	79.96	68.16	65.86	71.58	71.58	76.67
19-Apr-19	17:54	5:59	2456	29.57	29.57	29.57	29.07	29.07	29.07	29.07	29.07	80.51	82.13	81.59	76.61	71.58	76.61	71.58	73.27
20-Apr-19				29.07	29.57	29.57	29.57	29.07	29.07	29.57	29.57	77.71	80.51	79.42	81.59	78.81	79.36	80.51	83.2
21-Apr-19				29.57	29.57	29.57	29.57	29.57	29.57	29.57	29.57	84.8	85.86	85.86	85.86	85.86	85.86	86.39	86.92
22-Apr-19				29.57	29.57	29.57	29.57	29.57	29.57	29.57	29.57	87.44	87.44	86.39	86.92	87.44	88.49	88.49	89.53
23-Apr-19				29.57	29.57	29.57	29.57	29.57	29.57	29.57	30.07	89.01	88.49	88.49	87.44	90.05	87.97	89.01	89.59
24-Apr-19				30.07	29.57	29.57	29.57	29.57	29.57	29.57	29.57	91.14	88.49	89.01	89.01	83.2	78.87	83.2	84.8
25-Apr-19				29.57	29.57	29.57	29.57	29.57	29.57	29.57	29.57	84.8	85.33	85.86	87.44	85.86	84.8	86.39	86.92
26-Apr-19				29.57	29.57	29.57	29.57	29.57	29.57	29.57	29.57	86.92	87.44	86.92	87.97	89.01	87.97	87.97	88.49
27-Apr-19				29.57	29.57	29.57	29.57	29.57	29.57	29.57	30.07	89.01	89.01	88.49	88.49	88.49	89.01	89.53	90.63
28-Apr-19				30.07	30.07	29.57	30.07	29.57	30.07	30.07	30.07	90.63	90.63	90.05	90.11	90.05	90.63	90.11	91.66
29-Apr-19				30.07	30.07	30.07	30.07	30.07	29.57	30.07	30.07	91.14	91.14	91.66	89.59	90.11	89.01	89.07	92.68
30-Apr-19				30.07	30.07	30.07	30.07	29.57	29.57	29.57	29.57	91.14	90.11	91.14	90.63	76.67	80.51	81.59	84.8
1-May-19				29.57	29.57	29.57	29.57	29.57	29.57	29.57	29.57	84.8	87.44	87.44	87.44	87.97	88.49	88.49	90.05
2-May-19				29.57	29.57	29.57	29.57	29.57	29.57	30.07	30.07	89.53	89.01	89.53	89.53	90.05	89.53	90.11	91.14
3-May-19				30.07	30.07	30.07	30.07	30.07	30.07	30.07	30.07	91.14	91.14	90.11	91.14	90.11	90.11	90.63	91.66
4-May-19				30.07	30.07	30.07	30.07	29.57	29.57	29.57	30.07	91.66	90.63	90.11	92.17	89.01	88.49	90.05	90.63
5-May-19				30.07	29.57	29.57	29.57	29.57	29.57	29.57	29.57	89.59	89.01	89.01	89.01	85.86	85.33	87.97	88.49
6-May-19				29.57	29.57	29.57	29.57	29.57	29.57	29.57	29.57	89.01	89.01	88.49	81.05	74.45	79.42	79.96	83.74
7-May-19				29.57	29.57	29.57	29.57	29.07	29.07	29.57	29.57	84.27	84.8	84.27	85.86	74.95	78.26	81.05	83.74
8-May-19				29.57	29.57	29.57	29.57	29.57	29.57	29.57	29.57	83.74	83.74	83.74	85.86	85.86	86.39	87.44	87.44
9-May-19				29.57	29.57	29.57	29.57	29.57	29.57	29.57	29.57	88.49	87.44	87.97	87.97	86.92	87.97	87.97	89.01
10-May-19				29.57	29.57	29.57	29.57	29.57	29.57	29.57	29.57	88.49	87.97	89.01	89.01	89.53	89.01	89.53	90.05
11-May-19				29.57	29.57	29.57	29.57	29.57	29.57	30.07	30.07	90.05	89.53	89.53	89.53	88.49	90.05	90.11	93.19
12-May-19				30.07	30.07	30.07	30.07	30.07	30.07	30.07	30.07	91.66	91.14	89.59	90.63	90.63	90.63	90.63	91.14
13-May-19				30.07	30.07	30.07	30.07	30.07	30.07	30.07	30.07	91.66	91.14	90.11	90.63	89.59	90.11	90.11	91.66
14-May-19				30.07	30.07	30.07	30.07	30.07	30.07	30.07	30.07	91.14	91.14	90.63	90.63	90.11	90.63	91.14	91.66
15-May-19				30.07	30.07	30.07	30.07	30.07	30.07	30.07	30.07	92.17	91.66	89.07	93.19	91.66	89.59	91.14	92.17
16-May-19				30.07	30.07	30.07	30.07	30.07	30.07	30.07	30.07	93.7	91.66	91.66	92.17	92.17	91.14	92.17	92.17
17-May-19				30.07	30.07	30.07	30.07	30.07	30.07	30.07	30.07	92.68	92.17	92.17	92.68	91.66	92.17	91.66	92.68
18-May-19				30.07	30.07	30.07	30.07	30.07	30.07	30.07	30.07	92.68	92.17	92.17	92.17	92.68	92.17	93.19	92.68
19-May-19				30.07	30.07	30.07	30.07	30.07	30.07	30.07	30.07	92.17	93.19	92.17	94.21	93.7	92.17	93.7	93.7
20-May-19				30.07	30.07	30.07	30.07	30.07	30.07	30.07	30.07	93.7	93.7	92.17	93.19	92.17	93.19	95.22	93.7
21-May-19				30.07	30.07	30.07	30.07	30.07	30.07	30.07	30.07	94.21	92.68	92.17	92.68	92.17	92.68	92.68	93.7
22-May-19				30.07	30.07	30.07	30.07	29.57	30.07	30.07	30.07	94.21	93.19	92.17	91.66	84.27	90.11	90.63	92.68
23-May-19				30.07	30.07	30.07	30.07	30.07	30.07	30.07	30.07	92.17	92.68	91.66	92.68	89.07	90.11	92.68	93.19
24-May-19				30.07	30.07	30.07	30.07	30.07	30.07	30.07	30.07	92.68	93.7	89.59	91.14	90.11	89.59	91.66	92.17
25-May-19				30.07	30.07	30.07	30.07	30.07	30.07	30.07	30.07	92.68	92.17	92.17	91.66	90.63	91.14	92.68	93.7
26-May-19				30.07	30.07	30.07	30.07	30.07	30.07	30.07	30.07	93.7	93.19	92.17	91.14	89.59	91.66	91.66	93.19
27-May-19				30.07	30.07	30.07	30.07	30.07	30.07	30.07	30.07	93.7	92.17	91.14	91.14	90.63	92.17	92.68	94.21
28-May-19				30.07	30.07	30.07	30.07	30.07	30.07	30.07	30.07	93.7	92.68	90.11	91.14	90.63	92.17	92.17	93.7
29-May-19				30.07	30.07	30.07	30.07	30.07	30.07	30.07	30.07	93.19	91.14	91.66	92.17	92.17	92.68	93.7	94.71
30-May-19				30.07	30.07	30.07	30.07	30.07	30.07	30.07	30.07	94.21	94.21	91.66	92.17	93.19	93.19	94.21	94.21
31-May-19				30.07	30.07	30.07	30.07	30.07	30.07	30.07	30.07	93.7	92.17	92.17	93.19	93.19	93.19	93.7	93.7

Date	First Call	Last Call	Number of Calls	Temperature								Humidity							
				3am	6am	9am	12pm	3pm	6pm	9pm	12am	3am	6am	9am	12pm	3pm	6pm	9pm	12am
1-Jun-19				30.07	30.07	30.07	30.07	30.07	30.07	30.07	30.07	93.19	92.68	91.66	92.17	92.17	92.17	93.19	93.7
2-Jun-19				30.07	30.07	30.07	30.07	30.07	30.07	30.07	30.07	92.68	92.68	92.17	92.17	92.17	92.17	93.7	96.22
3-Jun-19				30.07	30.07	30.07	30.07	30.07	30.07	30.07	30.07	94.21	93.7	91.66	94.21	91.66	93.19	93.7	94.21
4-Jun-19				30.07	30.07	30.07	30.07	30.07	30.07	30.07	30.07	93.7	93.7	93.19	93.19	92.68	93.19	94.21	94.71
5-Jun-19				30.07	30.07	30.07	30.07	30.07	30.07	30.07	30.07	93.19	93.19	92.68	92.68	92.68	92.68	93.7	94.21
6-Jun-19				30.07	30.07	30.07	30.07	30.07	30.07	30.07	30.07	93.19	93.19	92.68	92.17	92.68	93.19	94.71	94.71
7-Jun-19				30.07	30.07	30.07	30.07	30.07	30.07	30.07	30.07	93.7	93.19	92.68	92.17	92.68	93.19	95.22	94.71
8-Jun-19				30.07	30.07	30.07	30.07	30.07	30.07	30.07	30.07	94.21	93.19	94.71	92.17	92.17	92.68	94.21	94.71
9-Jun-19				30.07	30.07	30.07	30.07	30.07	30.07	30.07	30.07	95.72	94.71	92.17	94.21	92.68	94.71	94.71	94.71
