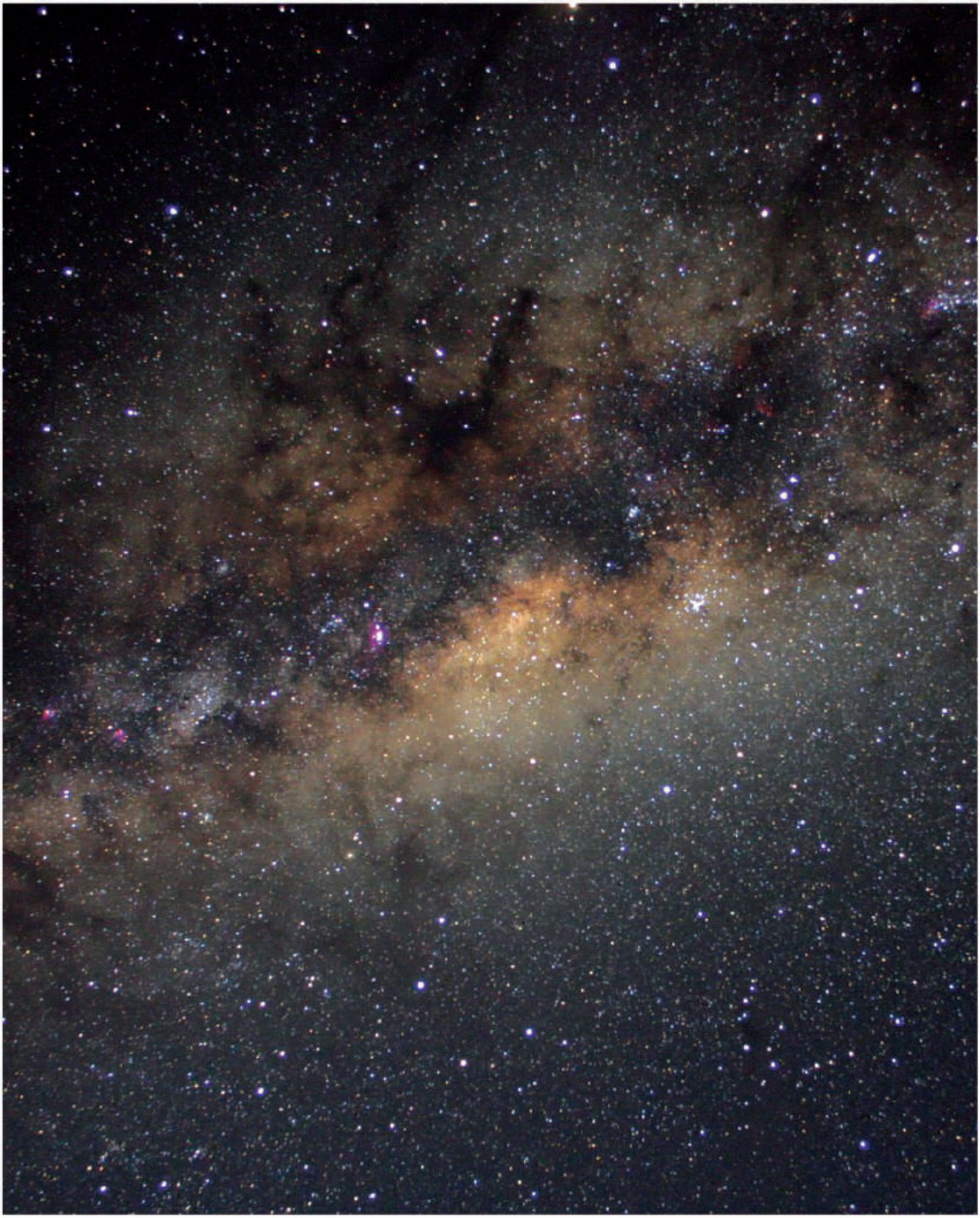


JAN 2019

THE JUMP-UP

WINTON, QUEENSLAND

A DARK-SKY SANCTUARY APPLICATION BY

AUSTRALIAN AGE OF DINOSAURS LIMITED

TO THE INTERNATIONAL DARK-SKY ASSOCIATION

Australian Age of Dinosaurs Limited

Lot 1 Dinosaur Drive
PO Box 408
Winton Qld 4735

07 4657 0078
info@aaod.com.au

ABN 79 130 127 392

Open daily, 8.30–5pm (Apr–Oct)
Open six days a week, 8.30–5pm (Nov–Mar)

australianageofdinosaurs.com

Compiled and written by staff and volunteers of the Australian Age of Dinosaurs Museum of Natural History.

A DARK-SKY SANCTUARY APPLICATION BY AUSTRALIAN AGE OF DINOSAURS LIMITED
TO THE INTERNATIONAL DARK-SKY ASSOCIATION, JAN 2019

Our guiding values: Passionate customer focus, Shared curiosity, Fair dinkum integrity, Dynamic evolution

SHORT CONTENTS

FULL CONTENTS

FULL CONTENTS

QUICK-REFERENCE GUIDE TO SANCTUARY CERTIFICATION

	IDSS CRITERIA	COMPLIANCE STATUS	REFERENCE
ELIGIBILITY			
1	A proposed IDSS must be a public or a private land legally protected for scientific, natural, educational, cultural, heritage or public enjoyment purposes.	Included in this application.	Refer to page 49
2	The IDSS must provide an opportunity for regular public nighttime access, with or without supervision. A portion of designated land may meet this requirement, or access must be available for a substantial fraction of given night. In some cases, such as when working with areas that protect endangered wildlife, archaeological sites, or other sensitive resources, this requirement may be waived or adjusted to meet important conservation goals.	Year-round public night-time access is provided at The Star Gallery. Supervised access with a Museum Tour Guide to the future Gondwana Stars Observatory will be available from May 2020.	Refer to page 22
3	In order to ensure public accessibility on private lands, the landowner(s) must allow the public to transit any part(s) of the property not included in the formally declared IDSS as required to reach designated viewing areas.	Public access to the IDSS is via Dinosaur Drive, which is open year round excluding road closures as a result of extreme events (eg fire and flood).	Refer to page 22
4	The Sanctuary must provide an exceptional dark-sky resource where the night-sky brightness at the zenith is routinely equal to or darker than 21.5 magnitudes per square arc second in the visual band and where significant light domes are not present toward the local horizon in any direction.	Information available in Section 2. Night-Sky Brightness Study.	Refer to pages 26 to 38

	IDSS CRITERIA	COMPLIANCE STATUS	REFERENCE
MINIMUM REQUIREMENTS AS A SANCTUARY			
1	A quality comprehensive Lighting Management Plan (LMP), adopted by the Board.	Included in this application.	Refer to pages 56 to 63
2	Evidence of the Museum's commitment to dark skies and quality outdoor lighting.	Information available in Section 2. Night Sky Brightness Study.	Refer to pages 26 to 38
3	A schedule denoting that 90% of all outdoor lighting in the IDSS will conform to the Sanctuary's LMP within five years of receipt of an IDA designation and a written commitment that 100% of the lighting will conform within ten years of the designation.	Included in this application.	Refer to page 57
4	A sky-brightness measurement program.	Information available in Section 2. Night Sky Brightness Study.	Refer to pages 26 to 38
5	A description of current and potential future threats to dark skies over the Sanctuary.	Included in this application.	Refer to page 62
6	Demonstration of interpretive tours or interpretive products related to dark skies and natural darkness.	Included in this application.	Outreach material refer to Section 5.5. Tour Procedures – Dark-Sky Interpretation refer to Appendix A
7	Demonstrate the dark sky is in a protected area acknowledged as an important scientific, natural and scenic resource value by jurisdictions higher than community level.	Included in this application.	Refer to page 22
8	Once established the Sanctuary must commit to erecting and maintaining appropriate signage indicating the International Dark-Sky Sanctuary designation and photo evidence sent to IDA for records along with a description of its location.	Included in this application.	Refer to page 57
9	Night-sky quality is established through calculations, maps, photographs and a plan put in place to address actual present and anticipated future threats to the night sky-quality.	Information available in Section 2. Night Sky Brightness Study.	Refer to pages 26 to 38

	IDSS CRITERIA	COMPLIANCE STATUS	REFERENCE
10	Night-sky quality is established through a determination of whether the minimum sky-quality standard has been met through sky brightness measurements made via an IDA-approved data collection method.	Information available in Section 2. Night Sky Brightness Study.	Refer to pages 26 to 38
OTHER CRITERIA			
1	Designate a formal point-of-contact person.	Naomi Miles, Business Development Manager.	business@aaod.com.au
2	Obtain a letter of nomination from a qualified IDA member nominator, as well a supporting letter from the Sanctuary managing agency.	Included in this application.	Refer to page 10 to 11
3	Provide additional letters of support from community organisations, clubs, groups etc	Included in this application.	Refer to Appendix B
4	Maps of the area indicating the Sanctuary's legal boundaries and its geographic context.	Included in this application.	Refer to pages 17 to 18
5	Provide management documents supporting dark skies and natural night-time darkness as a valued natural resource.	Included in this application.	Refer to pages 69 to 73
6	Lighting inventory plan	Included in this application.	Refer to pages 64 to 68
7	Any documentation of the scientific significance of the Sanctuary and ongoing efforts to preserve and promote these resources.	Included in this application.	Refer to pages 40 to 50
8	A summary of future plans for activities in the Sanctuary after receiving IDA certification.	Included in this application.	Refer to pages 51 to 55

The Museum is committed to contributing to responsible tourism and to the economic, social and environmental well-being of Winton and Outback Queensland.

info@aaod.com.au
Lot 1 Dinosaur Drive Winton,
Queensland 4735
+61 07 4657 0078
australianageofdinosaurs.com

19 October 2018

IDA Board of Directors
International Dark-Sky Association
3225 North First Avenue
Tucson, Arizona 85719-2103, USA

Dear IDA Board of Directors

The Jump-Up Dark-Sky Sanctuary

Please accept this application by the Australian Age of Dinosaurs Limited Board to have The Jump-Up in Queensland, Australia, recognised as a Dark-Sky Sanctuary.

The Australian Age of Dinosaurs Museum of Natural History (the Museum) is a not-for-profit organisation and charity focused on preserving and promoting Australian natural history to the world. The Museum is located on a 1,400-hectare mesa, known as The Jump-Up, outside of the township of Winton. The site, in Central West Queensland has been officially recognised as 'very remote Australia' and displays amazing dark-sky qualities with no light pollution. Over the last 17 months the Museum has worked hard to meet the requirements for International Dark-Sky certification, including developing a comprehensive Lighting Management Plan that has been adopted by the Board and establishing quality outdoor lighting and education material on the dark skies above The Jump-Up.

Recognition by the International Dark-Sky Association would help preserve the vast dark skies above The Jump-Up for future generations to enjoy as well as attract enthusiasts year-round to create a sustainable summer tourism product – with dark-sky education as its focus. This product is vital to the survival of the Museum in future years and to drought-stricken Queensland, as tourism becomes an increasingly important economic driver. The commitment of the Board, coupled with the overwhelming support from Winton locals and Central West Queensland as a whole, is testament to a community's commitment to protect and preserve The Jump-Up's pristine dark skies.

As a Director and Chairman of the Australian Age of Dinosaurs Limited Board, and a bronze member of the IDA (member number 51794), I personally support this application to the International Dark-Sky Association.

Yours sincerely

David A Elliott OAM
Executive Chairman
Australian Age of Dinosaurs Ltd

Travel Ogg
Science.Events

13 January 2019
Mr Adam Dalton,
International Dark Sky Association

Dear Adam,

Re: Letter of Nomination of the Australian Age of Dinosaurs as a Dark Sky Sanctuary.

Please accept this document as nomination for the Australian Age of Dinosaurs Board to be designated as a Dark Sky Sanctuary.

My appreciation for the Australian Age of Dinosaurs started in 2012 when I visited with a group tour of twenty solar eclipse chasers. The well-worn route to Winton takes in three of the most iconic museums in Australia: The Australian Age of Dinosaurs (AAOD), Qantas Founders Museum and The Waltzing Matilda Museum bringing a large volume of experience-seeking travellers to the area.

To this day, the AAOD stands out as one of the most professionally managed, and richly educative places I have visited. Their passion is on display in everything thing that they do.

As this application attests, the commitment to night-sky programs has already begun with astro-tourism ventures in the Jump-Up's Star Gallery. This, coupled with a history of educating natural heritage principles and a skill-set for museum and general public management, makes the AAOD a highly suitable candidate for a Dark Sky Place. (Knowing the scope of influence by the AAOD Board, expansion of the Sanctuary to include the Bladensberg National Park and the town of Winton, as a Dark Sky Community, would not be beyond them.)

As a member of the International Dark-Sky Association, and one who is keen for people, places and organisations to be rewarded for their commitment in preserving the night time environment, I whole heartedly nominate the Australian Age of Dinosaurs to be recognised by the International Dark Sky Association as a Dark Sky Sanctuary.

Sincerely yours,

Marnie Ogg

Director
TravelOgg Pty Ltd

97 Boorale Road, Terrey Hills NSW 2084 Australia +61417 689 003 www.travelogg.com.au

EXECUTIVE SUMMARY

An optical illusion. The rising full moon over the low-lying Channel Country appears larger near the horizon than it does in the night sky.

Australian Age of Dinosaurs Limited is a not-for-profit organisation in Winton, Queensland, that operates the Australian Age of Dinosaurs Museum of Natural History (the Museum). The Museum is located 24km south-east of Winton on top of a large mesa plateau known as The Jump-Up. The Museum is applying to the International Dark-Sky Association for the certification of International Dark-Sky Sanctuary for The Jump-Up.

The Jump-Up night skies are exceptionally clear and dark as there is no light pollution from human activity or urban centres – as substantiated through extensive light readings of the night sky. Since March 2017 40% of average monthly sky-quality measurements have equaled or exceeded 21.5 mpsas, and from February 2018 to November 2018 over 60 nights were recorded with an average measurement greater than 21.75 mpsas. Further, filtered measurements from November 2018 suggest that nearly 70% of recorded measurements were between 21.33 mpsas and 21.99 mpsas. The Jump-Up is on par with the

recently certified International Dark-Sky Sanctuary Stewart Island / Rakiura in New Zealand.

Central West Queensland draws visitors from all over the world to admire the natural environment, from the flat plains of the Channel Country to the mesa formations of the Vindex Ranges. The lack of population, low humidity and light pollution make the geographical location of the Museum site, atop The Jump-Up, an ideal spot to stargaze.

To ensure continued public engagement to this very remote Museum and region, while protecting the unique dark skies of The Jump-Up, an IDSS certification is sought in conjunction with the Museum's future plans to build an outdoor observatory. The future observatory and current Star Gallery are the first of many sustainable summer tourism products the Museum intends to introduce to the region to increase visitation and appreciation of the exceptionally dark skies above Central West Queensland. The IDSS certification would enable the Museum to broaden visitor awareness of light pollution while also protecting a spectacular natural resource.

The Jump-Up's outstanding dark skies meet all of the eligibility, minimum requirements and criteria set out by the IDA for Dark-Sky Sanctuaries. Further, the Museum has now been operating on The Jump-Up for ten years and is focused on scientific research, education and conservation of Australian natural history. The Museum is working towards becoming a sustainability champion so as to build a dynamic destination within Central West Queensland that will be the catalyst for ongoing growth and development across the region. As a tourism operator and repository of Australian natural history, the Museum is committed to providing and developing well-managed sustainable practices and high quality nature-based astro-tourism experiences, now and into the future.