10-Jun-19				30.07	30.07	30.07	30.07	30.07	30.07	30.07	30.07	93.19	93.7	93.19	93.19	92.68	93.7	93.7	94.21
11-Jun-19				30.07	30.07	30.07	30.07	30.07	30.07	30.07	30.07	93.7	94.21	93.19	93.7	93.19	93.19	93.19	93.7
12-Jun-19				30.07	30.07	30.07	30.07	30.07	30.07	30.07	30.07	94.21	93.19	92.68	92.68	94.21	94.21	95.22	93.7
13-Jun-19				30.07	30.07	30.07	30.07	30.07	30.07	30.07	30.07	94.21	92.17	92.17	93.7	94.21	93.7	93.19	94.21
14-Jun-19				30.07	30.07	30.07	30.07	30.07	30.07	30.07	30.07	94.71	93.19	93.19	93.19	93.7	92.68	94.71	93.19
15-Jun-19				30.07	30.07	30.07	30.07	30.07	30.07	30.07	30.07	94.21	93.19	93.19	93.19	92.68	92.68	94.21	93.19
16-Jun-19				30.07	30.07	30.07	30.07	30.07	30.07	30.07	30.07	93.7	92.17	93.19	94.21	92.68	93.7	94.21	94.21
17-Jun-19				30.07	30.07	30.07	30.07	30.07	30.07	30.07	30.07	93.7	93.19	93.19	92.68	92.68	93.19	93.7	93.7
18-Jun-19				30.07	30.07	30.07	30.07	30.07	30.07	30.07	30.07	94.21	93.7	93.7	93.19	94.21	93.7	94.71	94.71
19-Jun-19				30.07	30.07	30.07	30.07	30.07	30.07	30.07	30.07	94.21	93.7	93.19	93.19	93.7	93.7	95.22	93.7
20-Jun-19				30.07	30.07	30.07	30.07	30.07	30.07	30.07	30.07	95.22	94.21	93.19	93.7	92.68	93.19	94.21	94.71
21-Jun-19				30.57	30.07	30.07	30.07	30.07	30.57	30.57	30.57	94.78	94.21	94.71	93.7	94.21	94.78	95.78	95.78
22-Jun-19				30.57	30.57	30.07													
23-Jun-19																			
24-Jun-19																			
25-Jun-19																			
26-Jun-19																			
27-Jun-19																			
28-Jun-19																			
29-Jun-19																			
30-Jun-19																			
1-Jul-19																			
2-Jul-19																			
3-Jul-19																			
4-Jul-19																			
5-Jul-19																			
6-Jul-19																			
7-Jul-19																			
8-Jul-19				30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	95.38	93.87	94.88	94.37	94.88	94.88	94.37	93.36
9-Jul-19				30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	93.87	95.38	94.37	94.37	94.88	93.87	93.87	93.87
10-Jul-19				30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	95.38	95.88	94.37	95.88	95.38	94.88	94.37	94.37
11-Jul-19				30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	95.88	94.37	94.37	94.37	94.88	95.38	94.37	94.88
12-Jul-19				30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	95.88	96.38	93.87	94.88	95.38	94.37	95.38	95.88
13-Jul-19				30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	94.37	93.87	95.88	94.37	94.88	94.37	94.37	94.88
14-Jul-19				30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	94.37	94.88	94.88	94.88	95.88	93.36	95.38	95.88
15-Jul-19				30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	94.37	94.37	94.88	95.88	94.37	93.36	93.87	93.87

Date	First Call	Last Call	Number of Calls	Temperature								Humidity							
				3am	6am	9am	12pm	3pm	6pm	9pm	12am	3am	6am	9am	12pm	3pm	6pm	9pm	12am
16-Jul-19				30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	95.38	93.87	94.88	95.38	93.87	93.36	93.87	93.87
17-Jul-19				30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	94.37	94.37	93.87	94.88	95.38	94.88	96.38	95.88
18-Jul-19				30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	94.88	94.37	95.88	94.37	95.38	94.88	94.37	95.38
19-Jul-19				30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	94.37	95.88	94.37	94.37	95.38	96.38	95.38	94.37
20-Jul-19				30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	96.38	96.38	94.88	95.88	96.38	95.88	97.88	95.88
21-Jul-19	17:44	6:35	6490	30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	95.88	96.88	94.88	95.38	95.88	96.38	97.88	97.88
22-Jul-19	17:51	6:23	9267	30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	96.88	96.38	96.88	96.38	97.38	96.88	96.88	96.88
23-Jul-19	17:44	6:25	11234	30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	96.38	97.38	96.82	96.32	95.82	96.32	97.38	97.38
24-Jul-19	17:53	6:13	10394	30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	97.38	96.88	96.32	95.82	97.31	95.31	97.38	95.88
25-Jul-19	17:57	6:06	13868	30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	98.37	96.88	96.82	97.38	96.32	97.31	96.88	96.38
26-Jul-19	18:05	6:25	15596	30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	96.88	96.88	96.38	97.38	97.31	95.88	96.88	96.38
27-Jul-19	18:00	6:08	13442	30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	96.38	95.88	96.38	95.88	95.88	96.88	96.38	98.37
28-Jul-19				30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	97.38	95.88	96.38	97.38	95.82	94.81	96.38	97.88
29-Jul-19	18:05	6:12	7328	30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	94.88	97.88	96.32	92.85	93.36	93.36	94.37	94.37
30-Jul-19	17:58	6:09	3288	30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	93.87	94.88	93.87	94.37	93.87	93.87	93.87	94.37
31-Jul-19	18:02	6:06	6229	30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	93.87	94.37	93.87	93.87	93.36	93.36	93.87	93.87
1-Aug-19	18:06	6:05	15332	30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	94.37	94.37	94.37	94.37	94.37	93.36	94.88	94.37
2-Aug-19	17:58	6:04	14855	30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	94.37	94.37	93.87	93.87	92.85	93.36	93.87	93.36
3-Aug-19	18:07	6:13	14065	30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	93.87	93.36	93.36	92.85	93.36	93.87	94.37	93.87
4-Aug-19	18:00	6:07	15671	30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	93.87	93.36	93.36	93.87	94.37	93.36	93.87	93.87
5-Aug-19	17:58	6:04	15373	30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	93.87	93.36	93.87	93.87	93.36	93.87	94.37	93.87
6-Aug-19	17:57	6:09	10060	30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	94.37	93.87	92.85	93.36	93.87	93.36	93.87	93.87
7-Aug-19	18:06	6:09	4455	30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	93.87	93.87	92.85	93.87	93.87	93.87	93.87	93.87
8-Aug-19	18:04	6:00	2196	30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	93.36	93.87	93.36	92.85	93.36	92.34	93.36	93.36
9-Aug-19	17:52	6:01	4787	30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	93.36	93.36	92.85	92.85	93.36	94.37	93.36	93.87
10-Aug-19	18:03	5:59	5660	30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	92.85	93.36	92.85	93.36	93.36	93.87	93.36	93.87
11-Aug-19	17:55	6:01	5215	30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	93.36	93.36	93.36	93.36	93.36	93.36	92.85	93.87
12-Aug-19	17:56	5:59	4850	30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	93.36	93.36	92.34	93.36	92.85	92.85	93.87	93.87
13-Aug-19	18:00	6:07	3242	30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	93.36	92.85	93.36	92.85	93.36	92.85	93.36	93.36
14-Aug-19	17:59	6:00	2355	30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	93.87	93.36	93.87	93.87	92.85	93.87	93.87	93.36
15-Aug-19	17:59	5:35	2225	30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	93.36	94.88	92.85	93.36	93.36	93.87	93.87	92.85
16-Aug-19	18:00	5:23	1017	30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	93.87	94.88	93.87	93.36	93.87	93.87	94.37	93.87
17-Aug-19	18:01	5:27	2300	30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	93.87	94.37	94.37	94.37	93.87	94.88	94.37	94.37
18-Aug-19	18:04	6:19	7007	30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	94.37	93.87	93.87	94.37	94.88	94.37	93.87	93.87
19-Aug-19	17:52	6:07	3489	30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	93.87	93.36	93.87	92.85	93.87	93.87	94.37	93.36
20-Aug-19	17:59	6:00	6288	30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	93.87	93.87	93.36	92.85	92.85	92.85	93.87	93.36
21-Aug-19	18:06	6:11	8828	30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	93.87	93.36	93.87	93.36	93.36	93.87	93.36	94.37
22-Aug-19	18:05	6:09	12468	30.59	30.59	30.09	30.09	30.09	30.09	30.59	30.59	93.36	92.85	92.85	92.34	92.85	92.34	93.36	94.37
23-Aug-19	17:59	6:16	13084	30.59	30.59	30.59	30.09	30.09	30.09	30.59	30.59	92.85	92.85	93.36	93.36	93.36	92.34	93.36	93.87
24-Aug-19	18:02	5:52	12984	30.59	30.59	30.59	30.59	30.09	30.09	30.59	30.59	94.37	94.37	93.36	93.36	93.36	92.85	92.85	93.87
25-Aug-19	17:59	6:00	6102	30.59	30.59	30.59	30.09	30.09	30.09	30.59	30.59	94.37	93.36	92.34	92.85	92.85	92.34	93.36	93.36
26-Aug-19	18:01	5:47	3455	30.59	30.59	30.09	30.09	30.09	30.09	30.59	30.59	94.37	93.36	93.36	92.85	93.36	93.36	94.88	93.87
27-Aug-19	18:08	5:54	6017	30.59	30.59	30.59	30.09	30.09	30.09	30.59	30.59	93.36	93.36	93.36	93.36	93.36	92.85	93.36	93.36
28-Aug-19	18:06	6:18	5120	30.59	30.09	30.59	30.09	30.09	30.09	30.09	30.59	93.36	93.87	93.36	92.85	92.85	93.87	93.36	94.88
29-Aug-19	18:05	5:48	3250	30.59	30.09	30.09	30.09	30.09	30.09	30.09	30.09	93.36	93.36	92.85	92.85	92.34	92.85	93.36	94.37

Date	First Call	Last Call	Number of Calls	Temperature								Humidity							
				3am	6am	9am	12pm	3pm	6pm	9pm	12am	3am	6am	9am	12pm	3pm	6pm	9pm	12am
30-Aug-19	18:09	5:48	2552	30.09	30.09	30.09	30.09	30.09	30.09	30.09	30.09	92.85	94.37	93.36	92.34	92.85	92.85	93.87	93.87
31-Aug-19	18:03	5:47	4057	30.09	30.09	30.09	30.09	30.09	30.09	30.09	30.09	93.36	94.37	93.87	93.36	91.83	92.34	93.87	93.87
1-Sep-19	17:56	5:49	5164	30.09	30.09	30.09	30.09	30.09	30.09	30.09	30.09	92.85	93.87	93.36	93.36	93.87	92.34	92.85	92.85
2-Sep-19	17:56	5:55	4895	30.09	30.09	30.09	30.09	30.09	30.09	30.09	30.09	94.37	94.37	92.85	92.34	91.26	90.74	92.28	92.85
3-Sep-19	17:59	5:42	4569	30.09	30.09	30.09	30.09	30.09	30.09	30.09	30.09	92.34	92.85	92.79	92.28	90.23	90.74	91.77	91.77
4-Sep-19	18:09	5:41	1399	30.09	30.09	30.09	30.09	30.09	30.09	30.09	30.09	92.28	91.26	91.77	90.74	90.23	90.23	91.26	91.77
5-Sep-19	18:06	5:44	2778	30.09	30.09	30.09	30.09	30.09	30.09	30.09	30.09	91.77	91.77	91.77	92.28	91.26	91.26	92.28	93.29
6-Sep-19	18:11	5:43	2058	30.09	30.09	30.09	30.09	30.09	30.09	30.09	30.09	92.28	92.28	91.77	90.74	92.28	90.74	92.79	92.79
7-Sep-19	18:06	5:42	1267	30.09	30.09	30.09	30.09	30.09	30.09	30.09	30.09	92.79	90.74	92.28	91.77	92.28	92.28	93.29	92.79
8-Sep-19	18:07	5:38	1783	30.09	30.09	30.09	30.09	30.09	30.09	30.09	30.09	92.28	92.79	92.28	92.28	92.79	92.28	92.28	93.29
9-Sep-19	18:08	5:33	1726	30.09	30.09	30.09	30.09	30.09	29.59	30.09	30.09	91.26	92.28	92.28	91.26	91.77	87.64	90.23	90.23
10-Sep-19	18:13	5:30	2086	30.09	30.09	30.09	30.09	30.09	30.09	30.09	30.09	89.71	91.26	90.23	90.23	90.23	89.2	90.74	90.23
11-Sep-19	18:12	5:32	952	30.09	30.09	30.09	30.09	30.09	30.09	30.09	30.09	90.23	90.23	88.68	89.71	90.74	90.23	91.77	89.71
12-Sep-19	17:59	5:36	1226	30.09	30.09	30.09	30.09	30.09	30.09	30.09	30.09	89.71	90.23	89.71	91.77	90.23	90.74	90.23	89.71
13-Sep-19	18:06	5:38	770	30.09	30.09	30.09	30.09	30.09	30.09	30.09	30.09	90.74	90.74	91.26	91.26	89.71	91.26	90.23	90.23
14-Sep-19	18:08	5:38	724	30.09	30.09	30.09	30.09	30.09	30.09	30.09	30.09	90.23	89.2	89.71	91.26	89.71	90.23	89.2	89.2
15-Sep-19	18:07	5:30	651	30.09	30.09	30.09	30.09	30.09	30.09	30.09	29.59	90.74	89.2	90.74	91.26	90.74	89.2	89.2	90.23
16-Sep-19	18:03	5:32	651	29.59	29.59	29.59	29.59	29.59	29.59	29.09	29.59	90.74	90.23	89.71	88.68	89.71	86.59	83.43	84.43
17-Sep-19	18:10	5:41	1229	29.59	29.59	29.59	29.59	29.09	28.59	29.09	29.09	84.96	86.07	86.59	86.53	70.83	68.02	78	80.16
18-Sep-19	18:10	5:29	1014	29.09	29.09	29.09	29.09	28.59	28.59	28.59	28.59	82.3	83.9	84.96	79.08	57.58	54.03	62.24	69.09
19-Sep-19	18:11	5:39	2081	28.59	29.09	29.09	28.59	28.59	28.59	28.59	28.59	73.55	73.55	75.82	63.97	53.44	53.44	63.4	70.77
20-Sep-19	18:04	5:17	1311	28.59	29.09	29.09	29.09	29.09	29.09	29.09	29.09	72.44	76.3	76.3	76.3	79.08	80.16	81.24	82.84
21-Sep-19	18:07	5:49	3656	29.09	29.09	29.09	29.09	29.09	29.09	29.59	29.59	80.7	81.77	82.3	81.77	83.37	84.43	87.58	86.53
22-Sep-19	18:01	5:22	4177	29.59	29.59	29.59	29.59	29.59	29.59	29.59	29.59	86.01	85.48	87.05	87.05	84.96	87.05	86.53	86.53