INTRODUCTION

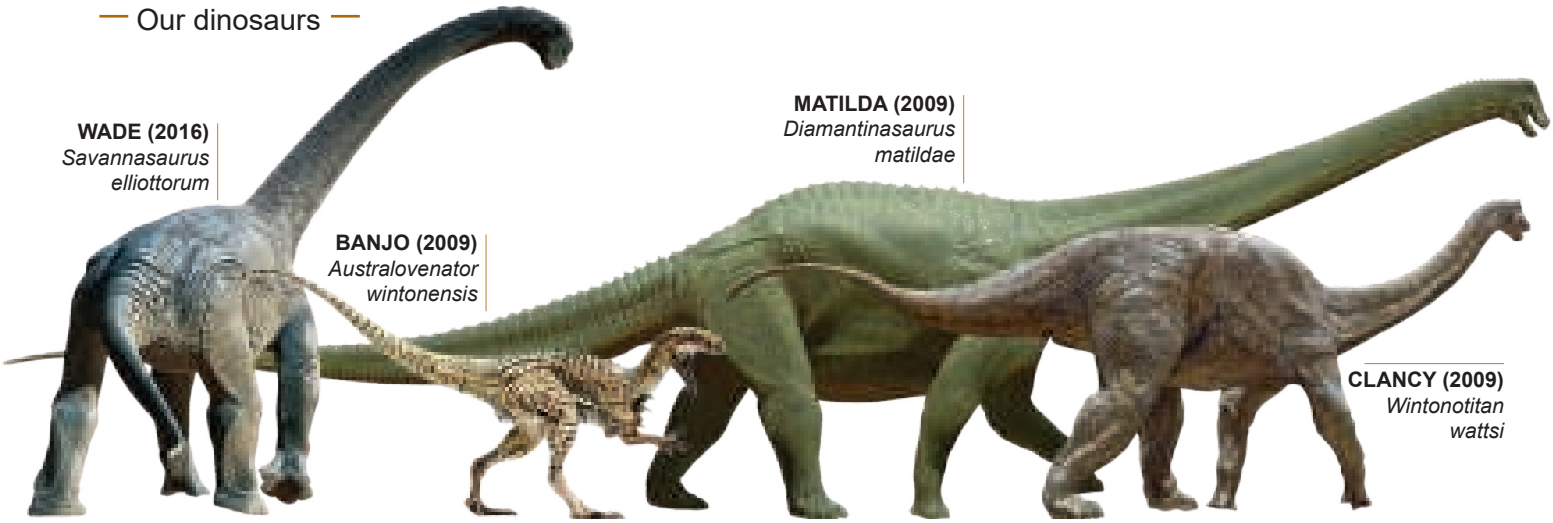
HISTORY

It had always been assumed that Australia did not have a comprehensive dinosaur record. However, following the accidental discovery of a large dinosaur femur in 1999, local graziers David and Judy Elliott started AAOD Incorporated, a not-for-profit museum, in 2002. With an interest in the natural world around them and an enthusiasm to learn, David and Judy were convinced dinosaur fossil specimens found in the Winton region would provide a great opportunity to bring the world to Winton, and to regional Queensland for the benefit of all western communities.

The Elliotts realised that no museum or other institution was telling the comprehensive story of the Australian continent's evolution through deep time and down through the ages to the present day. This became the challenging objective of the Australian Age of Dinosaurs Museum of Natural History, with the heart of the exhibitions being the story of Australia's unique dinosaurs. For the first seven years of its operation the Museum was based on the Elliott's property. During this time the Museum held annual dinosaur digs with support from the Queensland Museum and acquired the beginnings of a very large collection of dinosaur bones from the digs. In 2006 a fossil preparation facility was set up in a shed on the Elliott's property and this operated until 2009 before relocating to The Jump-Up, a 1,400-hectare mesa near Winton. An access road, laboratory, staff housing, water, power and volunteer facilities were funded by the Queensland Government and Winton Shire Council. Opened in July 2009 by the Queensland Premier, this was Stage 1 of the planned three-stage Museum development.

Coinciding with the opening, the holotype specimens of *Wintonotitan wattsi* (Clancy), *Diamantinasaurus matildae* (Matilda) – Australia's most complete sauropod skeleton, and *Australovenator wintonensis* (Banjo) – Australia's most complete theropod skeleton, were formally described and published. With strong ties to the Winton community the dinosaurs were named in honour of Andrew Barton 'Banjo' Paterson and his classic song "Waltzing Matilda", which was penned in Winton. With funding support from the Federal Government, Stage 2 of the Museum – comprising a Reception Centre with café, shop and a fossil holotype room – was opened in April 2012.

— Our dinosaurs —



GEOGRAPHY AND GEOLOGY

“The Queensland Outback is characterised by vast rolling downs, desert uplands and arid plains. Curiously, these modern landscapes and their inhabitants exist on rocks containing evidence of plants and animals that inhabited the region during the Age of Reptiles. Thus, these modern features represent the latest chapter in the geological story spanning hundreds of millions of years.” *Geology of Outback Queensland*.

The Museum is located on The Jump-Up, a unique mesa environment that is not well-represented in Outback Queensland. The cap-rock surface of The Jump-Up is solid rock allowing it to resist the same erosion that has eroded the surrounding countryside.

The Jump-Up lies within the Eromanga Basin, a basin with a 120-million-year history, spanning from the Late Triassic to the early Late Cretaceous. The last stage of development of the Eromanga Basin took place during and after the final retreat of the inland sea to the north, roughly 100 million years ago. Like much of the Winton Shire, The Jump-Up is part of the Winton Formation, where vast deposits of dinosaur fossils are found. It is these deposits that have made Winton renowned as the dinosaur capital of Australia.

FLORA AND FAUNA

The Jump-Up is home to a diverse array of fauna including over 50 reptile species, 120 bird species, 29 spider species (one of which is Australia’s most venomous huntsman, the shield huntsman, and another recently described new species of rattling tarantula), two buthid scorpions, and the recently discovered Goliath stick insect that can grow up to 30cm long. A Museum-developed database of all identified flora and fauna found on The Jump-Up is available to the public via the Museum’s website. By protecting the natural landscape of The Jump-Up, the Museum hopes to encourage the conservation of many endangered fauna and flora found in the Winton region as listed under the Environment Protection and Biodiversity Conservation Act 1999. These include the *Sminthopsis douglasi* (Julia Creek dunnart), *Grantiella picta* (painted honey-eater), *Swainsona murrayana* (slender darling pea), Acacia crombiei (pink gidgee), *Pezoporus occidentalis* (night parrot), *Pedionomus torquatus* (plains-wanderer) and *Geophaps scripta scripta* (squatter pigeon).

As well as protecting the native flora on The Jump-Up, the Museum is also recreating prehistoric Australia within the recessed and protected gullies of Dinosaur Canyon as part of the living gallery: the Cretaceous Garden. Within the Cretaceous Garden the Museum has created smaller exhibits of plants including Tree Fern Ravine, Valley of the Cycads and Waterfall Gorge. The plants that make up these exhibits are *Macrozamia moorei* (cycad), *Araucaria cunninghamii* (hoop pine), *Agathis robusta* (kauri pine), *Araucaria bidwillii* (bunya pine), *Callitris columellaris* (Cypress pine) and *Ginkgo biloba* (Chinese maidenhair tree). None of the gullies are man made and the original native trees remain in place.

DARK SKIES

The absence of densely populated areas and light pollution makes the location of The Jump-Up perfect to admire the thousands of stars in the night sky. The sky above The Jump-Up provides clear conditions to stargaze as a result of low humidity, lack of light pollution and no general pollution from cars or industry. The Museum’s commitment to protecting Australian natural history and furthering our understanding of the past for public enjoyment fits well in a location for astronomical observing with sky quality measurements often exceeding 21.5 mpsas. Offering free year-round access to The Star Gallery and future opportunities for visitors to explore the solar system through the Museum's Gondwana Stars Observatory, the Museum seeks to become an advocate for and protector of dark sky preservation and enjoyment.

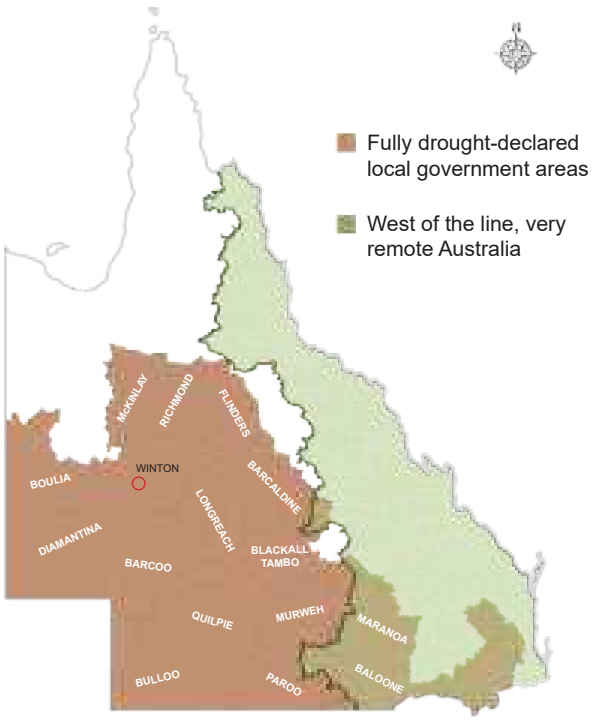
SECTION 1. THE JUMP-UP

1.1 GEOGRAPHICAL LOCATION

Winton is in Central West Queensland, 164km north-west of Longreach and 600km south-west of Townsville. The Museum is located just outside of the Winton township (143°10'E, 22°28'S) on a large mesa plateau or jump-up that was donated by Peter and Carol Britton (owners of Mount Landsborough Station near Winton) in September 2006. The Jump-Up spans 1,400-hectares of freehold land that is approximately 270m above sea level, stands 75m above the surrounding land and forms part of a mesa formation called the Vindex Range (refer to Maps 2 to 4). Connected via an all-weather road to the Landsborough Highway the Museum is open seven days a week in winter (1 April to 31 October), 8.30am to 5pm and six days a week in summer (1 November to 31 March). However, The Star Gallery is open year-round and is free.

The Jump-Up mesa has been interpreted as an ancient river channel and is comprised of kaolinite-altered laterites that are rich in ironstone. Over millions of years surrounding clay soils have eroded away leaving these weather-resistant rocks to form distinctive escarpments. The Jump-Up is like an island in the desert and home to many species of wildlife not found on the surrounding plains. Its many habitats and micro-climates make it richly diverse.

Map 1 *Areas of Queensland classified as very remote Australia and fully drought-declared*



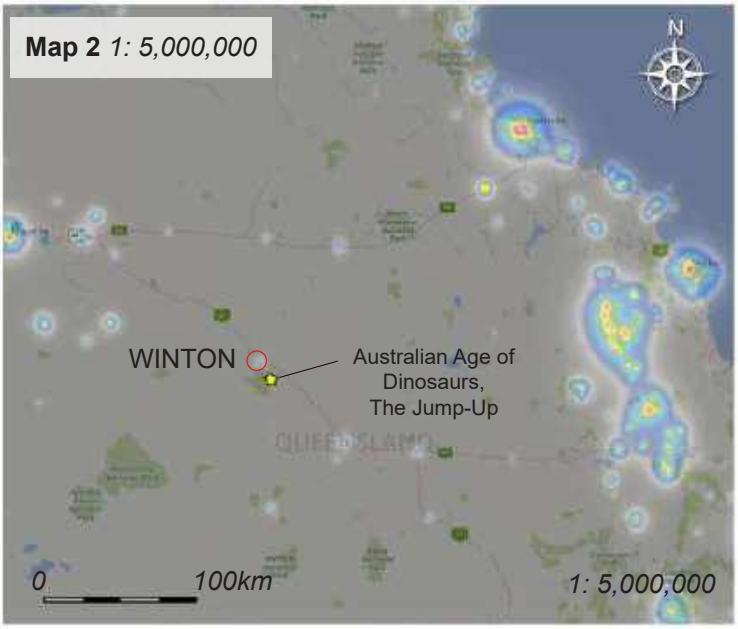
1.2 WINTON

Since June 2013 Winton Shire has been drought-declared and often experiences climatic extremes such as prolonged heat waves. The Accessibility/Remoteness Index of Australia (ARIA) ranks Winton, Queensland, at 14 – values range from 0 (high accessibility) to 15 (high remoteness). This value is based on road distance measurements from over 12,000 populated localities to the nearest service centres in five size categories based on population size (refer to Map 1). Despite the geographic isolation, visitation to the Museum on The Jump-Up, particularly during the cooler winter months, has grown by an average of 9.8% per year for the past five years (refer to Table 1). As the population within the Winton Shire consists of only 1,144 people across a total land area of 53,813.5km tourism is becoming an increasingly important and necessary economic driver.

Table 1 *Visitation to the Museum since opening on The Jump-Up in 2009* ** 6-month period only*

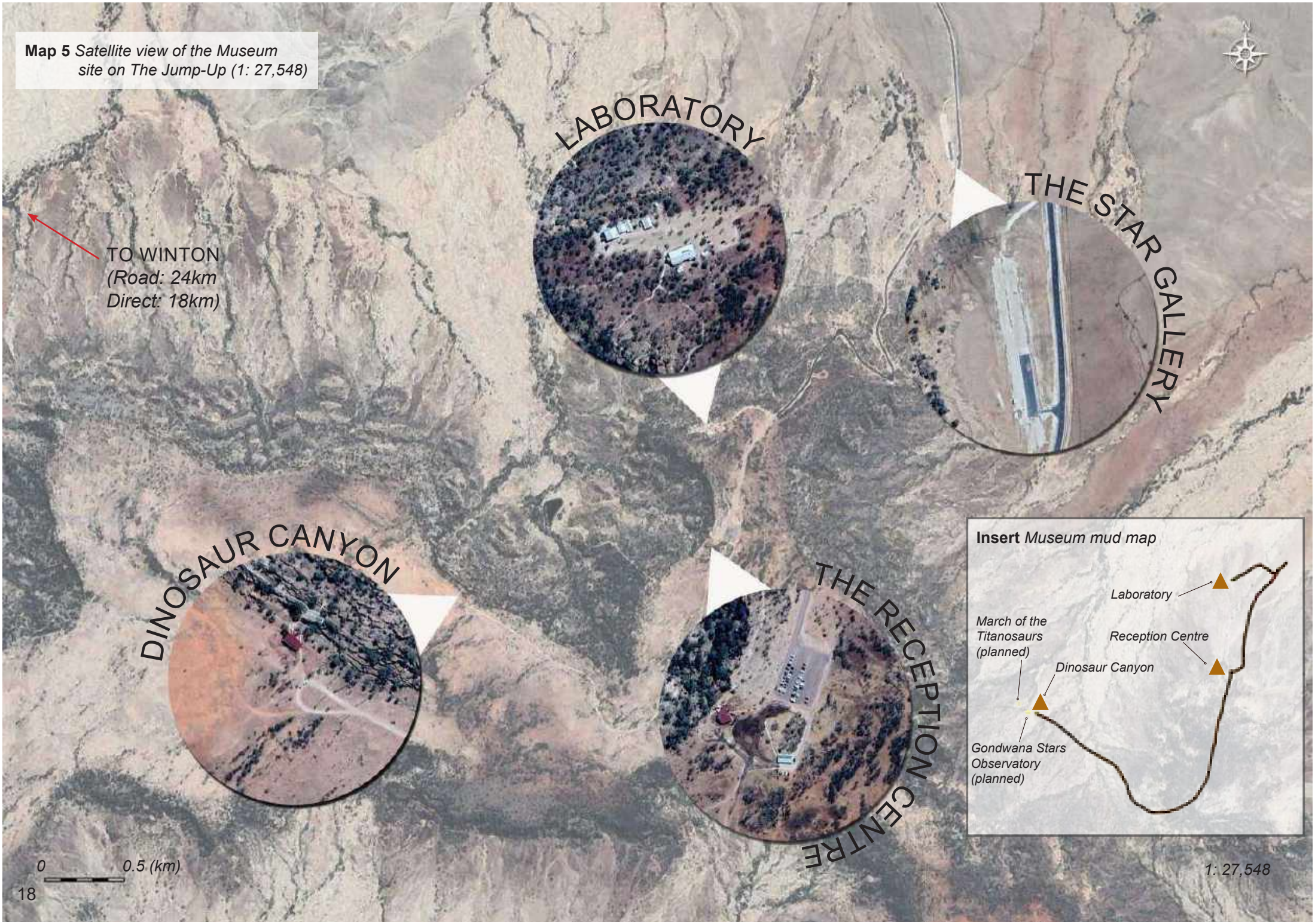
	2009/ 2010	2010/ 2011	2011/ 2012	2012*	2013	2014	2015	2016	2017	2018
Visitors received	9,368	13,066	16,488	11,195*	22,945	22,635	27,414	25,713	32,036	36,937


Aerial view of Winton, Qld


Map 2 1: 5,000,000
N
WINTON
Australian Age of
Dinosaurs,
The Jump-Up
QUEENSLAND
0
100km
1: 5,000,000


Map 3 1: 250,000
N
WINTON
Australian Age of
Dinosaurs,
The Jump-Up
0
5km
1: 250,000


Map 4 1: 105,850
N
WINTON
Australian Age of
Dinosaurs,
The Jump-Up
(1,400 ha)
0
3.8km
1: 105,850



Map 5 *Satellite view of the Museum site on The Jump-Up (1: 27,548)*

1.3 AUSTRALIAN AGE OF DINOSAURS

Construction of the Museum is divided into three stages with each stage occupying a different area of The Jump-Up (refer to Map 5). Construction of Stage 1, which includes a temporary fossil preparation building, two staff cottages and volunteer accommodation facilities, is now complete as is Stage 2, which consists of the Reception Centre and a public car park. Stage 3.1 Dinosaur Canyon has been completed and Stage 3.2 (March of the Titanosaurs exhibition and Gondwana Stars Observatory) is in the concept planning and fundraising stage. The Museum's main building, the Museum of Natural History (MNH) (Stage 3.3), will follow the completion of Stage 3.2. The exhibitions developed for the MNH will tell the story of the Australian continent's 4.5-billion-year evolution through deep time, the land and its biota, including the effects of the Earth's major extinction events. Visitors will be encouraged to reflect on how nature interconnects and changes through time, how Mankind has altered the Earth's natural rhythms, our reliance on water and minerals taken from the Earth and the need to protect the world's resources for future generations. The final message will be that the Earth is fragile, ever-changing and must be protected.