23-Sep-19	18:12	5:23	5722	29.59	29.59	29.59	29.59	29.59	29.59	29.59	29.59	86.53	87.05	88.1	86.01	86.01	87.58	88.61	89.2
24-Sep-19	18:08	5:39	7501	29.59	29.59	29.59	29.59	29.59	29.59	29.59	29.59	88.68	88.1	87.05	87.58	87.58	87.05	89.71	89.2
25-Sep-19	18:07	5:30	11131	29.59	29.59	29.59	29.59	29.59	29.59	29.59	29.59	89.2	88.68	88.68	88.16	88.16	88.16	89.71	90.23
26-Sep-19	18:06	5:39	3190	29.59	29.59	29.59	29.59	29.59	29.59	29.59	29.59	89.2	89.2	88.68	88.68	88.16	87.64	89.2	89.2
27-Sep-19	18:13	5:21	2899	29.59	29.59	29.59	29.59	29.59	29.59	29.59	29.59	89.2	88.16	88.16	88.16	88.16	87.64	88.16	89.2
28-Sep-19	18:11	5:18	3389	29.59	29.59				30.11	30.11	30.11	89.2	88.68				80.6	82.71	83.76
29-Sep-19	18:11	5:29	3088	30.11	30.11	30.11	30.11	29.61	29.61	29.61	29.61	83.24	83.24	81.69	81.17	70.4	61.95	70.95	75.3
30-Sep-19	18:14	5:19	2858	29.61	29.61	29.61	29.61	29.11	29.11	29.11	29.61	73.68	74.22	74.76	56.71	50.68	48.86	56.06	61.37
1-Oct-19	18:12	5:20	2893	29.61	29.61	29.61	29.11	29.11	29.11	29.11	29.11	64.24	67.62	67.62	51.28	44.55	45.17	51.28	54.88
2-Oct-19	18:17	5:18	4059	29.11	29.61	29.11	29.11	29.11	29.11	29.11	29.11	60.74	65.94	56.65	45.17	40.8	40.8	47.02	54.28
3-Oct-19	18:09	5:32	4958	29.11	29.11	29.11	29.11	29.11	29.11	29.11	29.61	56.06	61.31	54.28	45.17	40.8	38.9	46.41	54.34
4-Oct-19	18:16	5:35	5724	29.11	29.11	29.11	29.11	29.11	29.11	29.11	29.61	56.06	60.16	53.09	46.41	41.43	40.16	45.79	53.14
5-Oct-19	18:16	5:16	5582	29.61	29.61	29.61	29.11	29.11	29.11	29.11	29.11	54.93	58.47	57.3	45.79	41.43	39.53	47.63	53.09
6-Oct-19	18:19	5:10	5005	29.61	29.61	29.11	29.11	29.11	29.11	29.11	29.61	57.88	59.64	57.83	47.02	40.8	38.26	45.79	53.14
7-Oct-19	18:20	5:15	4277	29.61	29.61	29.61	29.11	29.11	29.11	29.61	29.61	59.05	59.64	58.47	47.02	41.43	40.8	50.13	55.53
8-Oct-19	18:11	5:13	3637	29.61	29.61	29.61	29.11	29.11	29.11	29.11	29.61	57.88	59.05	56.71	48.25	40.8	38.26	45.79	50.74
9-Oct-19	18:14	5:13	3451	29.61	29.61	29.11	29.11	29.11	29.11	29.11	29.61	53.14	57.3	53.69	43.3	38.26	36.99	45.17	51.94
10-Oct-19	18:10	5:18	3196	29.61	29.61	29.61	29.11	29.11	29.11	29.11	29.61	55.53	58.47	53.14	43.93	38.26	36.34	42.68	46.46
11-Oct-19	18:20	5:12	3074	29.61	29.61	29.11	29.11	29.11	29.11	29.61	29.61	51.34	53.74	46.41	38.9	36.34	33.77	40.85	45.84
12-Oct-19	18:11	5:11	2847	29.61	29.61	29.61	29.11	29.11	29.11	29.61	29.61	49.52	52.54	49.52	40.16	35.7	35.7	42.11	48.3
13-Oct-19	18:13	5:09	2475	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	54.34	58.47	57.3	51.34	44.61	43.98	47.08	50.13

Date	First Call	Last Call	Number of Calls	Temperature								Humidity							
				3am	6am	9am	12pm	3pm	6pm	9pm	12am	3am	6am	9am	12pm	3pm	6pm	9pm	12am
14-Oct-19	18:11	5:10	2200	29.61	29.61	29.61	29.11	29.11	29.11	29.61	29.61	55.53	57.88	56.71	47.63	43.93	44.55	48.3	52.54
15-Oct-19	18:14	5:13	2306	29.11	29.61	29.61	29.61	29.11	29.61	29.61	29.61	57.24	60.22	59.05	51.94	50.68	51.34	52.54	56.71
16-Oct-19	18:10	5:05	3158	29.61	29.61	29.61	29.61	29.11	29.11	29.61	29.61	60.8	63.67	62.52	56.71	47.02	44.55	51.94	56.71
17-Oct-19	18:16	5:28	4124	29.61	29.61	29.61	29.61	29.11	29.61	29.61	29.61	61.95	61.37	61.37	53.14	46.41	45.84	48.3	54.34
18-Oct-19	18:10	5:19	4041	29.61	29.61	29.61	29.11	29.11	29.61	29.61	29.61	56.12	60.8	56.12	47.02	42.68	40.85	44.61	51.34
19-Oct-19	18:21	5:27	4760	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	53.14	55.53	53.14	47.08	42.74	42.11	44.61	50.13
20-Oct-19	18:21	5:12	5668	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	53.74	58.47	56.71	48.3	43.98	44.61	48.3	51.94
21-Oct-19	18:16	5:24	6891	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	55.53	57.88	56.12	50.74	46.46	50.13	56.12	58.47
22-Oct-19	18:14	5:17	6119	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	60.8	62.52	62.52	57.88	50.13	49.52	51.94	54.93
23-Oct-19	18:13	5:20	4508	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	57.3	59.05	54.93	49.52	42.74	43.36	43.36	50.13
24-Oct-19	18:13	5:12	3102	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	50.13	51.34	51.34	43.98	39.59	41.48	40.85	44.61
25-Oct-19	18:13	5:14	6282	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	47.69	48.91	50.74	46.46	40.22	39.59	40.22	46.46
26-Oct-19	18:14	5:20	6730	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	50.74	57.3	57.88	51.34	49.52	45.84	60.22	62.52
27-Oct-19	18:16	4:59	7359	29.61	29.61	29.61	29.61	29.11	29.61	29.61	29.61	63.1	65.37	65.94	54.93	46.41	43.36	48.3	52.54
28-Oct-19	18:31	4:58	4060	29.61	29.61	29.61	29.11	29.61	29.61	29.61	29.61	57.88	59.05	53.14	46.41	43.98	43.98	48.91	55.53
29-Oct-19	18:31	4:59	3679	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	60.22	61.37	59.64	53.14	47.69	44.61	49.52	55.53
30-Oct-19	18:33	4:58	3304	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	59.05	61.37	56.71	46.46	42.74	42.11	48.91	56.12
31-Oct-19	18:21	4:49	3247	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	59.05	61.37	58.47	47.69	43.36	43.36	47.08	51.94
1-Nov-19	18:25	4:57	3206	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	54.34	57.88	55.53	50.74	45.23	45.23	48.91	52.54
2-Nov-19	18:29	4:54	3193	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	58.47	60.22	57.88	58.47	56.71	54.34	56.71	58.47
3-Nov-19	18:18	4:51	2915	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	61.37	63.1	61.95	63.1	57.88	53.14	56.12	59.05
4-Nov-19	18:30	5:03	2906	29.61	29.61	29.61	29.61	29.11	29.11	29.11	29.61	61.37	62.52	61.95	62.52	49.47	43.3	45.79	52.54
5-Nov-19	18:23	4:50	3102	29.61	29.61	29.61	29.11	29.11	29.11	29.61	29.61	57.3	59.64	58.47	50.68	41.43	38.9	45.23	47.69
6-Nov-19	18:27	4:49	2771	29.11	29.61	29.61	29.11	29.11	29.11	29.61	29.61	47.63	52.54	51.94	42.68	39.53	36.99	43.98	48.91
7-Nov-19	18:30	4:47	3113	29.61	29.61	29.61	29.11	29.11	29.11	29.61	29.61	51.34	56.12	51.94	43.3	37.62	35.7	38.95	43.98
8-Nov-19	18:24	4:50	3485	29.61	29.61	29.61	29.11	29.11	29.61	29.61	29.61	47.08	51.34	46.46	39.53	35.06	34.47	38.32	40.85
9-Nov-19	18:22	4:51	4124	29.61	29.61	29.61	29.11	29.61	29.61	29.61	29.61	46.46	49.52	43.98	40.16	37.68	35.11	38.95	43.36
10-Nov-19	18:23	4:50	4352	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	47.08	50.74	45.23	39.59	36.4	36.4	37.04	40.85
11-Nov-19	18:23	4:51	4451	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	47.69	51.34	44.61	38.95	35.11	34.47	40.22	47.08
12-Nov-19	18:23	4:52	4005	29.61	29.61	29.61	29.61	29.61	29.61	29.61	30.11	48.91	51.94	43.98	40.85	37.68	35.76	37.68	43.42
13-Nov-19	18:24	4:54	3451	30.11	29.61	29.61	29.61	29.61	29.61	29.61	29.61	46.52	48.91	46.46	42.74	39.59	38.32	39.59	38.95
14-Nov-19	18:24	4:51	2601	30.11	29.61	29.61	29.61	29.61	29.61	29.61	30.11	44.04	46.46	42.74	39.59	37.68	35.76	37.68	37.1
15-Nov-19	18:28	4:54	2267	30.11	30.11	30.11	30.11	30.11	30.11	30.11	30.11	40.91	45.9	44.04	41.54	39.01	37.74	41.54	43.42
16-Nov-19	18:31	4:52	1947	30.11	30.11	29.61	29.61	30.11	30.11	30.11	30.11	47.13	48.97	42.11	38.32	35.17	33.88	34.52	35.17
17-Nov-19	18:33	4:46	2051	30.11	30.11	29.61	29.61	30.11	30.11	30.11	30.11	37.1	41.54	39.59	34.47	32.58	31.93	33.23	33.88
18-Nov-19	18:28	4:49	2269	30.11	30.11	30.11	30.11	30.11	30.11	30.11	30.11	38.37	44.04	39.64	35.17	33.23	31.27	31.93	33.23
19-Nov-19	18:38	4:57	2444	30.11	30.11	30.11	30.11	30.11	30.11	30.11	30.11	39.64	43.42	41.54	39.64	37.1	35.81	41.54	44.66
20-Nov-19	18:28	4:59	3662	30.11	30.11	30.11	30.11	30.11	30.11	30.11	30.11	47.75	53.8	53.8	53.8	45.9	42.17	43.42	43.42
21-Nov-19	18:36	4:46	5484	30.11	30.11	30.11	30.11	30.11	30.11	30.11	30.11	45.9	50.79	45.9	42.17	39.64	39.01	42.79	47.75
22-Nov-19	18:32	4:50	6366	30.11	30.11	30.11	30.11	30.11	30.11	30.11	30.11	48.97	50.19	45.28	42.17	39.64	39.01	40.91	47.13
23-Nov-19	18:49	4:54	9793	30.11	30.11	30.11	30.11	30.11	30.11	30.61	30.61	48.36	52	43.42	39.64	39.64	37.1	40.33	43.48
24-Nov-19	18:34	5:06	12409	30.11	30.11	30.11	30.11	30.11	30.61	30.61	30.61	45.9	48.97	44.66	44.66	44.66	44.72	50.25	55.65
25-Nov-19	18:32	5:05	17106	30.61	30.61	30.61	30.61	30.61	30.61	30.61	30.61	56.83	59.17	59.17	56.83	51.46	52.66	56.83	59.17
26-Nov-19	18:32	4:58	15101	30.11	30.11	30.11	30.11	30.11	30.61	30.61	30.61	56.77	59.7	56.18	56.77	53.8	52.06	63.22	64.93
27-Nov-19	18:33	4:44	11462	30.61	30.61	30.11	30.11	30.11	30.11	30.11	30.11	63.22	64.93	65.43	62.58	56.77	59.11	65.43	63.73

Date	First Call	Last Call	Number of Calls	Temperature								Humidity							
				3am	6am	9am	12pm	3pm	6pm	9pm	12am	3am	6am	9am	12pm	3pm	6pm	9pm	12am
28-Nov-19	18:34	4:52	6619	30.11	30.11	30.11	30.11	30.11	30.11	30.11	30.11	63.73	64.86	61.43	60.28	56.18	52	54.99	58.53
29-Nov-19	18:35	4:53	4937	30.11	30.11	30.11	30.11	30.11	30.11	30.11	30.11	59.7	60.86	57.36	51.4	47.75	42.79	45.9	50.19
30-Nov-19	18:47	5:08	4700	30.11	30.11	30.11	30.11	30.11	30.11	30.11	30.11	52.6	55.59	53.2	49.58	48.36	47.13	50.79	52
1-Dec-19	18:37	4:40	4382	30.11	30.11	30.11	30.11	30.11	30.11	30.11	30.11	53.8	56.77	54.4	52.6	44.66	43.42	45.28	48.36
2-Dec-19	18:36	4:47	3780	30.11	30.11	30.11	30.11	29.61	30.11	29.61	30.11	51.4	53.2	53.8	50.19	43.98	40.28	45.23	49.58
3-Dec-19	18:39	4:44	3568	30.11	30.11	30.11	30.11	30.11	30.11	30.11	30.11	50.79	53.8	51.4	47.13	42.17	40.28	41.54	44.66
4-Dec-19	18:38	4:42	4300	30.11	30.11	30.11	30.11	30.11	30.11	30.11	30.11	47.75	50.19	45.28	40.91	39.01	37.74	40.91	43.42
5-Dec-19	18:44	4:48	3959	30.11	30.11	30.11	30.11	30.11	30.11	30.61	30.11	45.9	50.19	47.75	45.28	42.79	44.04	49.03	52.6
6-Dec-19	18:40	4:49	4042	30.11	30.11	30.11	30.11	30.11	30.11	30.61	30.11	50.79	54.4	48.97	45.9	44.04	43.42	47.81	45.28
7-Dec-19	18:42	4:46	4176	30.11	30.11	30.11	30.11	30.11	30.11	30.11	30.61	47.13	52	47.75	43.42	40.28	39.64	40.91	44.1
8-Dec-19	18:40	4:49	5174	30.11	30.11	30.11	30.11	30.11	30.61	30.61	30.61	47.13	50.79	45.28	40.28	38.37	36.51	38.43	45.34
9-Dec-19	18:46	4:57	8069	30.61	30.11	30.11	30.11	30.61	30.61	30.61	30.61	44.1	45.9	40.91	39.64	38.43	37.15	39.07	44.72
10-Dec-19	18:42	4:54	9040	30.61	30.61	30.61	30.61	30.61	30.61	30.61	30.61	43.48	45.96	46.58	48.42	46.58	52.06	56.83	60.92
11-Dec-19	18:42	5:01	9202	30.61	30.61	30.61	30.61	30.61	30.61	30.61	30.61	58	59.76	57.42	50.85	49.03	49.03	55.05	55.05
12-Dec-19	18:43	4:59	5771	30.61	30.61	30.61	30.61	30.61	30.61	30.61	30.61	54.46	58.59	51.46	47.81	46.58	45.34	47.81	52.06
13-Dec-19	18:43	4:50	4244	30.61	30.61	30.61	30.61	30.61	30.61	30.61	30.61	52.66	56.83	53.86	49.64	48.42	47.19	51.46	49.64
14-Dec-19	18:44	4:59	4713	30.61	30.61	30.61	30.61	30.61	30.61	30.61	30.61	53.26	56.24	53.26	50.85	50.25	48.42	56.24	57.42
15-Dec-19	18:46	4:58	4862	30.61	30.61	30.61	30.61	30.61	30.61	30.61	30.61	59.76	62.64	58.59	55.05	50.25	53.26	59.17	63.79
16-Dec-19	18:45	4:54	4116	30.61	30.61	30.61	30.61	30.61	30.61	30.61	30.61	62.64	64.36	62.07	57.42	52.06	49.03	52.66	57.42
17-Dec-19	18:48	4:50	2476	30.61	30.61	30.61	30.61	30.61	30.61	30.61	30.61	60.92	62.64	58.59	49.03	45.96	44.72	47.81	47.19
18-Dec-19	18:48	5:13	5711	30.61	30.61				30.59	30.59	30.59	50.85	55.65				40.81	41.43	43.91
19-Dec-19	18:51	4:57	7360	30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	46.97	52.42	45.75	45.75	43.91	42.05	48.19	51.82
20-Dec-19	18:49	5:16	8215	30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	57.76	61.84	59.52	55.99	52.42	55.99	60.68	61.84
21-Dec-19	18:49	4:56	4980	30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	61.84	63.58	64.15	63	58.35	55.99	58.93	61.84
22-Dec-19	18:48	4:57	11479	30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	61.84	64.15	60.1	57.17	53.01	59.52	69.27	69.83
23-Dec-19	18:50	4:55	8225	30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	68.71	69.27	65.3	59.52	55.99	57.76	64.73	66.44
24-Dec-19	18:51	4:50	10322	30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	65.3	67.58	61.26	56.58	54.21	51.22	62.42	65.87
25-Dec-19	18:55	4:54	14577	30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	65.3	68.71	62.42	61.84	58.93	54.8	58.93	58.35