1.4 CLIMATE

Winton is classified as a hot semi-arid climate zone with two bioregions: Channel Country and Mitchell Grass Downs. Summers are dry with temperatures ranging from 21°C to 39°C while temperatures in winter range from 9°C to 32°C. Temperatures above 30°C are experienced throughout the year, and it is common for temperatures above 40°C to be recorded from October to March. Rainfall is concentrated in summer during the wet season with an average annual rainfall of 355mm. Over the last 125 years Winton has had a mean average of 31.5 rain days per year and a mean average of 58.6 cloudy days a year over the past 54 years with most of these falling between November and March.

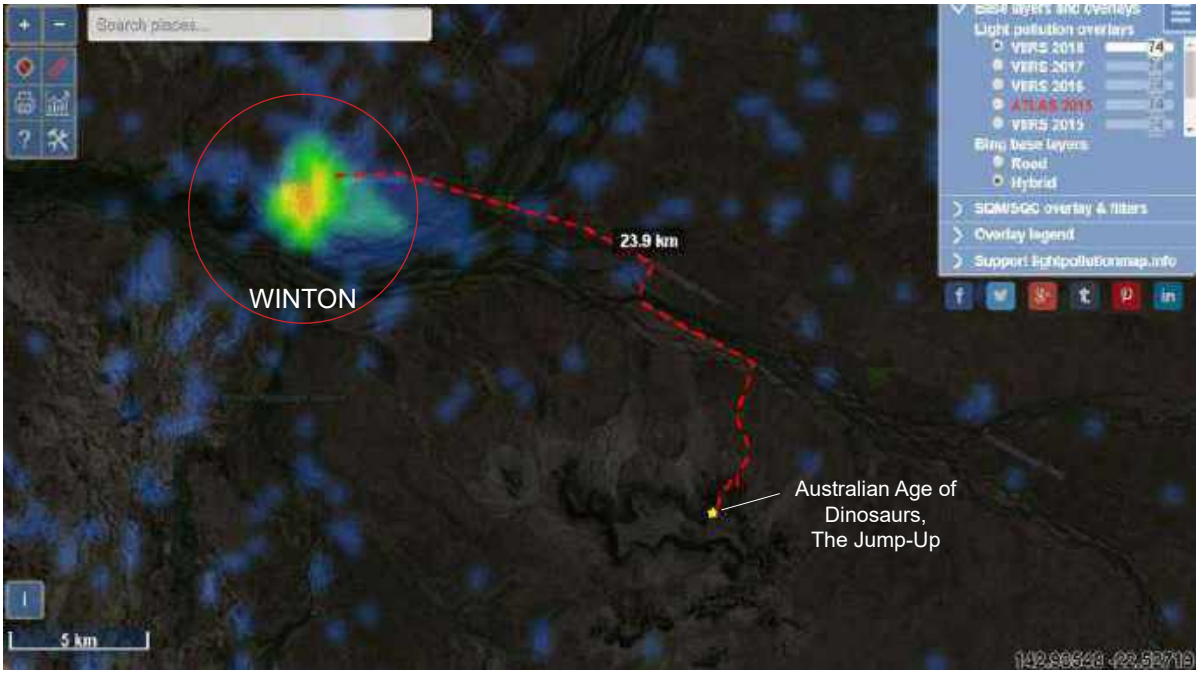
1.5 PROTECTING THE DARK SKY ABOVE THE JUMP-UP

The extraordinary dark-sky above The Jump-Up is an important natural resource that has been included in the Museum's policy development and supporting documentation for several years. This includes the Environmental Policy (2015) statement to commit to "setting appropriate and challenging environmental improvement targets by regularly reviewing progress and continually improving upon minimising our operational environmental impact" (refer to Section 5). Within the Museum's Charter for Sustainability and Responsible Tourism (2015) the Museum stated that "we will ensure that sustainability principles are a prime driver of the Museum's development project and that energy efficiency options are considered thoroughly." With this Charter the Museum went on to pledge to "...work with external agencies to ensure best practice in the management of our resources and ensure Staff and Volunteers have an understanding of the environmental factors that affect us." (refer to Section 5). From these documents the practical requirements necessary to protect the dark sky above The Jump-Up have been implemented through the identification of activity risks, mitigation measures, emission reduction plans, best-practice initiatives and improvements. This includes the planned certification of The Jump-Up as a Dark-Sky Sanctuary within the Museum's Environmental Management Plan (2018) (refer to Section 5).

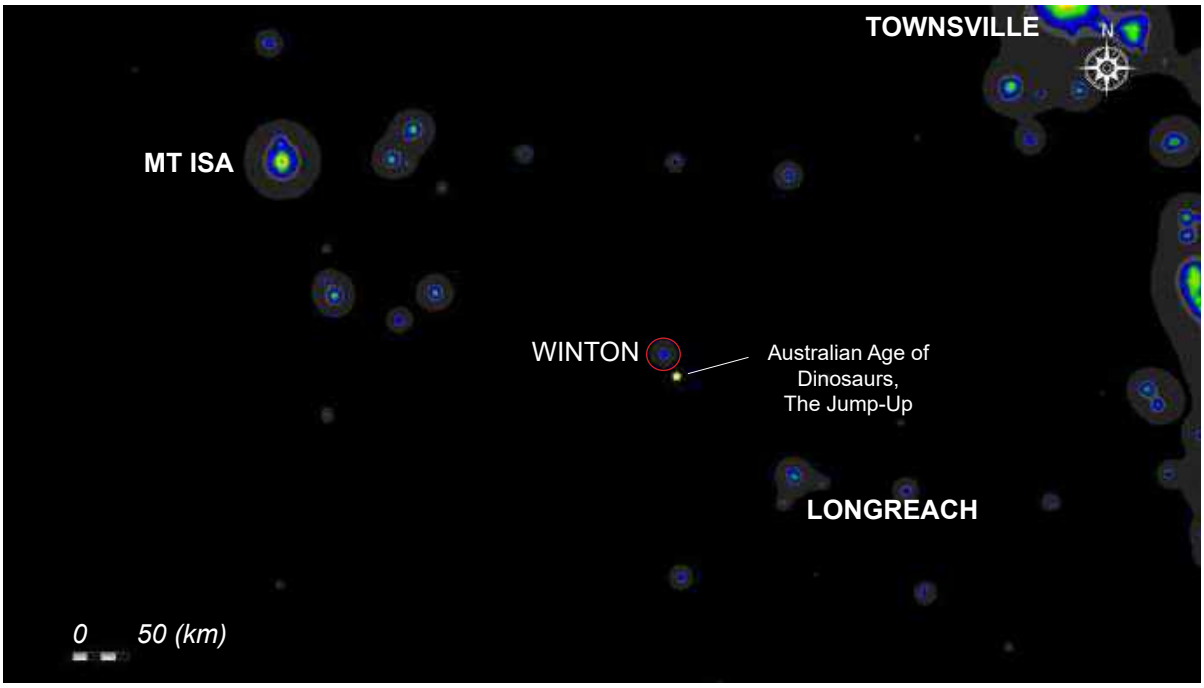
1.6 ISOLATION FROM LIGHT POLLUTION

The Jump-Up and its immediate environs (including Bladensberg National Park to the south-west) is isolated from cities and from the nearest town of Winton. The Museum has no light pollution of its own as evidenced in the radiance map (refer to Map 6) and sky-brightness maps (refer to Maps 7 and 8). The Museum's Lighting Management Plan is relatively simple as all lighting on site is controlled by the Museum and all outdoor lighting (refer to Section 4.2) conforms to IDSS guidelines and applicable local, regional and national laws. The Museum does not provide power or lighting at The Star Gallery, though in the future IDA-regulated lighting will be supplied in the public toilets. The nearest commercial power from the Museum is 24km by road and 18km by line of sight.

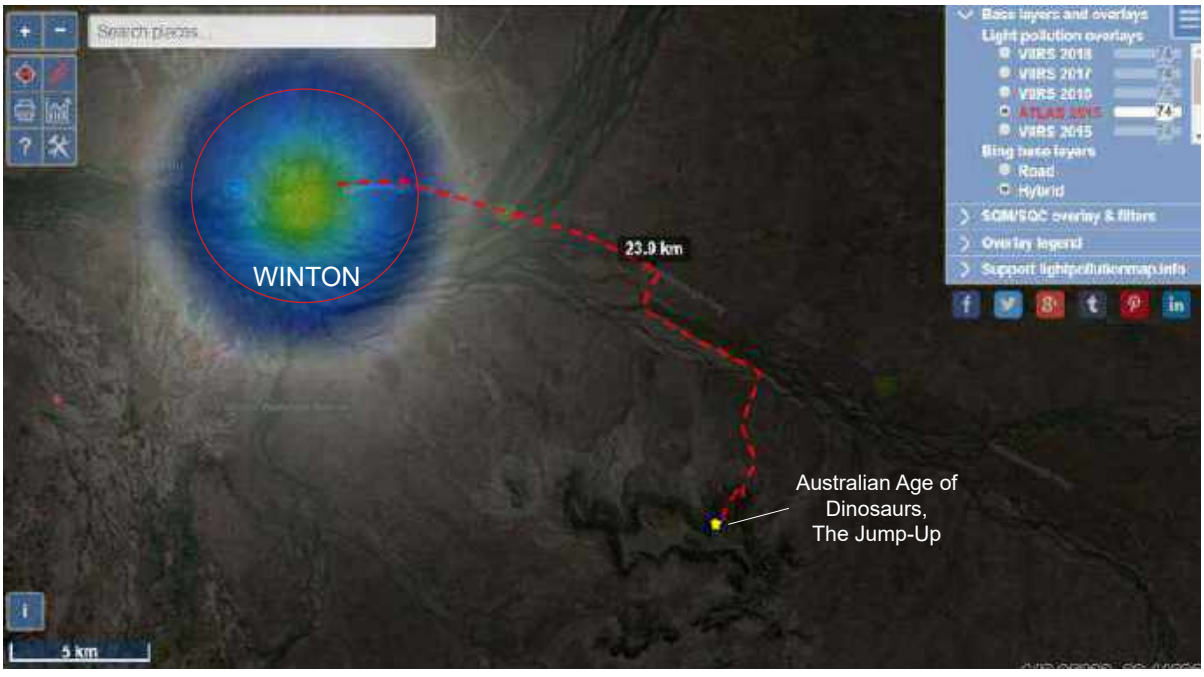
The Museum's two permanent sky quality meters, at Dinosaur Canyon and The Star Gallery, have been placed in locations with 360° unobstructed views of the sky. From the collected and collated results both locations indicate The Jump-Up rates between a class 1 to 2 on the Bortle scale and achieves a typical luminance of below 0.2 mcd/m^2. Night-sky brightness readings of 21.5 mpsas or greater on The Jump-Up are common and in complete agreement with visual observations.



Map 6
Light-pollution map 2018, using 74% Visible Infrared Imaging Radiometer Suite (VIIRS) overlay

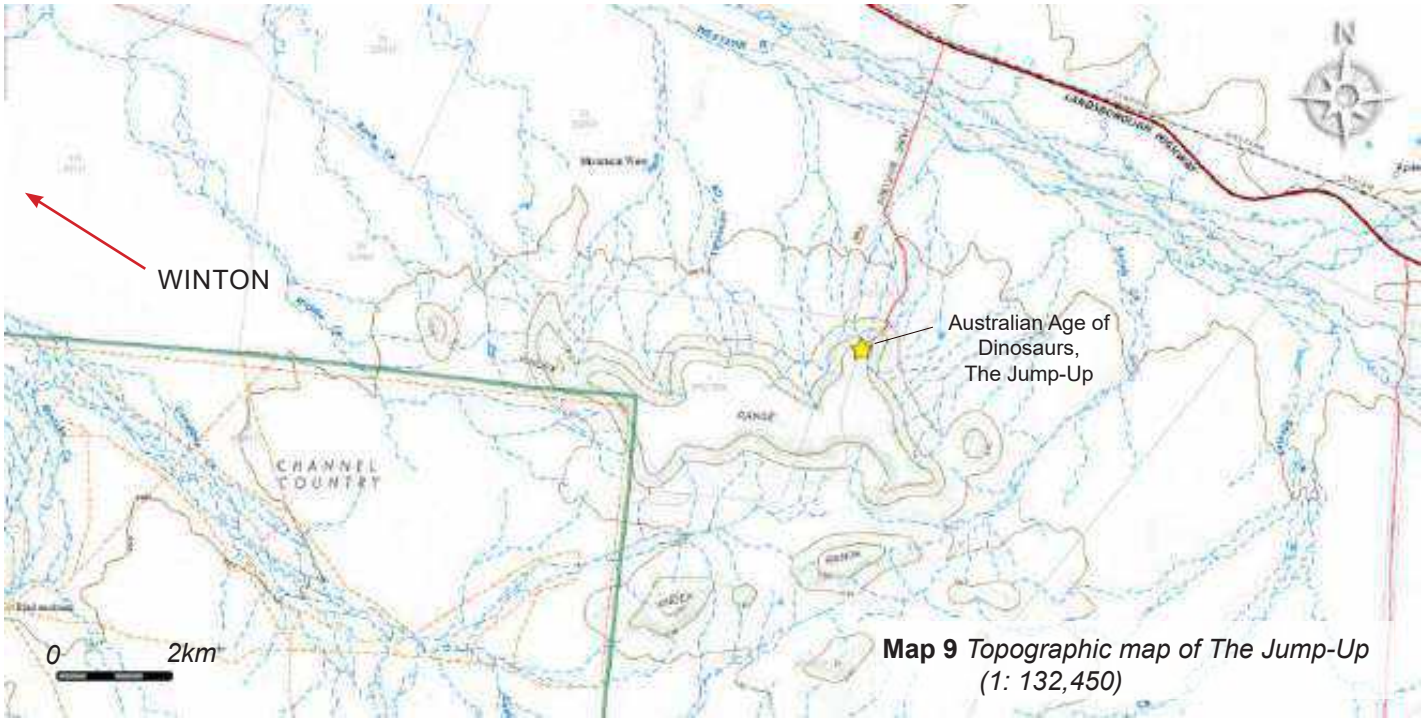


Map 7
Light-pollution map 2006, using 100% World Atlas (ATLAS) overlay



Map 8
Light-pollution map 2017, using 74% Visible Infrared Imaging Radiometer Suite (VIIRS) overlay

1.7 TOPOGRAPHY AND GEOLOGY



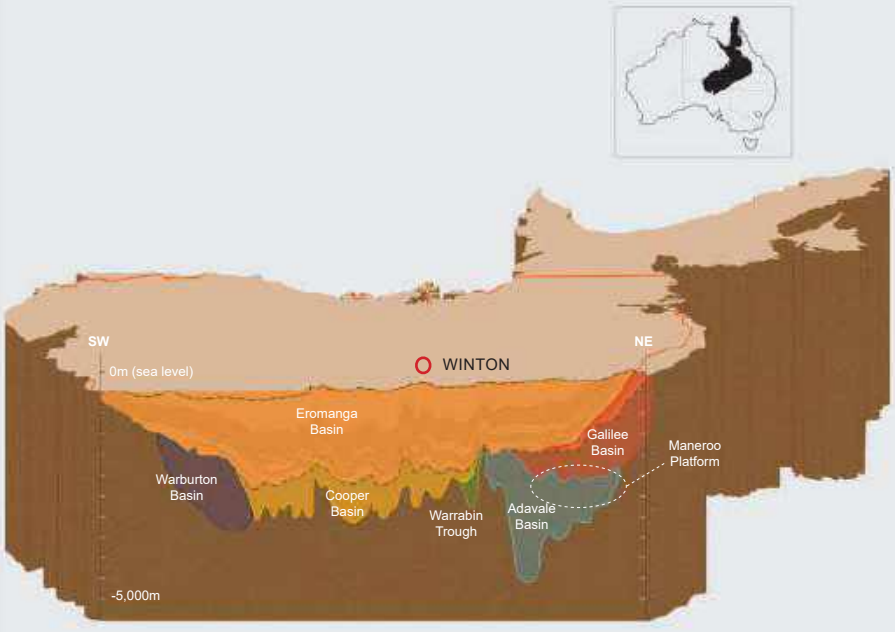
Map 9 *Topographic map of The Jump-Up (1: 132,450)*

The Winton Shire is characterised by mostly flat grassland with occasional plateaus, which has been used for pastoral activity since around 1875. The town of Winton lies on the north bank of the Western River, a braided river that often runs dry and, when visible from the air, is the landform that gives this region, the Channel Country, its name. The Western River, at one of only three major junction points along its length and flows into the Diamantina River.