26-Dec-19	19:05	4:55	7007	30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	58.93	65.3	64.15	61.26	57.76	54.8	56.58	57.17
27-Dec-19	19:02	5:12	17205	30.59	30.59	30.59	30.59	30.59	31.09	31.09	31.09	57.76	61.84	55.99	54.8	51.22	48.86	51.88	56.05
28-Dec-19	18:51	4:58	5876	31.09	31.09	31.09	31.09	31.09	31.09	31.09	31.09	58.41	59.58	61.91	65.36	63.06	60.16	60.16	60.16
29-Dec-19	18:57	5:02	11775	31.09	31.09	31.09	31.09	31.09	31.09	31.09	31.09	60.16	67.07	65.93	57.82	53.07	54.86	61.33	62.49
30-Dec-19	18:52	5:01	7794	31.09	31.09	31.09	31.09	31.09	31.09	31.09	31.09	64.79	67.64	68.21	68.21	65.36	61.91	66.5	67.07
31-Dec-19	18:57	5:03	7351	31.09	31.09	31.09	31.09	31.09	31.09	31.09	31.09	65.36	68.21	66.5	61.91	57.82	54.27	62.49	67.07
1-Jan-20	19:00	4:59	5030	31.09	31.09	31.09	31.09	31.09	31.09	31.09	31.09	68.21	69.9	67.64	66.5	64.21	61.33	67.64	69.34
2-Jan-20	18:55	5:00	3129	31.09	31.09	31.09	31.09	31.09	31.09	31.09	31.09	69.34	71.58	69.34	65.93	63.64	62.49	65.93	67.07
3-Jan-20	18:54	5:07	6082	31.09	31.09	31.09	31.09	31.09	31.09	31.09	31.09	67.07	70.46	67.07	64.79	63.06	72.69	73.25	72.69
4-Jan-20	18:54	5:03	4801	31.09	31.09	31.09	31.09	31.09	31.09	31.09	31.09	72.14	74.36	71.02	71.02	68.77	69.34	73.25	73.8
5-Jan-20	18:54	5:03	470	31.09	31.09	31.09	31.09	31.09	31.09	31.09	31.09	72.69	74.36	71.58	70.46	69.9	68.77	72.14	71.58
6-Jan-20	18:59	5:06	2786	31.09	31.09	31.09	31.09	31.09	31.09	31.09	31.09	71.02	73.25	71.02	70.46	67.07	66.5	71.58	71.02
7-Jan-20	18:55	5:24	30452	31.09	31.09	31.09	31.09	31.09	31.09	31.09	31.09	71.02	73.25	71.58	72.14	72.14	71.58	74.91	78.19
8-Jan-20	19:11	5:11	13041	31.09	31.09	31.09	31.09	31.09	31.09	31.09	31.09	79.27	80.35	81.96	83.03	85.15	86.73	88.81	89.85
9-Jan-20	18:54	5:14	13747	31.09	31.09	31.09	31.09	31.09	31.09	31.09	31.09	91.39	91.9	92.92	93.43	93.43	93.94	94.44	94.44
10-Jan-20	18:55	5:04	3293	31.09	31.09	31.09	31.09	31.09	31.09	31.09	31.09	94.95	94.44	96.95	95.45	95.45	96.45	96.95	95.45
11-Jan-20	18:59	5:04	8481	31.09	31.09	31.09	31.09	31.09	31.09	31.09	31.09	98.44	96.95	97.45	95.45	97.45	97.45	97.45	97.45

Date	First Call	Last Call	Number of Calls	Temperature								Humidity							
				3am	6am	9am	12pm	3pm	6pm	9pm	12am	3am	6am	9am	12pm	3pm	6pm	9pm	12am
12-Jan-20	18:57	4:57	2519	31.09	31.09	31.09	31.09	31.09	31.09	31.09	31.09	97.95	97.95	97.95	98.44	98.44	98.44	98.94	98.94
13-Jan-20	19:07	5:01	1877	31.09	31.09	31.09	31.09	31.09	31.09	31.09	31.09	98.44	98.44	98.94	99.43	98.94	99.43	98.94	99.92
14-Jan-20	19:08	5:08	2098	31.09	31.09	31.09	31.09	31.09	31.09	31.09	31.09	99.43	99.43	98.94	99.43	98.94	99.43	99.92	99.43
15-Jan-20	19:01	5:17	15948	31.09	31.09	31.09	31.09	31.09	30.59	30.59	31.09	99.92	99.43	99.92	98.94	99.43	99.85	100	99.43
16-Jan-20	19:12	5:07	4347	31.09	31.09	31.09	31.09	31.09	30.59	30.59	30.59	100	99.43	99.92	99.43	99.92	99.85	98.87	100
17-Jan-20	19:12	5:07	6909	31.09	31.09	31.09	30.59	30.59	30.59	30.59	31.09	100	100	99.92	100	100	100	99.85	100
18-Jan-20	19:07	5:08	10143	31.09	31.09	31.09	31.09	30.59	30.59	31.09	31.09	99.92	98.94	99.43	99.92	99.36	100	99.43	100
19-Jan-20	19:02	5:07	7057	31.09	31.09	31.09	31.09	31.09	31.09	31.09	31.09	99.43	100	100	100	100	100	100	100
20-Jan-20	19:13	5:05	2969	31.09	31.09	31.09	31.09	31.09	31.09	31.09	31.09	100	99.43	100	100	100	100	99.92	100
21-Jan-20	19:23	5:05	2915	31.09	31.09	31.09	31.09	31.09	31.09	31.09	31.09	100	100	100	100	100	100	100	100
22-Jan-20	19:24	5:08	2014	31.09	31.09	31.09	31.09	31.09	31.09	31.09	30.59	100	100	100	100	99.92	100	100	100
23-Jan-20	19:14	5:06	1916	30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	100	99.36	99.85	100	100	99.85	99.85	100
24-Jan-20	19:21	5:07	1654	30.59	30.59	30.59	30.59	30.59	30.59	30.59	30.59	99.85	99.85	100	100	99.85	99.85	99.85	99.85
25-Jan-20	19:19	5:03	1532	30.59	30.59	30.59	30.59	30.59	30.09	30.09	30.09	99.85	100	99.85	99.36	99.85	100	99.78	100
26-Jan-20	19:20	5:15	1990	30.09	30.09	30.09	30.09	30.09	29.59	29.59	29.59	99.78	98.8	98.8	99.78	99.29	98.73	96.75	97.25
27-Jan-20	19:21	5:13	1801	29.59	29.59	29.59	29.59	29.59	29.09	29.09	29.09	96.75	97.25	97.25	96.25	95.25	93.17	92.15	92.15
28-Jan-20	19:21	5:11	1712	29.09	29.59	29.59	29.09	29.09	29.09	29.09	29.09	92.15	93.23	94.24	93.17	92.15	89.59	89.07	89.07
29-Jan-20	19:22	5:09	1477	29.09	29.09	29.09	29.09	29.09	28.59	28.59	28.59	89.59	91.13	91.13	90.1	88.03	84.84	84.84	85.36
30-Jan-20	19:05	5:12	1953	28.59	28.59	28.59	28.59	28.59	28.59	28.59	28.59	85.36	89.01	90.56	86.41	82.19	78.96	78.96	80.04
31-Jan-20	19:18	5:31	1857	28.59	28.59	28.59	28.59	28.09	28.09	28.09	28.09	81.12	85.36	85.36	81.12	77.28	75.09	77.82	80.52
1-Feb-20	19:20	5:29	2203	28.09	28.59	28.59	28.59	28.09	28.09	28.59	28.09	84.25	86.93	87.97	86.93	81.06	76.19	79.5	83.72
2-Feb-20	19:21	5:23	2185	28.59	28.59	28.59	28.59	28.59	28.59	28.59	28.59	85.36	87.45	88.49	89.01	86.93	85.89	84.84	86.41
3-Feb-20	19:19	5:15	2339	28.59	28.59	28.59	28.59	28.59	28.59	28.59	28.59	86.93	88.49	87.97	83.25	77.88	74.6	76.79	78.42
4-Feb-20	19:10	5:15	2041	28.09	28.59	28.59	28.09	28.09	28.09	28.09	28.09	77.82	82.19	83.78	76.73	72.33	68.98	67.85	71.22
5-Feb-20	19:21	5:18	2280	28.09	28.09	28.09	28.09	28.09	28.09	28.09	28.09	70.1	74.54	76.19	76.19	71.77	70.1	71.22	70.66
6-Feb-20	19:14	5:24	2503	28.09	28.09	28.09	28.09	28.09	28.09	28.09	28.59	70.1	78.37	80.52	82.13	79.99	79.45	82.13	85.36
7-Feb-20	19:07	5:32	3846	28.59	28.59	28.59	28.59	28.59	28.59	28.59	28.59	86.41	88.49	88.49	87.97	86.41	86.41	86.93	88.49
8-Feb-20	18:51	5:24	11748	28.59	29.09	29.09	29.09	29.09	29.09	29.09	29.09	89.53	90.62	90.62	91.13	91.13	91.13	92.15	92.15
9-Feb-20	18:59	5:39	2405	29.09	29.09	29.09	29.09	29.09	29.09	29.09	29.09	92.66	93.17	93.67	93.17	93.67	93.67	92.15	92.66
10-Feb-20	19:00	5:13	1521	29.09	29.09	29.09	29.09	29.09	29.09	29.09	29.09	93.67	92.66	94.18	93.17	93.67	93.17	92.15	93.67