Winton is situated on the Great Artesian Basin (refer to Map 10), the world's largest and deepest artesian basin containing layered formations of Mesozoic sedimentary rocks. The water that is drawn from this basin arrives to the surface at over 80°C and is channelled through cooling ponds before being distributed throughout the town. Within the Great Artesian Basin is the Eromanga Basin, a basin that covers 1,000,000km^2 and lies atop the Galilee, Warburton, Cooper and Adavale Basins and Warrabin Trough. The sedimentary sequence in the Eromanga Basin is thickest in the centre, at just over 1.8 kilometres.

The Jump-Up plateau rises 75m above the surrounding Channel Country (refer to Map 9) and represents the height of the Earth's surface between 20 and 30 million years ago. Since then the surrounding land has eroded down to its current level. This erosion has only had minor effects on The Jump-Up due to its highly resistant cap rock. While dinosaur fossils may be present underneath The Jump-Up, the hard cap-rock surface prevents their recovery or movement to the surface. Although slight, The Jump-Up's elevation means that there is less atmospheric turbulence and light refraction from the stars to affect telescope clarity.

Map 10 *Great Artesian Basin and Winton*



1.8 NIGHT-TIME ACCESS TO THE MUSEUM

The Museum has two night-time access opportunities for visitors. These are:

1. THE STAR GALLERY

Location

At the base of The Jump-Up on a 80m x 14m bitumen pad (refer to Map 5).
Access is via Dinosaur Drive.

Facilities

Planned extensions to the site include toilets, water station, signage, concrete seating and rubbish bins (maintained by the Museum), though camping will remain prohibited. Signage at the site will include dark-sky information and Dark-Sky Sanctuary signage.

Access hours

This area is free and accessible to visitors 24 hours a day, year-round.

Supervision

This is an unsupervised area used at the discretion of visitors.

Readings from SQM 2 located at this site will continue to be recorded and compared with SQM 1 readings at Dinosaur Canyon (the future Gondwana Stars Observatory site). All comparative data, improvements to the site and photographs of signage will be included in the annual report to IDA.

2. GONDWANA STARS OBSERVATORY

Location

Adjacent to Dinosaur Canyon Outpost. Access is via Dinosaur Drive and Britton Way.

Facilities

The future Gondwana Stars Observatory will include precast concrete-panel walls, a raised concrete viewing deck, telescope mounting infrastructure, angled concrete seating, equipment storage room and disabled-access ramps. The earthworks around the observatory will include meteorite-crater landscaping and concrete simulated meteorite obtrusions, 250m safety balustrading along the cliff edge at Dinosaur Canyon for night visitation safety, 250m disabled-access footpath and lighting, and external concrete seating along the footpath. Completion is set for May 2020.

Access hours

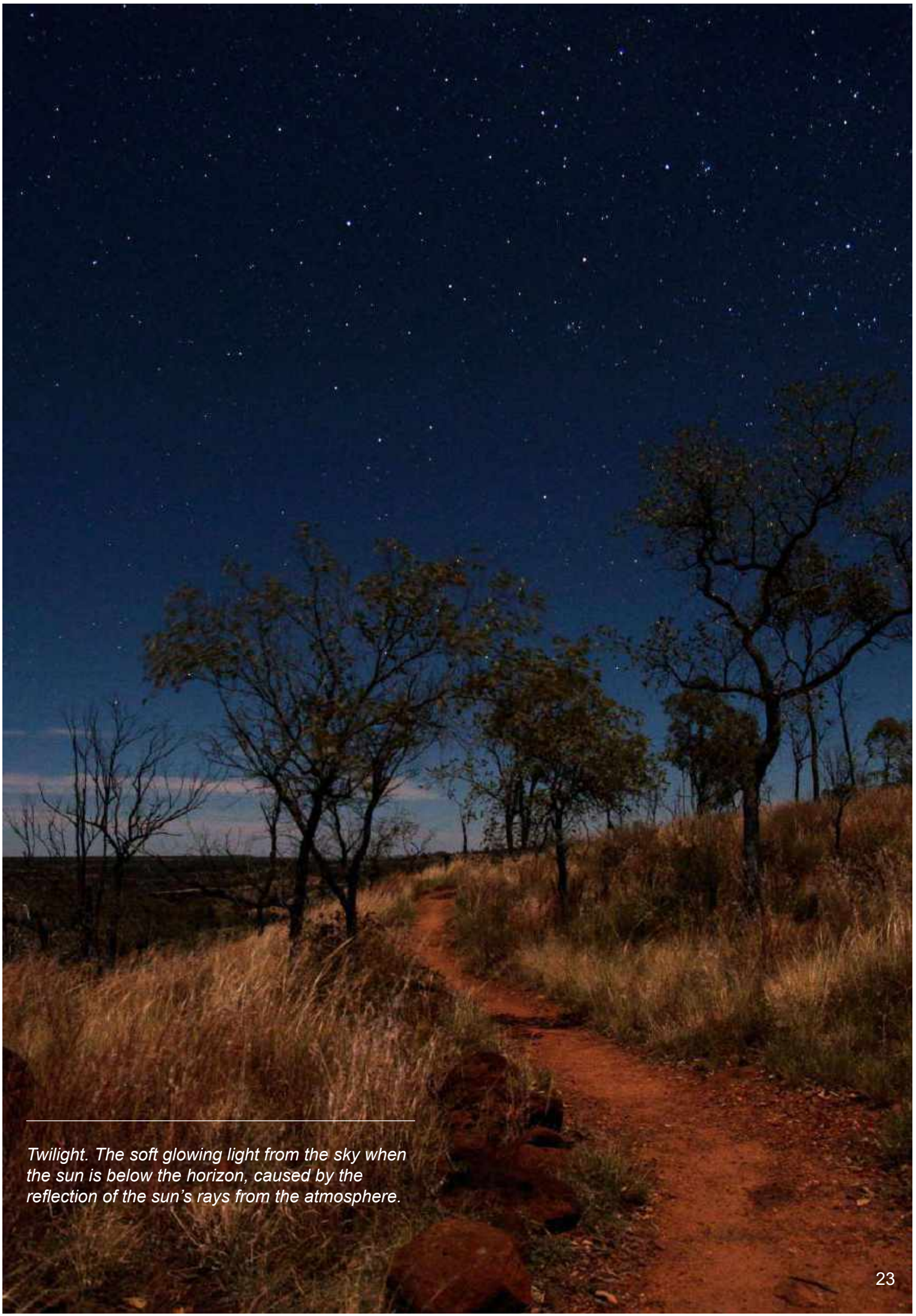
The observatory will be accessible by interpretive guided tours only.

Supervision

This is a supervised area with trained Museum Tour Guides.

In the event of an extreme natural disaster, such as fire or flood events, access to the Museum and night-time access areas may be closed by the Winton Shire Council. Notification of access closures will appear on the Museum's social media pages, website and via signage on Dinosaur Drive.

The Star Gallery looking south-west towards The Jump-Up.



Twilight. The soft glowing light from the sky when the sun is below the horizon, caused by the reflection of the sun's rays from the atmosphere.

Full moon on The Jump-Up taken using a Nikon D750 camera attached to a NexStar 6SE computerised telescope.

Seen from Earth, the central plane of our galaxy, the Milky Way, forms a dense stream of stars across the sky. Taken at the edge of Dinosaur Canyon using a NexStar 6SE computerised telescope with a D750 camera with a wide-angle lens set on a tripod.

Photos taken by Honorary Technicians Peter and Mary Carroll using a NexStar 6SE computerised telescope during the 25 October 2018 full moon event on The Jump-Up to demonstrate the brightness of the night sky despite the presence of the Moon.

Foreground artificially lit on the Guardian of the Bridge statue at Dinosaur Canyon Outpost taken using a NexStar 6SE computerised telescope with a D750 camera with a wide-angle lens set on a tripod.

SECTION 2. NIGHT-SKY BRIGHTNESS STUDY

2.1 BACKGROUND

Winton is located in Central West Queensland, in very remote Australia. The Museum is 24km south-east of Winton on top of a 75m-high 1,400-ha mesa called The Jump-Up. The focus of this Night-Sky Brightness Study is The Jump-Up site.

With extensive climatic records dating back over 54 years, the Winton Shire typically has a mean average of 58.6 (16%) cloudy days and 31.5 (8%) rain days a year across a total land area of 53,813km^2. Despite its size, only 1,144 people (2017 Census) live in the Winton Shire, the majority of whom reside in the CBD. Despite its remoteness The Jump-Up site is uniquely positioned in close proximity to the Winton township for services and supplies while being far enough away to enjoy unpolluted dark skies.

A comprehensive Night-Sky Brightness Study has never been undertaken in Winton or on The Jump-Up before now. The satellite images from the World Atlas of Artificial Night-Sky Brightness map (2015) and NASA Earth (2016) indicate the levels and impact of light pollution from the Winton CBD and surrounding region is minimal to non-existent (refer to Maps 11 and 12). Photos 1 and 2 also demonstrate the extent of light pollution at ground level from the Winton CBD as seen from The Jump-Up.

Map 11 *Light pollution map of Winton and The Jump-Up, using 92% overlay, World Atlas (2015)*

Map 12 *Central West Queensland and Winton 'flat' map, Worldview NASA Earth data, (30 December 2016). This image is drawn from a global composite map that selects the best cloud-free nights in each month over each continent*

Photos 1 and 2 *Night and day. View from The Jump-Up looking north-west towards Winton. Photos taken with an IPhone 8 at 7.30pm, 20 November 2018 (with waxing gibbous moon 91% visibility from 3.58pm) and 7.30am, 21 November 2018 (sunrise 5.36am)*

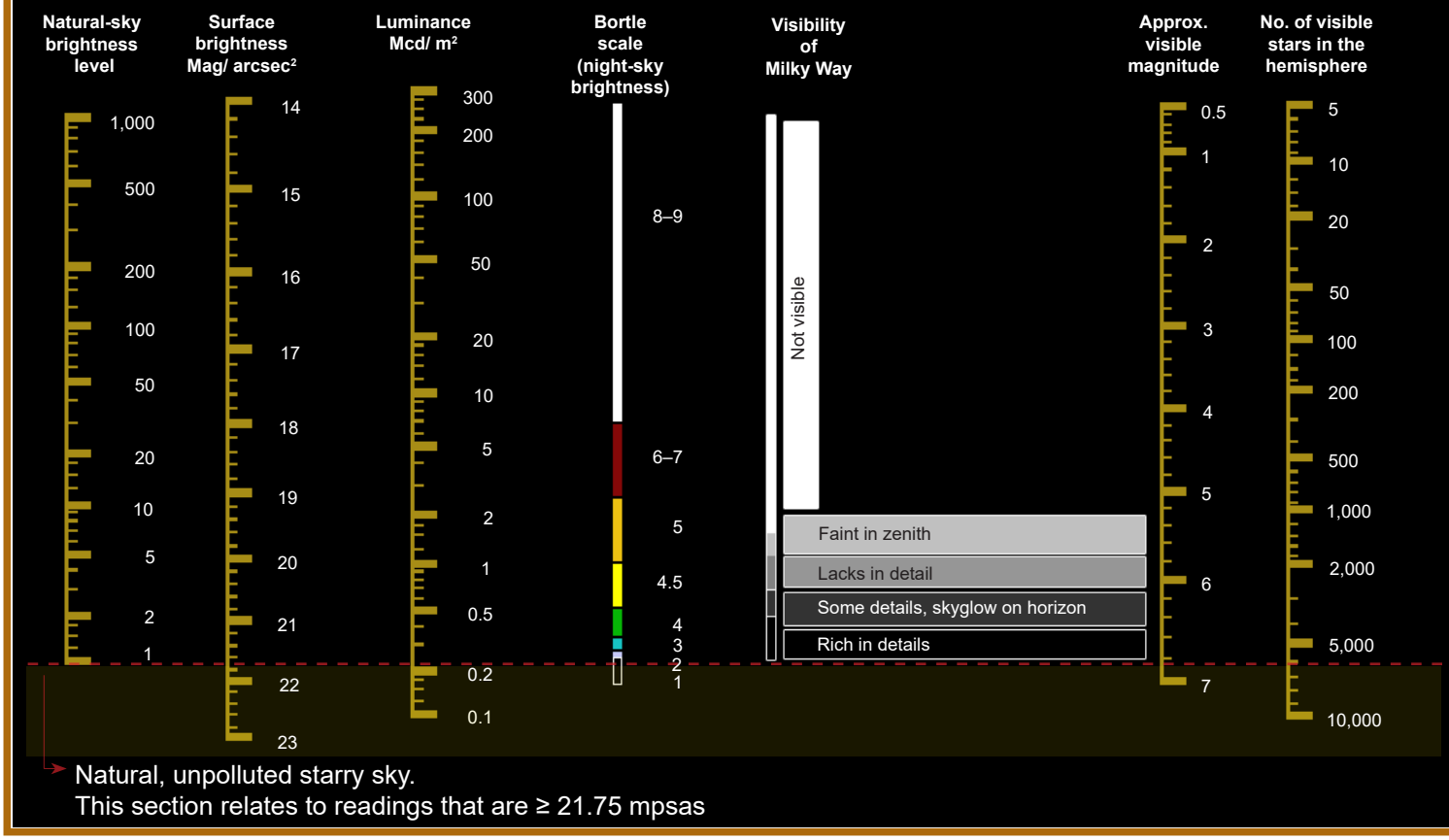
Photo 1 *Winton and lightning strike*

Photo 2 *Winton and cloud cover*

2.2 NIGHT-SKY BRIGHTNESS STUDY

This Night-Sky Brightness Study has been quantified through magnitudes per square arc second (mpsas) readings that have then been compared against the nomogram below (refer to Figure 1). The highlighted section relates to readings equal to or greater than 21.75 mpsas, when night skies are naturally unpolluted.

Figure 1 *Nomogram available from the Dark Skies Awareness website that ties several commonly used metrics together and enables a helpful first-order conversion.*



Using this nomogram, when readings of 21.75 mpsas or higher are attained the night-sky brightness is at its optimal darkest level, luminance is minimal, the Milky Way is highly visible and more stars (including very faint stars) are detectable.

2.3 STUDY-SPECIFIC INFORMATION

The Jump-Up covers an area of 14 square kilometres, is nearly 1.75km wide (north to south) and 7.5km long (east to west). The Jump-Up is connected to the Winton mains power grid via a single-wire Earth return (SWER) network. Auxiliary power is provided by two 20KVA generators located at the Fossil Preparation Laboratory and the Reception Centre. These generators are able to power the Laboratory, Maloney Lodge, Cottages 1 and 2, Amenities building and the Reception Centre for 20 hours on ~50L of diesel. Solar power is located at the Laboratory (3KVA solar unit), Amenities building (11KVA solar unit) and Dinosaur Canyon (a 3.5KVA solar unit with battery backup), with the two former solar systems feeding power back into the mains power grid.

The Jump-Up is owned by Australian Age of Dinosaurs Limited a not-for-profit (company limited by guarantee) organisation that operates the Museum. The Jump-Up has no brightly lit areas in the form of public lighting infrastructure and highway, street and advertising lighting are non-existent. Land use consists of a nature sanctuary and the Museum (refer to Section 4).

Transportation to the Museum is limited to drive-day travel only. Guided tours to Dinosaur Canyon are via a electric/solar-powered shuttle bus.

2.4 ELIGIBILITY FOR CERTIFICATION

Over 98% of The Jump-Up is undeveloped land protected by the Museum as a restricted nature area

1. **Protected land**
   The proposed DSS certification encompasses the entire Jump-Up site. This site is owned by the Museum for the purposes of conserving and promoting natural history. The Jump-Up site is surrounded by privately owned pastoral property and, to the south-west, Bladensberg National Park. This national park is 849km^2 and managed by the Queensland Parks and Wildlife Service.

2. **Regular public night-time access**
   The Museum is committed to providing public night-time access through the free Star Gallery and, in the future, through tours of Gondwana Stars Observatory. There are no restrictions on access to The Star Gallery although camping is prohibited. In 2018 36,937 visitors came to The Jump-Up and participated in a guided tour of the Museum. To ensure the future sustainability of the Museum and the region, night-time tourism (particularly during summer) will encourage new and repeat visitors to experience The Jump-Up dark skies and learn about their preservation.

3. **Exceptional dark skies**
   The Jump-Up is an exceptional dark-sky resource with night-sky brightness routinely recorded at equal to or greater than 21.5 mpsas. As the areas on The Jump-Up where the Museum operates at night are minimal, sky glow is not an issue and curfews for overnight guests are in place.

2.5 INITIAL SURVEYS OF THE JUMP-UP

2.5.1 The observation team

Survey 1 was undertaken on 26 September 2016 between 8.30–9.30pm and survey 2 on 27 September 2016 between 4am–5am by Grant Salmond with assistance from Museum founders David and Judy Elliott and Museum staff members Tanya Mellar and Alan Bulbeck. The surveys were carried out using a hand-held SQM reader on a tripod. Data was also collected from the stationary SQM 1 at Dinosaur Canyon.

Left to right *Judy Elliott, Grant Salmond, Tanya Mellar and Alan Bulbeck (photo taken by David Elliott)*

2.5.2 Observational conditions

During survey 1 and 2 no clouds were present, however, The Jump-Up received 68mm of rain several days prior between 15–21 September. This out-of-season rainfall created a dimming effect (as evidenced by early morning mist) prior to and following the observational period.

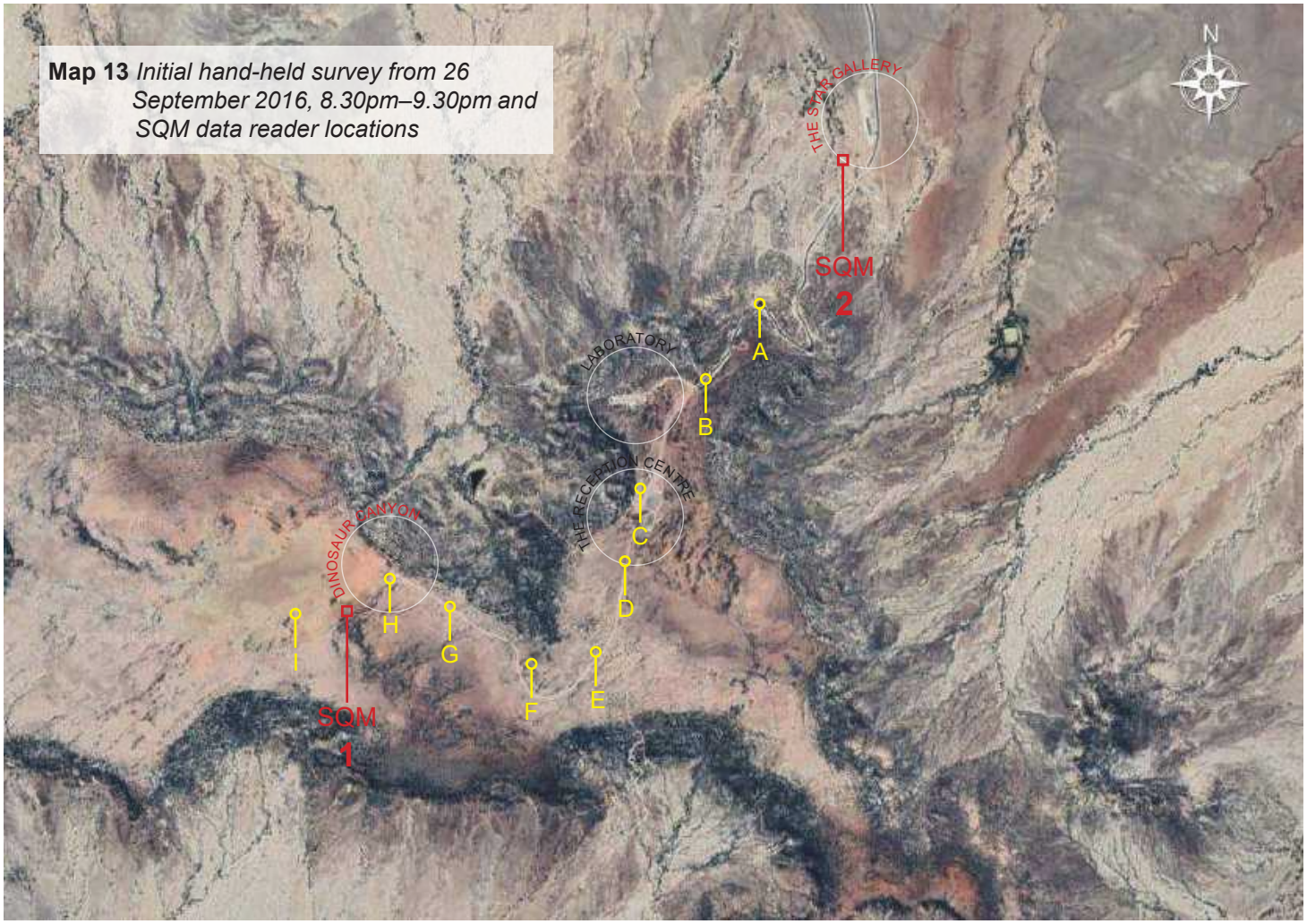
Temperature	Rain	Sunrise/Sunset	Moonrise/Moonset
Max: 29°C Min: 13°C	0.00mm	06:13am/06.25pm	02:49am/02:17pm
Wind/Gust	**Cloud**	**Humidity**	**Precipitation**
13kmh /17km/h	0%	26%	0.00mm

2.5.3 Site coverage and results

During survey 1 nine hand-held readings along a 4.77km route from the base of The Jump-Up to Dinosaur Canyon (east to west) were recorded (refer to Map 13). These sample points are located at and between the Museum's two stationary SQM readers. The night-sky readings were collected using a Unihedron hand-held Sky Quality Meter. The results of these readings showed an average sky quality of 21.63 mpsas, a minimum reading of 21.60 mpsas and a maximum of 21.66 mpsas (refer to Graph 1).

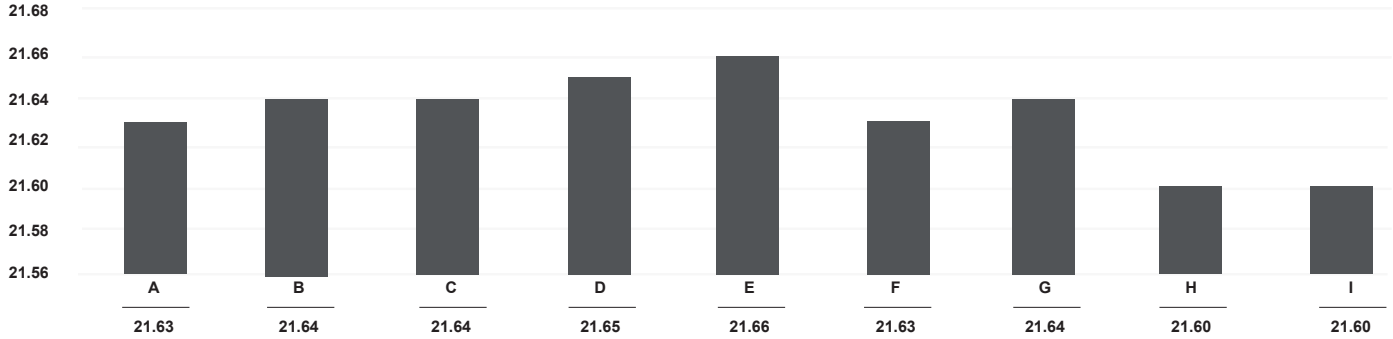
During survey 2 seven readings using a Unihedron hand-held Sky Quality Meter and stationary Unihedron Sky Quality Meter (SQM 1) were recorded at Dinosaur Canyon. The comparative results of these readings showed an average sky quality of 21.86 mpsas, a minimum reading of 21.72 mpsas and a maximum of 21.98 mpsas (refer to Graph 2). The difference between the two SQM readers equated to an average of 0.3 mpsas.

Based on these initial surveys, two Sky Quality Meters were permanently installed: at Dinosaur Canyon (at the site of the future Gondwana Stars Observatory) and at the base of The Jump-Up (the site of The Star Gallery).

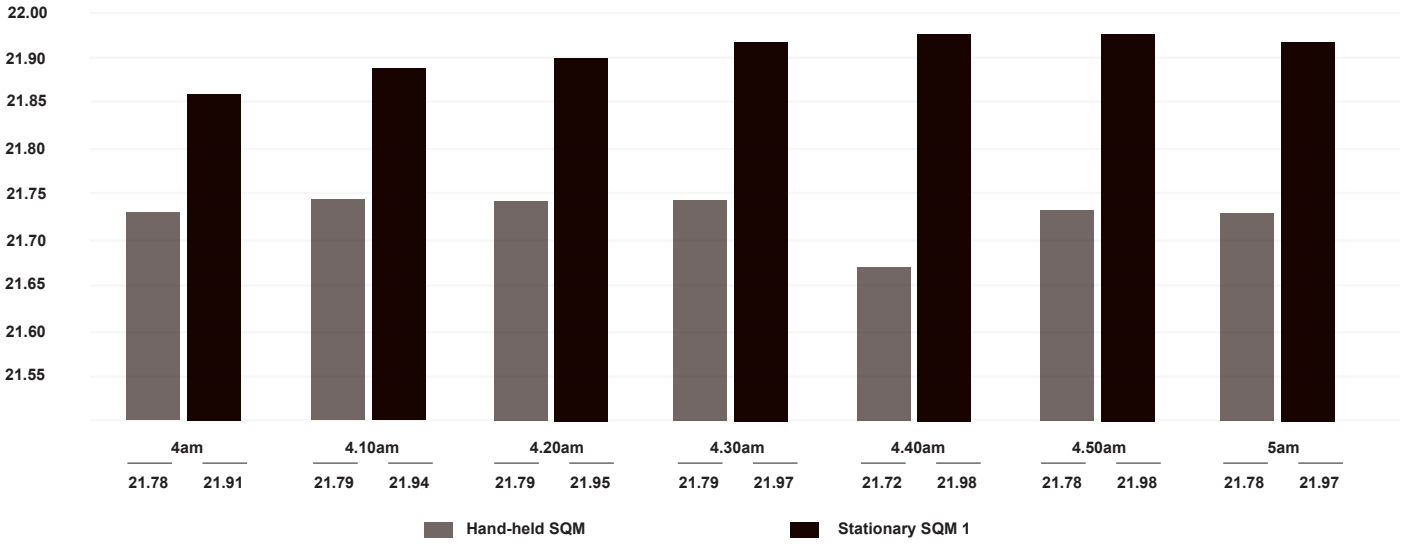


Map 13 *Initial hand-held survey from 26 September 2016, 8.30pm–9.30pm and SQM data reader locations*

Graph 1 *Survey 1, 26 September 2016, 8.30pm–9.30pm*



Graph 2 *Survey 2, 27 September 2016, 4am–5am*



2.6 IN-DEPTH SURVEY OF THE JUMP-UP

Since 19 March 2017 the Museum has collected data from two stationary Unihedron SQM readers, both pointing to the zenith with 360° unobstructed views of the sky.

Dinosaur Canyon ***SQM 1*** *data reader. Mounted on a re-purposed umbrella stand pointing to the zenith.*

The Star Gallery ***SQM 2*** *data reader. Mounted on a star picket pointing to the zenith.*

2.6.1 The observation team

The indepth survey was carried out by Grant Salmond and Kate Louis from March 2017 to November 2018 using two computer-operated auto-logging SQM readers for both night-sky brightness observations and GPS readings.

SQM 1 and 2 are recharged and data is downloaded on the first day of every second month. A log of all recharging sessions is kept on site and includes the name of the person making the recording, date and time. Records to date show little variation in the voltage or recharge on both meters from 4.94V to 4.95V.

2.6.2 Observational conditions

Winton has a fairly predicable climate with extended periods of dry atmospheric conditions with many cloud free days including over the course of the survey. Typically summer will experience extended periods of prolonged dry heat followed by mild temperate conditions in winter.

Climate data for Winton (2002-2018)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Mean max temp (C°)	37.8	37.2	35.7	32.9	28.7	24.8	25.3	27.7	32.0	36.2	38.0	39.0
Mean min temp (C°)	24.3	23.2	21.4	17.5	13.1	9.8	8.9	9.7	14.3	18.6	21.7	23.8
Mean rainfall (mm)	75.1	62.8	63.4	16.6	12.6	21.8	14.8	8.3	13.3	6.7	25.2	35.0

2.6.3 Results

The results of the indepth survey for SQM 1 and 2 are presented in Tables 2 and 3, and Graphs 3 and 4. The raw data including comparative SQM readings is available in Appendix C. Note all data has been corrected by -0.1 to make allowances for the glass cover over the top of both SQM readers.

The monthly average mpsas from 9pm to 4am and average standard deviation are displayed in Tables 2 and 3. The monthly number of readings greater than 21.5 mpsas relate to the total number of records over the entire month, with 144 records (on average) recorded daily. From these calculations the percentage of readings equal to and greater than 21.5 mpsas to 21.74 mpsas and readings 21.75 mpsas and above are displayed in Graphs 1 and 2.

SQM 1 was set up at Dinosaur Canyon from 19 March 2017 though, for a more accurate picture, Table 1 begins from April 2017 to November 2018. From 22 April 2018 to 16 June 2018 SQM 2 was set up at Dinosaur Canyon, alongside SQM 1 to ensure both Sky Quality Meters were calibrated correctly. Since 17 June 2018 SQM 2 has been permanently located at The Star Gallery.

SQM 1: The results of this SQM show an average monthly sky quality of 19.93 mpsas, as averaged from all results collected from 9pm to 4am (including moon nights). The average percentage of monthly readings equal to or greater than 21.5 mpsas has been calculated at 40% of all results and the average percentage of monthly readings equal to or greater than 21.75 mpsas at 28% of all results (refer to Graph 3).

SQM 2: The results of this SQM show an average monthly sky quality of 19.88 mpsas as averaged from all results collected from 9pm to 4am (including moon nights). The average percentage of monthly readings equal to or greater than 21.5 mpsas has been calculated at 43% of all results and the average percentage of monthly readings equal to or greater than 21.75 mpsas at 35% of all results (refer to Graph 4) .

The high percentage of measurements equal to or greater than 21.75 mpsas at both sites indicate The Jump-Up is an excellent dark-sky site. On the Bortle scale these readings rate between a class 1 to 2 with a limiting magnitude of 6.8 to 7. The Milky Way is very visible and detailed, casting obvious diffused shadows on the ground as luminance dips below 0.2 mcd/m^2. For more detailed information relating to the average daily mpsas used to calculated the average monthly measurements refer to Appendix C.