11-Feb-20	19:03	5:30	2442	29.59	29.59	29.59	29.59	29.09	29.09	29.09	29.59	94.24	92.72	94.75	92.72	92.66	90.62	91.13	92.72
12-Feb-20	18:46	5:22	1620	29.59	29.59	29.59	29.59	29.59	29.09	29.09	29.09	91.7	92.21	93.23	92.72	92.21	90.62	90.62	90.62
13-Feb-20	18:57	5:28	2533	29.09	29.59	29.59	29.09	29.09	29.09	28.09	28.59	90.62	91.19	93.74	92.66	91.13	87.51	96.57	97.62
14-Feb-20	19:01	5:23	1262	28.59	28.59	28.59	28.59	28.09	28.09	28.09	28.59	98.61	98.12	98.61	98.12	96.57	96.57	96.57	96.63
15-Feb-20	19:04	5:26	3349	28.09	28.59	28.59	28.59	28.09	28.09	28.09	28.09	97.07	97.62	97.62	97.13	96.57	96.57	97.07	97.07
16-Feb-20	19:01	5:23	2704	28.59	28.59	28.59	28.09	28.09	28.09	28.09	28.59	98.12	98.12	98.12	97.56	96.07	96.07	96.07	97.13
17-Feb-20	18:57	5:21	3633	28.59	28.59	28.59	28.09	28.09	28.09	28.09	28.09	97.62	97.13	97.62	96.57	96.57	96.57	96.57	96.07
18-Feb-20	18:56	5:26	2557	28.09	28.09	28.09	28.09	28.09	27.59	27.59	28.09	95.57	96.57	96.57	96.07	94.57	93.5	93	94.06
19-Feb-20	18:50	5:28	1793	28.09	28.09	28.09	28.09	28.09	28.09	27.59	28.09	94.57	95.57	95.07	93.56	92.03	91.52	89.93	92.54
20-Feb-20	19:00	5:34	7304	28.59	28.59	28.59	28.59	28.09	28.09	28.09	28.59	93.11	94.12	94.12	91.07	88.95	89.47	90.5	92.6
21-Feb-20	18:55	5:29	2152	29.09	28.59	28.59	28.59	28.59	28.59	28.59	28.59	91.64	94.12	94.62	92.6	91.07	90.04	90.56	93.11
22-Feb-20	19:04	5:29	1819	28.59	29.09	29.09	28.59	28.59	28.59	28.59	28.59	93.61	95.69	93.17	92.09	92.09	90.56	89.01	90.04
23-Feb-20	18:51	5:29	1734	28.59	29.09	28.59	28.59	28.59	28.59	28.59	28.59	92.09	93.17	92.6	91.07	88.49	89.01	86.41	87.45
24-Feb-20	19:05	5:28	1741	28.59	28.59	28.59	28.59	28.59	28.59	28.59	28.59	87.97	90.04	88.49	85.36	84.31	83.25	84.84	85.89
25-Feb-20	18:57	5:30	1704	28.59	28.59	28.59	28.59	28.59	28.09	28.59	28.59	86.41	88.49	87.45	83.25	81.12	78.37	82.72	84.31

Date	First Call	Last Call	Number of Calls	Temperature								Humidity							
				3am	6am	9am	12pm	3pm	6pm	9pm	12am	3am	6am	9am	12pm	3pm	6pm	9pm	12am
26-Feb-20	18:49	5:32	2026	28.59	28.59	29.09	29.09	28.59	28.59	28.59	29.09	85.36	87.97	87.51	86.47	81.65	78.96	84.31	86.99
27-Feb-20	19:01	5:33	3583	29.09	29.09	29.09	29.09	28.59	28.59	29.09	29.09	85.95	88.03	87.51	85.95	83.78	80.58	81.71	86.47
28-Feb-20	19:00	5:31	1982	29.09	29.09	29.09	29.09	28.59	28.59	28.59	29.09	88.03	89.59	88.55	85.95	81.65	80.04	82.72	83.84
29-Feb-20	18:44	5:31	2101	29.09	29.09	29.09	29.09	28.59	28.59	28.59	28.59	84.89	86.47	84.89	82.24	78.96	76.79	76.79	79.5
1-Mar-20	18:41	5:32	4318	29.09	29.09	29.09	29.09	29.09	29.09	29.09	29.09	82.24	83.84	82.78	81.71	80.1	81.17	84.37	86.99
2-Mar-20	18:54	5:34	4432	29.09	29.59	29.09	29.09	29.09	29.09	29.59	29.09	87.51	88.1	87.51	85.95	83.84	83.84	87.58	89.07
3-Mar-20	18:49	5:34	3925	29.09	29.59	29.09	29.09	29.09	29.09	29.09	29.09	88.55	89.13	89.07	87.51	83.84	81.71	83.31	83.84
4-Mar-20	18:57	5:28	2049	29.09	29.09	29.09	29.09	28.59	28.59	28.59	29.09	86.99	87.51	88.03	88.55	81.12	77.88	79.5	83.84
5-Mar-20	18:51	5:44	1980	29.09	29.09	29.09	28.59	28.59	28.59	28.59	29.09	84.37	86.47	86.47	79.5	74.6	73.5	75.7	81.71
6-Mar-20	18:53	5:34	2064	29.09	29.09	29.09	29.09	28.59	28.59	29.09	29.09	82.78	85.42	83.84	80.64	77.34	73.5	77.39	83.31
7-Mar-20	18:45	5:42	2030	29.09	29.09	29.09	28.59	28.59	28.59	28.59	29.09	84.37	86.47	84.37	77.88	72.94	70.16	70.71	77.94
8-Mar-20	18:45	5:40	2124	29.09	29.09	28.59	28.59	28.59	28.59	28.59	28.59	80.64	82.78	79.5	70.71	67.34	65.63	67.34	70.16
9-Mar-20	18:42	5:35	2105	28.59	28.59	28.59	28.59	28.59	28.59	28.59	28.59	71.83	76.79	74.05	67.34	65.63	65.63	69.03	71.27
10-Mar-20	18:39	5:49	1976	28.59	28.59	28.59	28.59	28.59	28.59	28.59	28.59	72.94	76.25	75.15	70.71	69.03	67.34	68.47	72.94
11-Mar-20	18:42	5:36	1877	29.09	29.09	29.09	28.59	28.59	28.59	29.09	29.09	75.21	80.64	78.48	74.05	70.71	70.71	74.66	76.85
12-Mar-20	18:45	5:29	1556	29.09	29.09	29.09	29.09	29.09	28.59	29.09	29.09	79.02	80.1	81.17	82.24	79.02	78.96	78.48	80.64
13-Mar-20	18:47	5:35	1811																
14-Mar-20	18:37	5:33	2403	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	77.43	79.54	80.07	77.96	73.13	70.4	71.5	73.13
15-Mar-20	18:49	5:40	2030	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	75.3	77.43	78.49	73.68	70.4	67.62	68.74	71.5
16-Mar-20	18:48	5:36	2646	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	73.13	76.9	76.37	71.5	68.18	65.37	68.18	70.95
17-Mar-20	18:44	5:40	2086	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	71.5	73.68	73.68	68.74	65.37	63.1	64.8	67.62
18-Mar-20	18:26	5:37	1724	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	67.62	71.5	69.85	66.5	64.8	63.67	65.94	66.5
19-Mar-20	18:46	5:41	1881	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	67.62	73.13	70.95	65.94	63.67	60.8	64.8	67.06
20-Mar-20	18:41	5:39	2094	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	68.74	72.59	70.95	68.18	65.94	63.1	65.37	68.74
21-Mar-20	18:41	5:38	2103	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	67.06	70.95	68.18	65.94	64.24	62.52	64.8	68.18
22-Mar-20	18:41	5:40	1697	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	70.95	74.22	72.59	67.06	62.52	61.95	65.37	70.4
23-Mar-20	18:38	5:42	2039	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	72.59	76.37	74.76	69.29	63.67	60.22	61.37	68.18
24-Mar-20	18:22	5:37	2576	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	70.4	73.68	70.95	64.8	62.52	59.64	61.37	64.24
25-Mar-20	18:42	5:43	2519	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	65.37	68.74	65.94	61.37	60.22	58.47	58.47	60.8
26-Mar-20	18:32	5:39	2414	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	60.8	65.94	61.95	58.47	56.71	56.12	56.71	58.47
27-Mar-20	18:31	5:43	2836	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	58.47	63.67	60.8	58.47	56.71	55.53	55.53	58.47
28-Mar-20	18:36	5:41	2771	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	59.64	65.37	64.8	59.05	57.3	55.53	54.93	57.88