Table 2 *SQM 1, Apr 2017–Nov 2018*

SQM 1	DATE	Mpsas 9pm to 4am monthly average	9pm to 4am standard deviation monthly average	Monthly no. readings 21.5 to 21.74 mpsas	Monthly no. readings ≥ 21.75 mpsas	% monthly readings 21.5 to 21.74 mpsas	% monthly readings ≥21.75 mpsas
2017	APR	19.43	0.75	662	253	41	17
	MAY	19.89	0.97	674	219	29	10
	JUN	19.12	0.98	717	378	27	11
	JUL	19.96	0.87	747	515	30	24
	AUG	20.02	1.00	734	576	41	30
	SEPT	20.17	0.83	815	621	52	40
	OCT	20.28	0.77	857	640	53	43
2018	FEB	21.13	0.50	776	546	72	54
	MAR	20.20	0.68	707	524	47	36
	APR	19.69	1.00	479	260	30	20
	MAY	19.60	1.09	658	302	26	11
	JUN	19.65	1.18	779	365	32	8
	JUL	19.69	1.11	660	327	25	11
	AUG	19.96	1.02	637	511	32	26
	SEPT	20.24	0.81	770	623	48	39
	OCT	19.88	0.77	888	735	53	50
	NOV	19.97	0.81	814	711	54	48

Graph 3 *SQM 1, percentage of dark-sky nights where the night-sky brightness is routinely ≥21.5 mpsas*

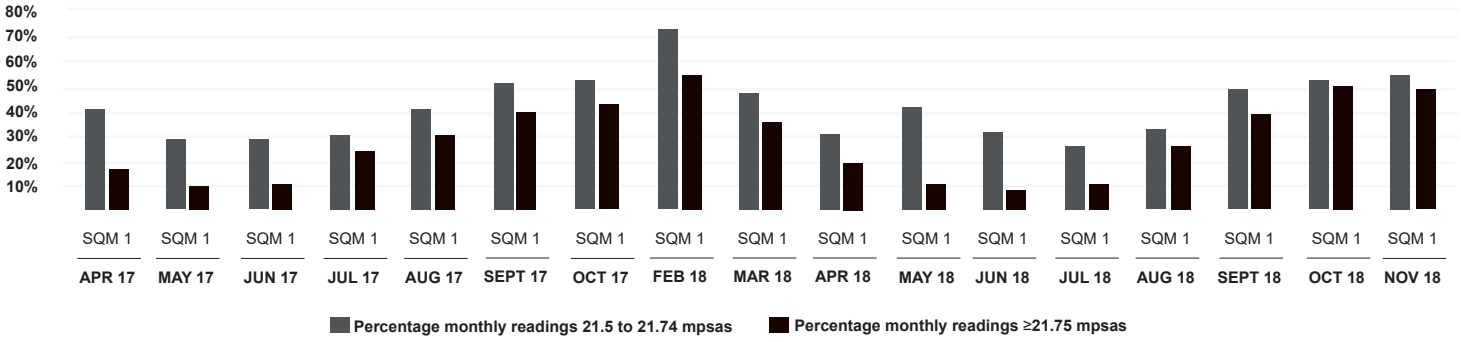
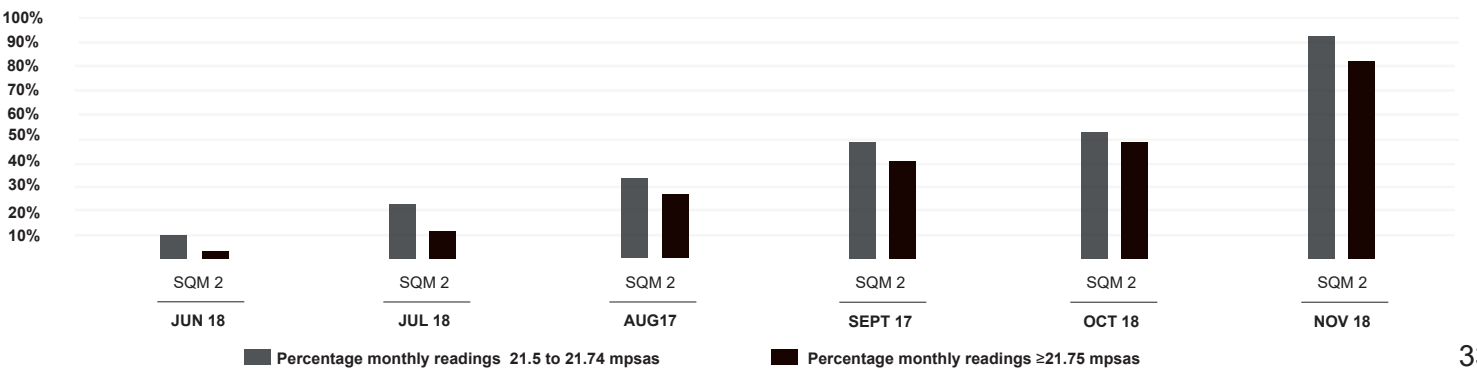


Table 3 *SQM 2, Jun 2018–Nov 2018*

SQM 2	DATE	Mpsas 9pm to 4am monthly average	9pm to 4am standard deviation monthly average	Monthly no. readings 21.5 to 21.74 mpsas	Monthly no. readings ≥21.75 mpsas	% monthly readings 21.5 to 21.74 mpsas	% monthly readings ≥21.75 mpsas
2018	JUN	17.92	1.41	132	84	10	3
	JUL	19.65	1.10	598	334	23	12
	AUG	19.93	1.03	652	516	34	26
	SEPT	20.21	0.80	785	630	49	40
	OCT	19.68	0.97	870	683	52	49
	NOV	21.90	0.06	415	345	92	82

Graph 4 *SQM 2, percentage of dark-sky nights where the night-sky brightness is routinely ≥21.5 mpsas*



2.6.4 Ongoing night-sky monitoring

The Museum takes the responsibility of monitoring and reporting The Jump-Up night sky seriously and all compiled data will be included in the Museum's annual report submission to the IDA.

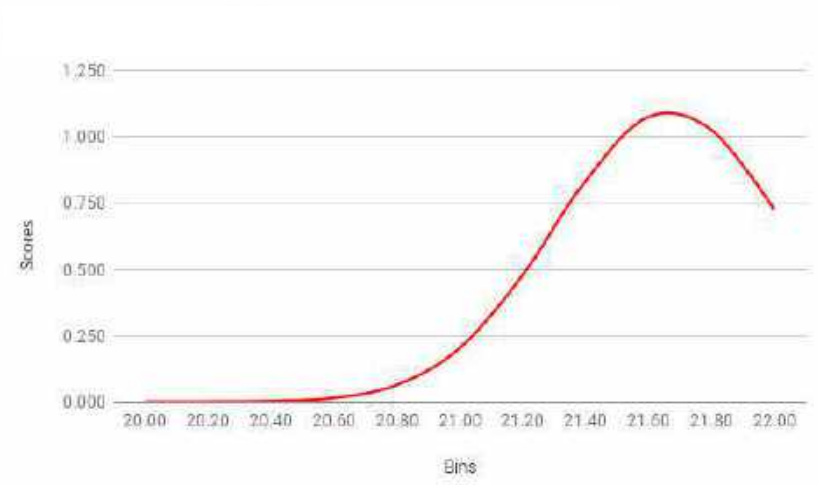
Night-sky brightness readings will continue to be taken daily and compiled monthly, being made available on the Museum's website. A review of these readings will be undertaken every twelve months and the Museum Management Team will ensure that the readings remain on par with IDA regulations.

Night-sky brightness measurements will continue to be recorded and monitored at The Star Gallery, Dinosaur Canyon and new sites will be added on the far western and south-western corners of The Jump-Up in early 2019.

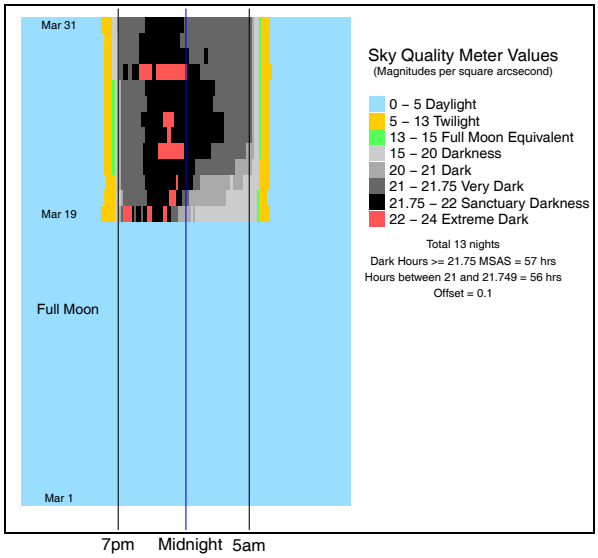
2.6.5 Sky quality

The exceptional sky quality on The Jump-Up is best demonstrated in the raw data available in Appendix C and in Graphs 5 to 30. In Graph 5 SQM data from November 2018 has been filtered to include only measurements from 20 mpsas to 22 mpsas. This sky quality distribution shows a mean reading of 21.66 mpsas and a standard deviation of 0.33 indicating that nearly 70% of recorded measurements were between 21.33 mpsas and 21.99 mpsas. Graphs 6 to 30 display the recorded fluctuations in sky darkness of SQM 1 and 2. The graphs measure magnitudes per square arc second by taking a reading every ten minutes throughout the day and night, with a full day/night cycle collecting 144 measurements. The graphs show time across the x-axis, with 7pm to 5am as the focus. The vertical axis displays the days of the month and full-Moon cycles. The graphs are accompanied by a colour-coding legend that ranges from daylight (0–5 mpsas) to extreme darkness (22–24 mpsas). The graphs visually demonstrate the high levels of darkness measured on The Jump-Up since March 2017 and the minimal differences between Dinosaur Canyon (SQM 1) and The Star Gallery (SQM 2), indicating the level of light across The Jump-Up is consistent.

Note some nights from December to February are affected by higher humidity as a result of the annual wet season.

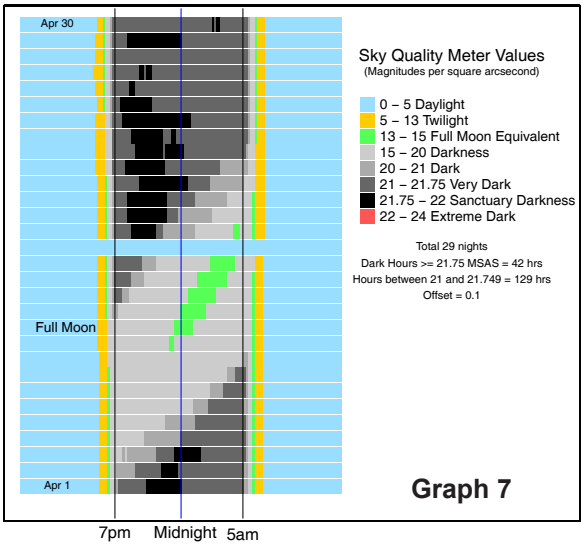


Graph 5 *Sky quality distribution for November 2018 displaying only measurements from 20 mpsas to 22 mpsas displayed*

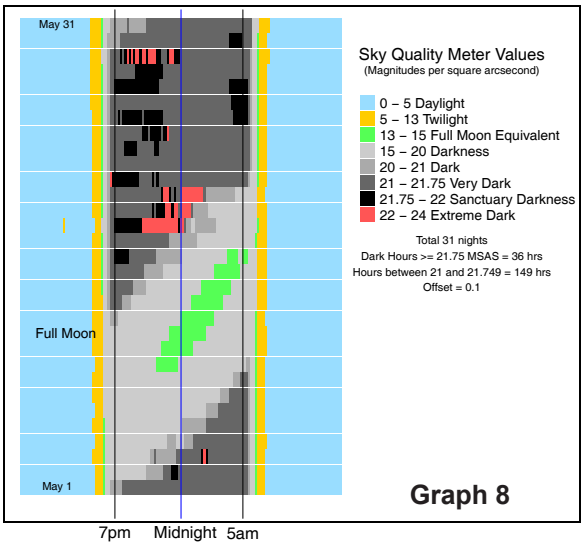


Graph 6 *Recorded fluctuation in sky darkness based on a full day/night cycle collecting 144 measurements*

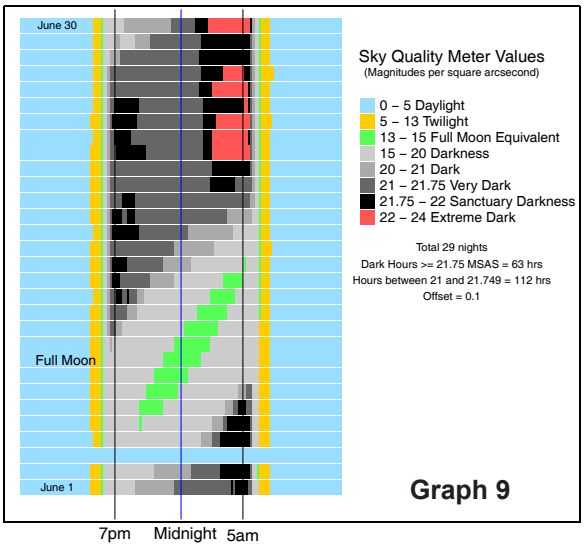
Sky Darkness Plot April 1 to April 30, 2017
Dinosaur Canyon SQM1



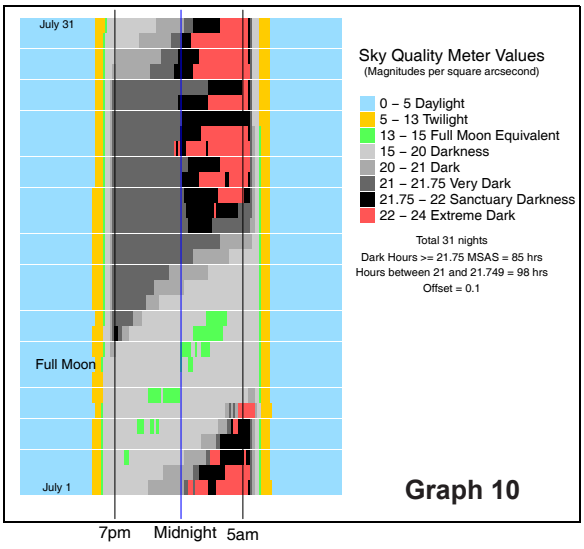
Sky Darkness Plot May 1 to May 31, 2017
Dinosaur Canyon SQM1



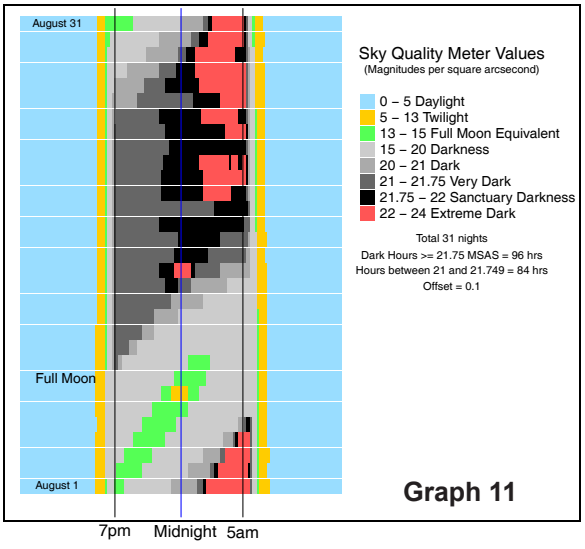
Sky Darkness Plot June 1 to June 30, 2017
Dinosaur Canyon SQM1



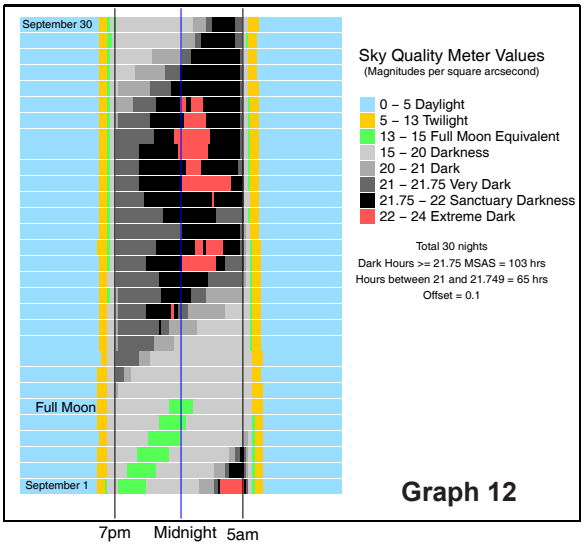
Sky Darkness Plot July 1 to July 31, 2017
Dinosaur Canyon SQM1



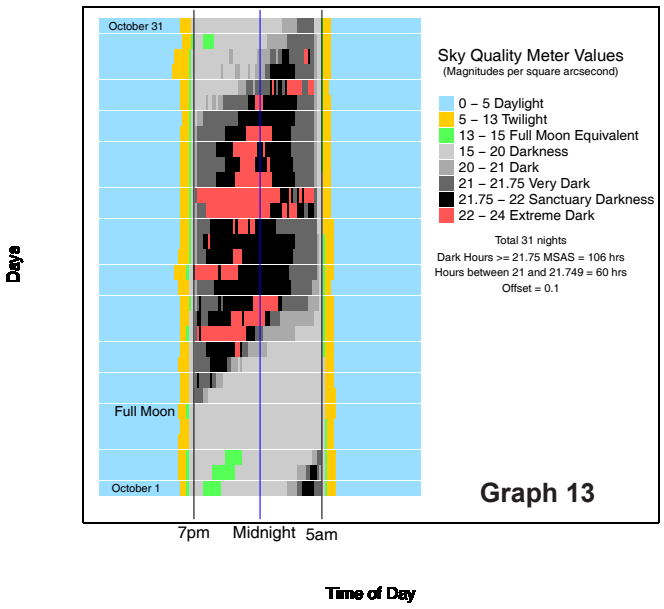
Sky Darkness Plot August 1 to August 31, 2017
Dinosaur Canyon SQM1



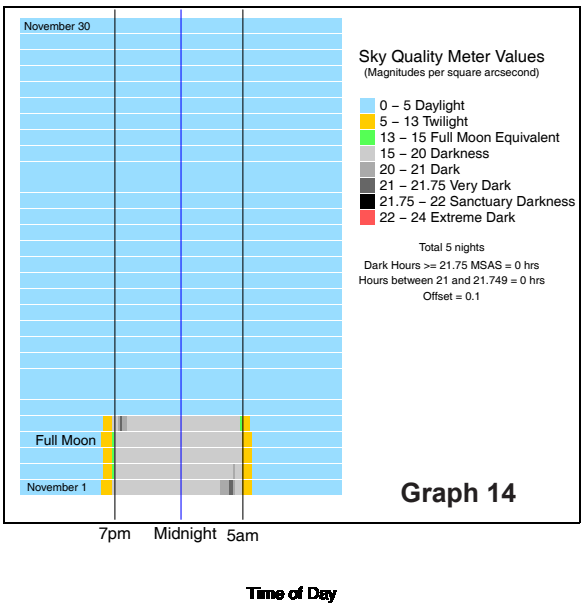
Sky Darkness Plot September 1 to September 30, 2017
Dinosaur Canyon SQM1



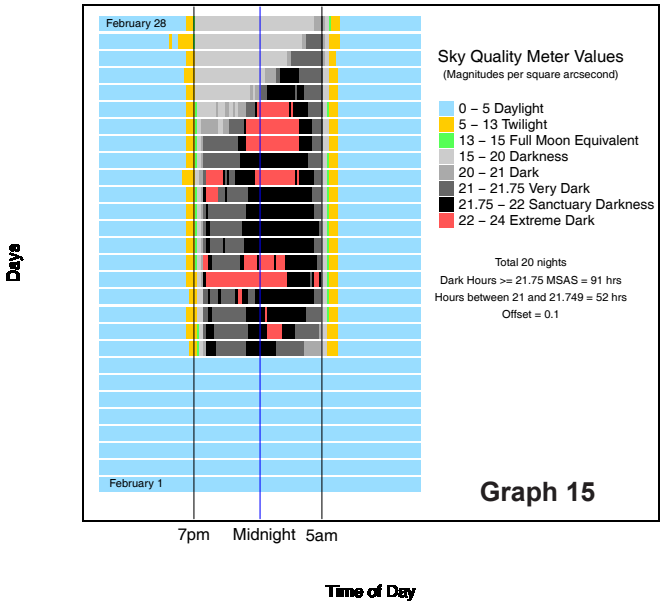
Sky Darkness Plot October 1 to October 31, 2017
Dinosaur Canyon SQM1



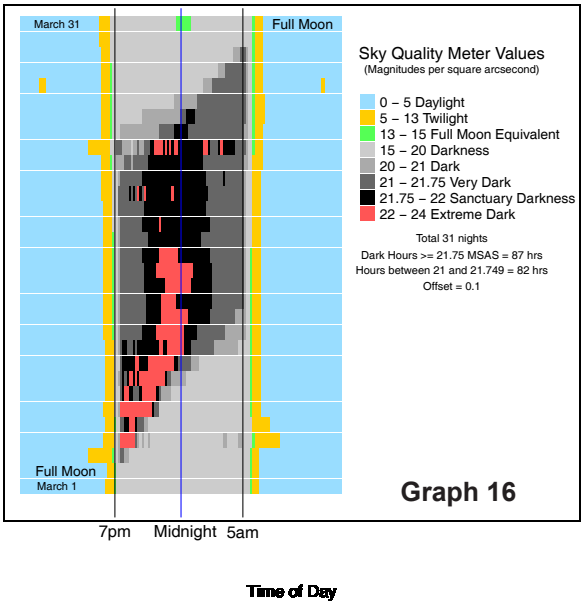
Sky Darkness Plot November 1 to November 30, 2017
Dinosaur Canyon SQM1



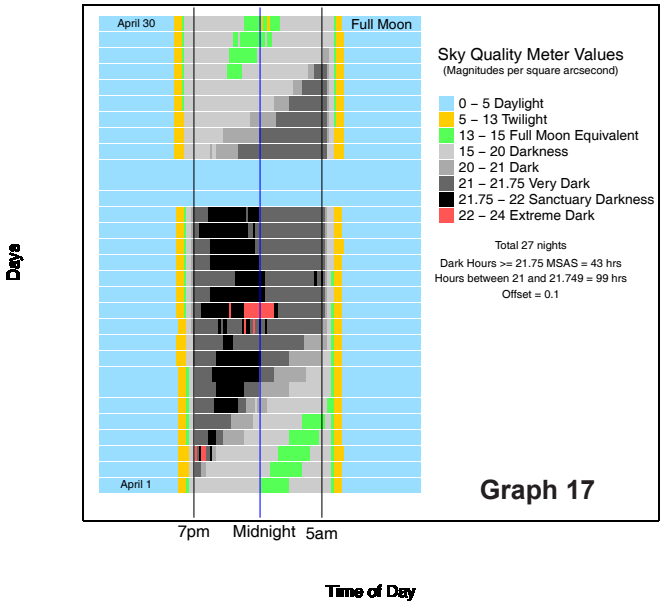
Sky Darkness Plot February 1 to February 28, 2018
Dinosaur Canyon SQM1



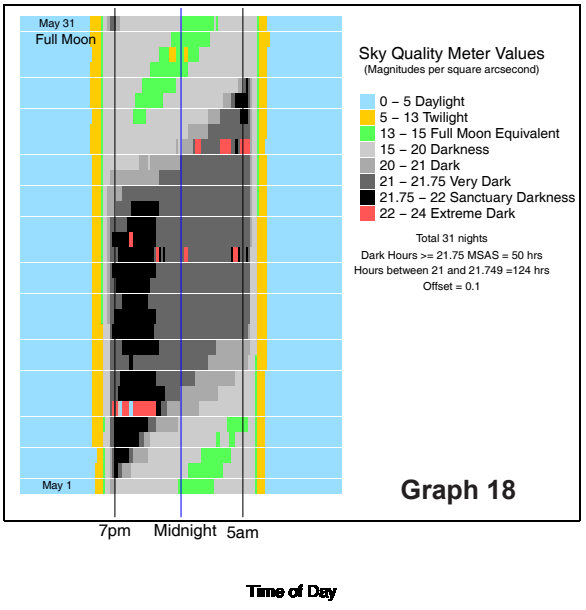
Sky Darkness Plot March 1 to March 31, 2018
Dinosaur Canyon SQM1



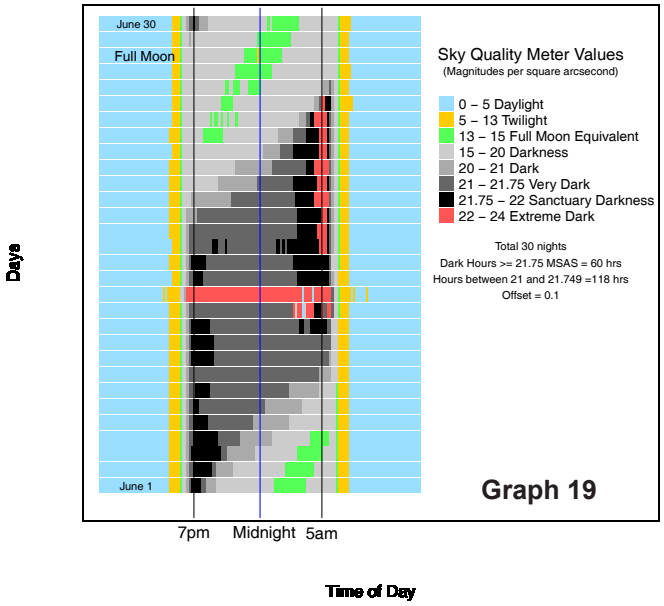
Sky Darkness Plot April 1 to April 30, 2018
Dinosaur Canyon SQM1



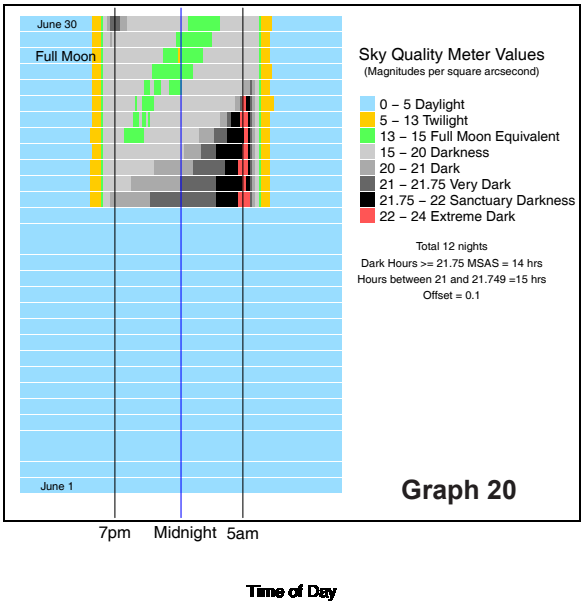
Sky Darkness Plot May 1 to May 31, 2018
Dinosaur Canyon SQM1



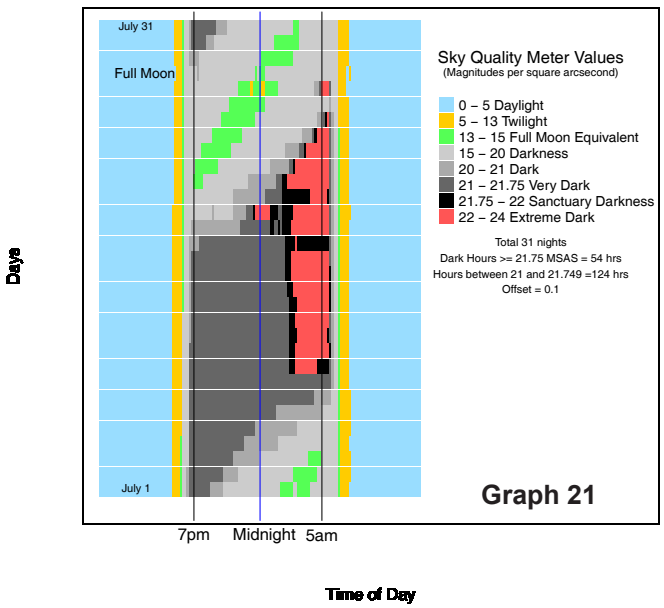
Sky Darkness Plot June 1 to June 30, 2018
Dinosaur Canyon SQM1



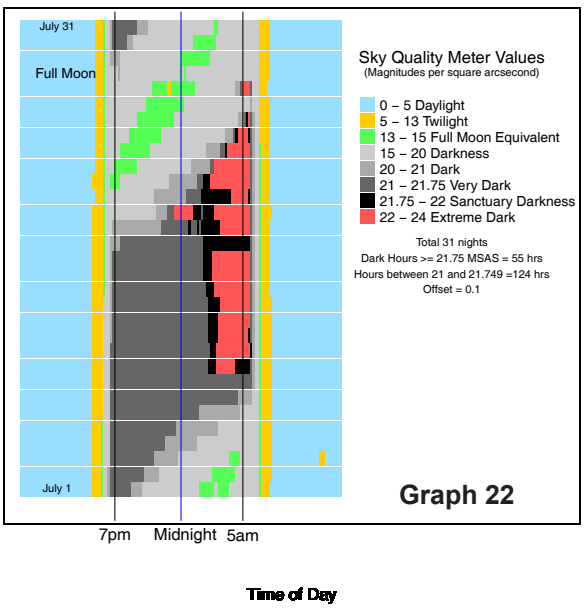
Sky Darkness Plot June 1 to June 30, 2018
Base SQM2



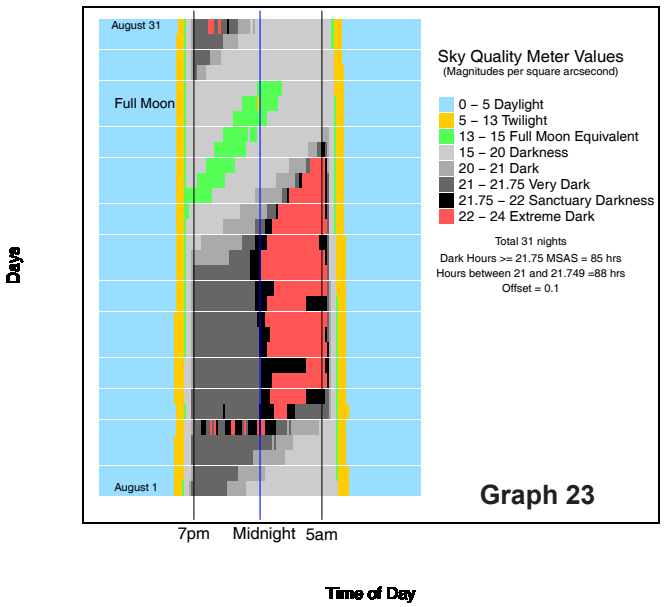
Sky Darkness Plot July 1 to July 31, 2018
Dinosaur Canyon SQM1



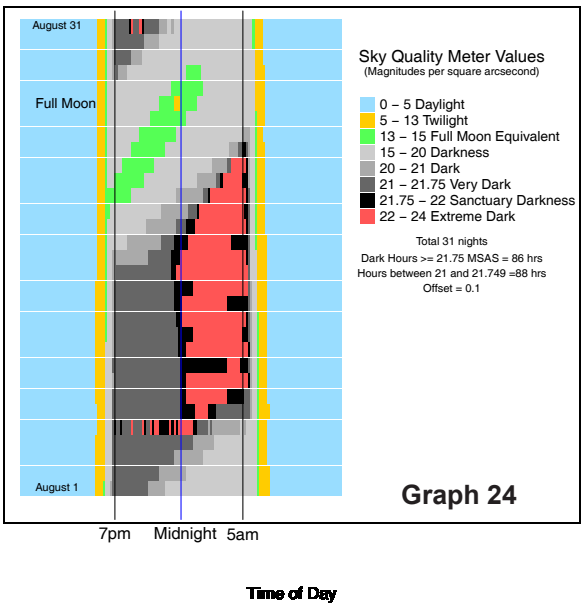
Sky Darkness Plot July 1 to July 31, 2018
Base SQM2



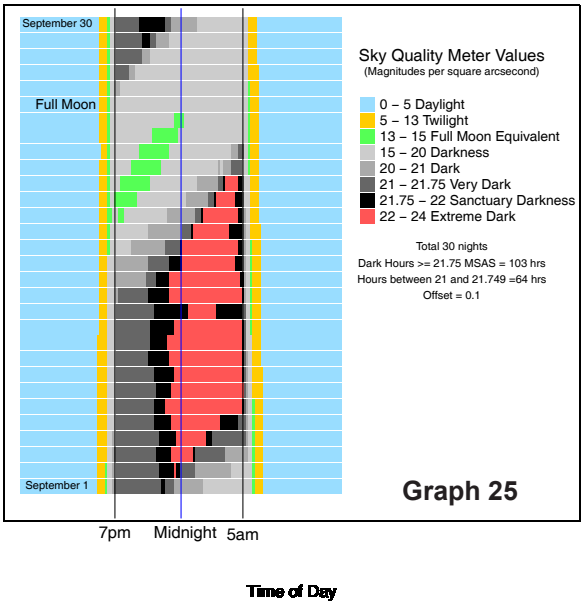
Sky Darkness Plot August 1 to August 31, 2018
Dinosaur Canyon SQM1



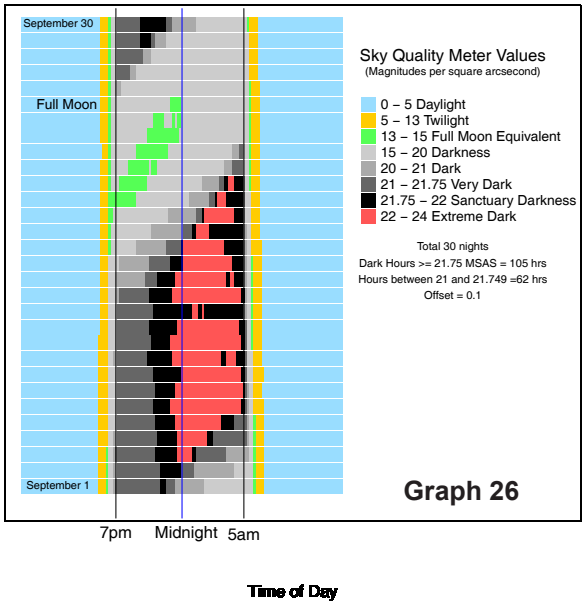
Sky Darkness Plot August 1 to August 31, 2018
Base SQM2