29-Mar-20	18:27	5:40	2524	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	62.52	64.8	60.22	57.3	55.53	54.34	56.12	59.05
30-Mar-20	18:36	5:44	2956	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	64.8	65.37	61.37	58.47	55.53	55.53	57.3	64.8
31-Mar-20	18:32	5:44	3435	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	67.62	70.4	65.37	60.8	59.05	57.88	60.22	65.94
1-Apr-20	18:22	5:49	3089	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	66.5	67.62	65.94	56.71	54.93	53.74	54.93	59.64
2-Apr-20	18:34	5:49	3078	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	61.95	67.06	65.94	57.3	53.74	51.34	53.74	59.64
3-Apr-20	18:18	5:43	2519	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	61.95	65.94	63.67	57.88	56.12	55.53	56.71	61.95
4-Apr-20	18:26	5:49	2507	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	61.95	65.37	65.94	61.95	58.47	57.3	57.3	63.67
5-Apr-20	18:15	6:11	2300	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	64.24	68.18	67.62	61.37	57.3	55.53	56.71	61.95
6-Apr-20	18:15	5:53	2536	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	64.8	68.18	66.5	62.52	58.47	57.3	61.95	66.5
7-Apr-20	18:11	5:55	2697	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	70.4	73.13	72.59	73.13	72.04	69.85	72.04	73.68
8-Apr-20	18:28	6:00	4539	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	75.3	76.9	76.37	75.3	72.59	72.59	74.76	76.9
9-Apr-20	18:11	6:15	4888	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	77.43	80.07	80.59	78.49	75.83	73.68	76.37	77.96
10-Apr-20	18:09	5:54	4257	30.11	30.11	30.11	30.11	29.61	29.61	29.61	29.61	78.55	79.6	80.13	80.13	69.85	64.24	69.85	72.04

Date	First Call	Last Call	Number of Calls	Temperature								Humidity							
				3am	6am	9am	12pm	3pm	6pm	9pm	12am	3am	6am	9am	12pm	3pm	6pm	9pm	12am
11-Apr-20	18:12	5:53	2769	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	73.13	75.3	75.83	72.04	63.1	60.22	61.95	65.94
12-Apr-20	18:13	5:58	2992	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	68.74	72.04	72.59	67.62	63.67	63.1	67.06	70.4
13-Apr-20	18:11	6:08	4920	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	72.04	74.22	74.22	71.5	68.74	66.5	70.95	72.04
14-Apr-20	18:05	6:00	3816	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	74.76	76.37	76.37	74.76	70.4	68.74	70.95	72.59
15-Apr-20	18:06	6:17	5968	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	74.76	76.9	76.37	72.59	67.62	64.8	67.62	70.4
16-Apr-20	17:57	5:57	3712	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	72.59	75.3	74.76	70.4	68.18	65.37	63.67	68.18
17-Apr-20	17:58	5:54	4559	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	70.95	72.59	70.95	67.06	62.52	59.64	59.64	65.37
18-Apr-20	18:10	6:06	3861	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	67.06	69.29	68.18	65.37	61.95	60.22	61.95	65.37
19-Apr-20	17:57	5:55	4549	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	67.62	70.4	68.74	64.24	62.52	61.37	61.95	64.24
20-Apr-20	18:03	6:08	4952	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	67.06	69.29	69.29	64.8	61.95	61.95	63.1	66.5
21-Apr-20	17:53	5:52	4282	29.61	30.11	30.11	29.61	29.61	29.61	29.61	29.61	68.74	71.56	71.56	65.94	63.1	60.8	63.1	65.37
22-Apr-20	17:58	5:55	5446	29.61	29.61	29.61	29.61	29.61	29.61	29.61	29.61	67.06	68.74	65.37	63.1	60.8	60.8	59.64	61.37
23-Apr-20	17:55	6:20	5680	30.11	30.11	29.61	29.61	29.61	29.61	30.11	30.11	64.3	67.12	64.8	61.95	60.8	58.47	59.7	64.3
24-Apr-20	17:51	6:12	5450	30.11	30.11	30.11	30.11	30.11	30.11	30.11	30.11	65.43	68.24	69.35	63.16	59.7	56.77	60.28	65.43

Appendix E: Long-term Summary Statistics of Chemical Analytes at CO-WS-14 (October 2017 to April 2020)

Measure	Unit	Min	Max	Range	Median	Mean	SE
pH		7.3	8.2	0.9	7.75	7.737	0.053
Electrical Conductivity	µS/cm	285	360	75	340	339.25	3.33
Total Dissolved Solids	mg/L	175	250	75	200	200.25	4.206
Total Suspended Solids	mg/L	2.5	22	19.5	2.5	4.625	1.041
Fluoride	mg/L	0.1	0.4	0.3	0.3	0.285	0.015
Nitrate as NO_3	mg/L	0.002	1.1	1.098	0.25	0.214	0.058
Nitrite as NO_2	mg/L	0.002	0.61	0.608	0.25	0.16	0.036
NOx as N	mg/L	0.002	0.31	0.308	0.008	0.026	0.015
Calcium Dissolved	mg/L	9.2	13	3.8	12	11.76	0.197
Potassium Dissolved	mg/L	1	3	2	1.3	1.453	0.121
Magnesium Dissolved	mg/L	16.5	23	6.5	21	20.725	0.323
Sodium Dissolved	mg/L	18.5	24	5.5	21	21.075	0.282
Bicarbonate HCO_3 as CaCO3	mg/L	60	100	40	89.5	88.05	2.014
Carbonate CO_3^{2-} as $CaCO_3$	mg/L	<5	<5	0	<5	<5	0
Hydroxide OH as $CaCO_3$	mg/L	<5	<5	0	<5	<5	0
Total Alkalinity as $CaCO_3$	mg/L	60	100	40	89.5	88.05	2.014
Chloride	mg/L	29	140	111	31	37.1	5.447
Sulphate	mg/L	26	81	55	28.25	31.125	2.66
Ionic Balance	mg/L	-42	3.6	45.6	0.56	-1.605	2.557
Hardness as $CaCO_3$	mg/L	2.93	130	127.07	110	108.671	5.851
Sum of Anions	mg/L	2.82	7.21	4.39	3	3.308	0.327
Sum of Cations	mg/L	3.1	120	116.9	3.37	12.297	8.975
Silica	mg/L	8.2	20	11.8	18	16.985	0.561
Aluminium Dissolved	mg/L	0.005	0.02	0.015	0.005	0.006	0.001
Antimony Dissolved	mg/L	<0.001	<0.001	0	<0.001	<0.001	0
Arsenic Dissolved	mg/L	<0.001	<0.001	0	<0.001	<0.001	0
Barium Dissolved	mg/L	0.004	0.1	0.096	0.005	0.019	0.007
Boron Dissolved	mg/L	0.005	0.1	0.095	0.09	0.08	0.007
Cadmium Dissolved	mg/L	0	0	0	0	0	0
Chromium Dissolved	mg/L	<0.001	<0.001	0	<0.001	<0.001	0
Cobalt Dissolved	mg/L	<0.001	<0.001	0	<0.001	<0.001	0
Copper Dissolved	mg/L	0	0.001	0	0	0.001	0
Iron Dissolved	mg/L	0.005	0.415	0.41	0.03	0.048	0.02
Lead Dissolved	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	0
Manganese Dissolved	mg/L	0	0.27	0.27	0.15	0.162	0.018
Mercury Dissolved	mg/L	0	0.13	0.13	0	0.007	0.006
Molybdenum Dissolved	mg/L	0	0.001	0.001	0.001	0.001	0
Nickel Dissolved	mg/L	0	0.001	0	0	0.001	0
Selenium Dissolved	mg/L	<0.001	<0.001	0	<0.001	<0.001	0
Strontium Dissolved	mg/L	0.038	0.056	0.018	0.048	0.048	0.001
Tin Dissolved	mg/L	0	0.01	0.01	0	0.001	0.001
Zinc Dissolved	mg/L	0	0.01	0.009	0.001	0.002	0