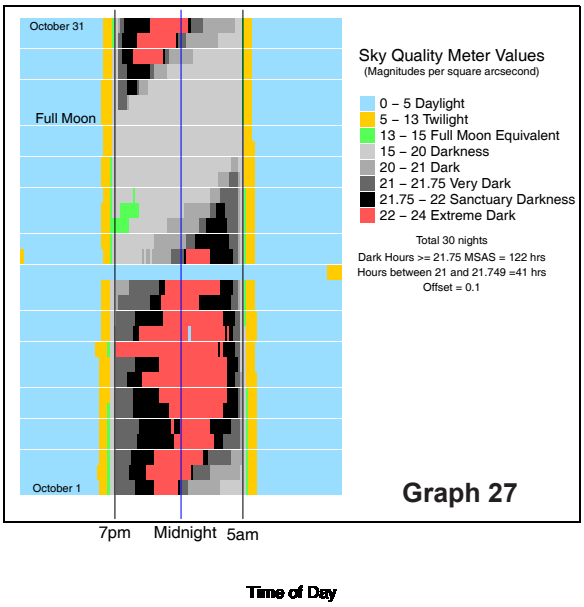
Sky Darkness Plot September 1 to September 30, 2018
Dinosaur Canyon SQM1



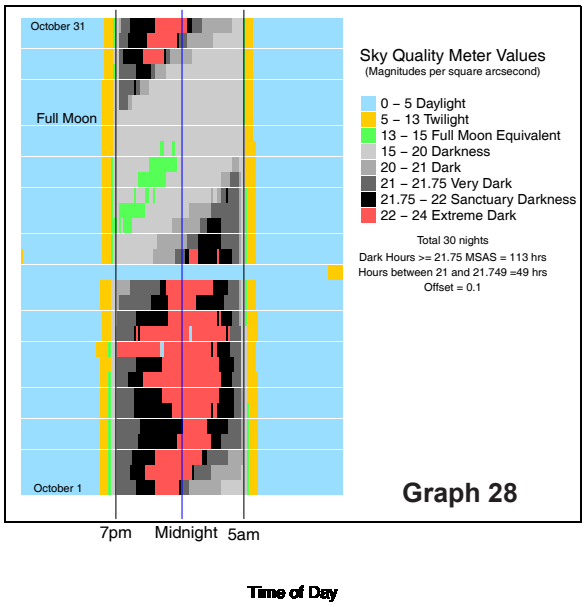
Sky Darkness Plot September 1 to September 30, 2018
Base SQM2



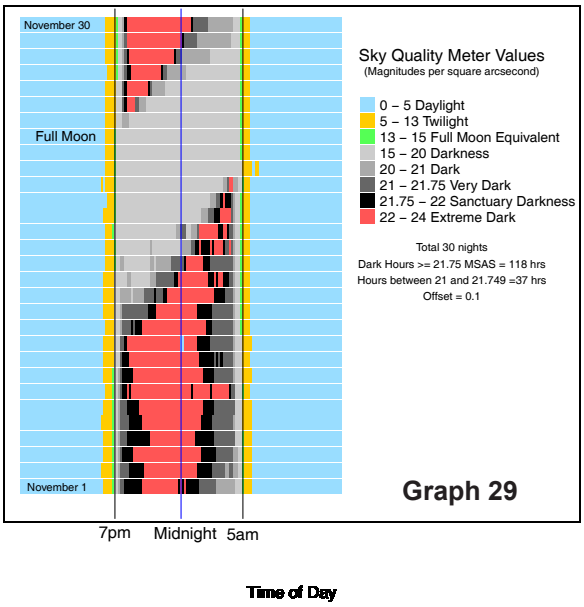
Sky Darkness Plot October 1 to October 31, 2018
Dinosaur Canyon SQM1



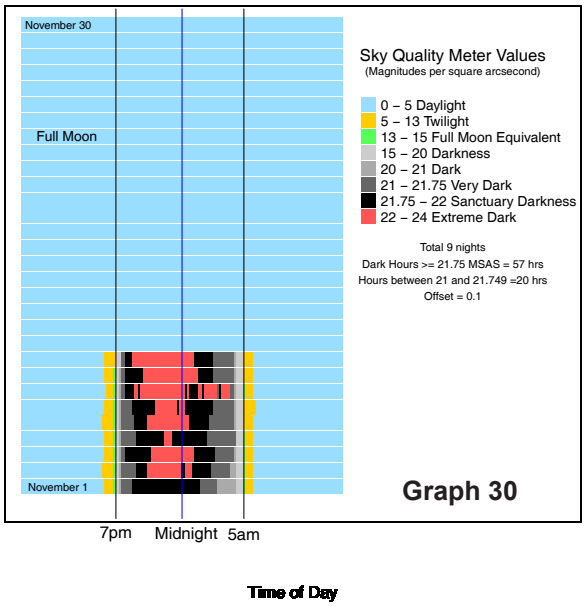
Sky Darkness Plot October 1 to October 31, 2018
Base SQM2



Sky Darkness Plot November 1 to November 30, 2018
Dinosaur Canyon SQM1



Sky Darkness Plot November 1 to November 30, 2018
Base SQM2



Gondwana Stars Observatory concept artwork.

SECTION 3. SUSTAINABILITY

The Australian Age of Dinosaurs Museum of Natural History is a relatively young museum that intends to become, quietly, a sustainability champion within the museum sector.
–Museum Charter for Sustainability and Responsible Tourism (July 2015)

The Museum has worked tirelessly for many years to become socially, economically and environmentally sustainable. The benefits of embedding a culture of sustainable practice throughout the Museum are threefold:

1) create a self-sufficient business focused on Australian natural history in Central West Queensland, marketed through the promotion of palaeo-tourism, astro-tourism and ecotourism
2) instigate economic growth and development in very remote Australia and
3) meet the Museum's current needs without compromising the social, economic or environmental sustainment of future generations.

While the Museum is still developing, sustainable practices have already begun and are included in the Museum's future plans. These practices are in line with the IDA's criteria for IDSS certification.

3.1 SOCIALLY SUSTAINABLE

Social sustainability at the Museum relates to creating an inclusive destination that promotes wellbeing by understanding what people need from the places they visit and work. Social sustainability includes policies and procedures, training and organisational structures, community support, and tourism products and supporting activities.

3.1.1 Policies and procedures

The Museum's policies have been adopted by the Board and reflect the Museum's commitment to ethical conduct and organisational integrity. The Museum's policy and procedures are a work in progress with documents continually being developed and added. A number of policies have been approved by the Board in the core areas of:

- Governance: including a Delegations Policy and Risk Management Plan
- Exhibitions and Tours: including extensive tour procedures and interpretation material
- Protective Services: including Work Health and Safety, on site contractors and maintenance
- Administration: including Reception Centre, Cretaceous Café and Dinosaur Stampede procedures
- Customer Service: Customer Service policy and procedures, House Rules, Environmental Policy and Plan and Museum Charter for Sustainability and Responsible Tourism
- Employment and recruitment: including uniforms, drug and alcohol, volunteers, equal employment opportunity, anti-discrimination, grievances and resolution and
- Financial: including procurement, cash handling and salary sacrifice.

Our objective as a responsible and forward-thinking member of the regional community, and as a potential influencer of visitors' understanding of the Earth's fragility and ever-changing nature, is to commit to both sound sustainability practices through environmental performance and to deliver responsible tourism through exhibition and program messaging. **Museum Environmental Policy (July 2015)**

3.1.2 Community support

The Museum has been an active contributor to local, regional and national tourism since it opened its doors on The Jump-Up in 2009. Of high importance and focus to the Museum since its beginnings has been the commitment to support local growth and development, accreditations and local and regional tourism memberships.

- **Regional and state tourism and the Museum**

Outback Destination Tourism Plan 2017–2020, Tourism and Events Queensland.
Palaeotourism is listed as one of four destination 'hero' experiences to deliver the destination's tourism vision, brand promise and the 'themes' that underpin the destination's vision and brand.

The Outback, Gulf and Western Downs Tourism Opportunity Plan, Tourism and Events Queensland.
The Museum is listed as one of 23 catalyst projects for the destination. The Museum was included in the plan as Stage 3 is "...considered a marquee project that represents the character and appeal of the Region and which will drive ongoing growth and development of tourism across the region."

Inquiry into Opportunities and Methods for Stimulating the Tourism Industry in Northern Australia.
The Museum and Dinosaur Stampede National Monument were recognised as natural attractions in the region that generations will come to.

- **Awards and recognition**

The Museum won the award for best Major Tourist Attraction at the Outback Queensland Tourism Awards in 2016 and 2017, and received the runner-up award (with Capricorn Caves of Rockhampton) in the Queensland Tourism Industry Council (QTIC) Prize for Innovation in Tourism in 2017. In 2016 the Museum won the gold award for Major Tourist Attraction in Queensland at the Queensland Tourism Awards. The Museum is also a 2018 Travellers' Choice Award Winner listing the attraction in the top 1% of museums worldwide.

Australian Tourism Accreditation Program (ATAP), Australian Tourism Industry Council.
The Museum is a certified ATAP business, having met the specific quality-assurance criteria and demonstrated a commitment to consumer expectations in regards to customer service and the standards of business practice. All ATAP-accredited businesses undertake regular on-site audits to ensure continued compliance.

Ecocertified, nature based tourism operator, Ecotourism Australia.
The ecotourism certification program assures travellers that certified products are backed by a strong, well-managed commitment to sustainable practices and provide high quality nature-based tourism experiences.

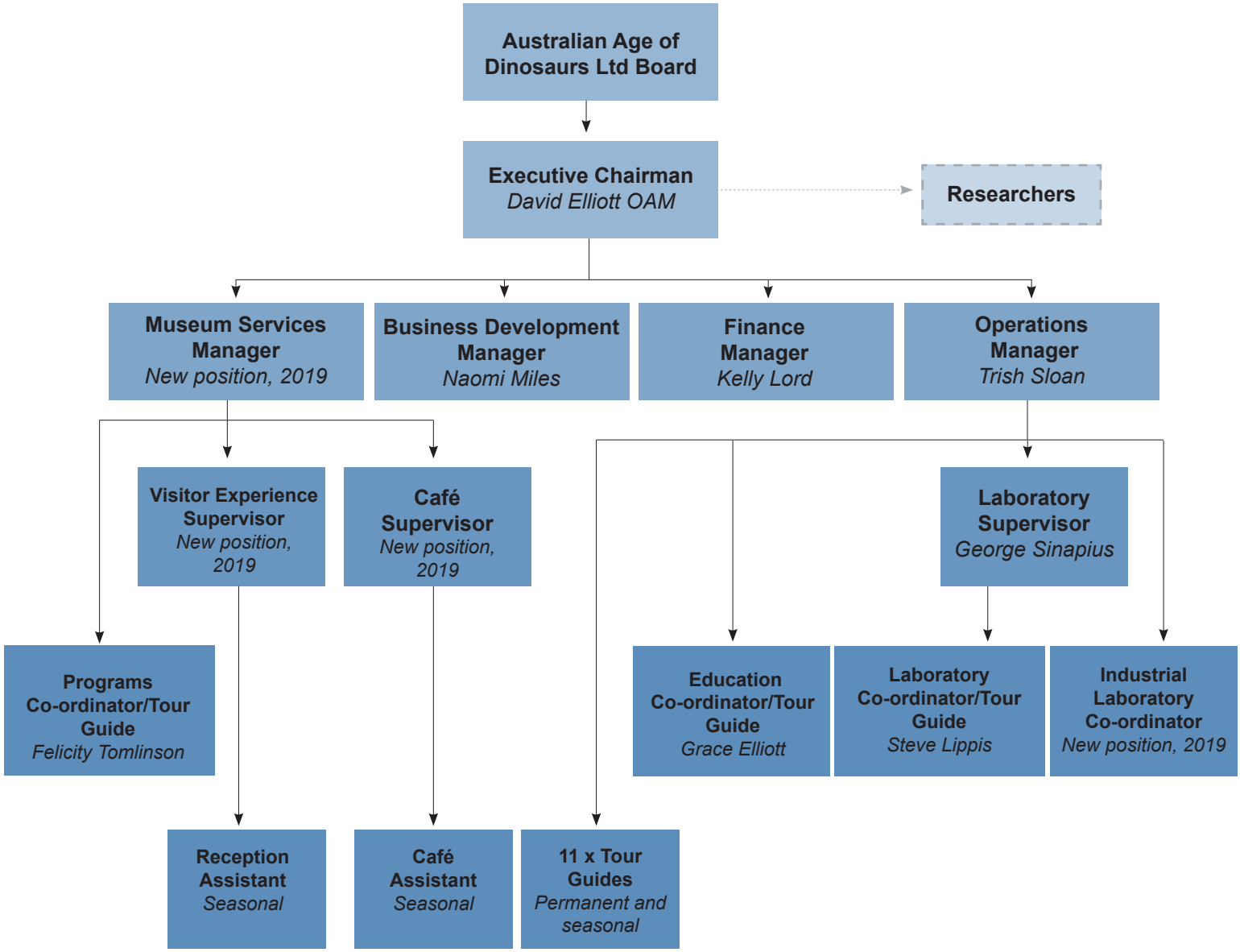
Savannah Guide Station and enterprise member, Savannah Guides.
The Savannah Guides are made up of a network of professional tour guides and tour operators working with researchers, national park agencies and local communities. The Museum's support of the Savannah Guides helps to provide continuous and professional standards of interpretation, guiding and natural resource management.

3.1.3 Organisational structure

The Museum is currently organised into three core functions with a permanent full-time manager leading each section: Operations, Finance and Business Development. Each manager reports directly to the Executive Chairman (refer to Figure 2). A Corporate Training Plan with set workshops has been mandated to all staff and includes tour content, interpretation, industry knowledge, customer service and interpersonal skills.

The Museum is currently governed by a board of seven directors with expertise across fields of business, finance and palaeontology. The Museum's Board protects the operations of the organisation, takes custodianship of the fossil collection and promotes the development of a world-class museum of natural history.

Figure 2 *Organisation structure: management (2019)*



KEY PERSONNEL MANAGING THE MUSEUM

NAME	POSITION TITLE	REPORTING STRUCTURE	RESPONSIBILITY
David Elliott OAM	Executive Chairman and Company Director	Reports to the Board	*Provide overall leadership; act as the primary spokesperson for the Board; facility development; construction and infrastructure; public funding applications*
Naomi Miles	Business Development Manager	Reports to the Executive Chairman	*Visitor experience; education; business and commercial operations; marketing; memberships; graphic design*
Kelly Lord	Finance Manager	Reports to the Executive Chairman	*Finance; payroll; risk management; insurance; budgeting and business planning*
Trish Sloan	Operations Manager	Reports to the Executive Chairman	*Visitor operations; laboratory; collection management; work, health and safety; asset maintenance*

- **Memberships**
- Outback Queensland Tourism Association (OQTA), trade membership.
- Winton Business and Tourism Association Incorporated, business membership.
- Queensland Tourism Industry Council (QTIC), company membership.
- Tourism and Events Queensland (TEQ), tourism advocate.
- International Dark-Sky Association (IDA), bronze member.

3.1.4 Tourism products, experiences and activities

The Museum has developed a range of public guided-tour products, experiences and activities (refer to Table 4). Alongside these products are a range of catered options including a night-sky BBQ following the wholesale group tour of the Museum. During these evening sky talks Tour Guides use carefully compiled Museum tour interpretation procedures (refer to Appendix A) to entertain and educate visitors as they look up at the southern sky. This tour includes information relating to the protection of the night sky and the negative effects of light pollution.

The customer-focused culture at the Museum is based on a commitment to total visitor experience and engagement. This objective is achieved by inviting the public to touch real dinosaur bones, to engage with passionate and enthusiastic guides and to participate in unique programs that actively involve the visitors in scientific processes and research. The delivery of a world-class visitor experience underpins every tourism endeavour offered by the Museum.

The Museum also encourages visitors to use The Star Gallery a that has been set up for visitors to use year-round. Access is unrestricted, though overnight stays are not permitted. Examples of Museum outreach material can be found in Section 5.5.
These documents include:
- two posters displaying information relating to The Star Gallery
- a brochure with stylised constellations from the Southern Hemisphere and light-pollution information
- excerpts from Museum staff newsletters
- excerpts from a Museum membership newsletter
- a dedicated webpage on the Museum's website www.australianageofdinosaurs.com/page/101/the-dark-sky

3.1.5 Education outreach

The Jump-Up is an ideal location for astronomers to use the naturally dark skies of Central West Queensland for research, education and observations. When the future Gondwana Stars Observatory is completed local, national and international astronomy clubs and individuals will use the facilities provided and be at a centre of astronomical education in Australia.

The Museum Management Team is committed to ensuring the night skies above The Jump-Up are monitored and recorded. Outreach is currently focused on the preservation of the night skies above The Jump-Up and includes downloadable outreach material (refer to Section 5.5) and regular night-sky talks. In 2018 40 night-sky talks (during wholesale Ultimate Dinosaur night tours) were held at the Reception Centre to 811 visitors.

As more data is collected and compiled it will be made available online and to the Museum's remote education programs and dark sky focused outreach to nearby communities. Through this data the Museum will launch its distance education program via the Distance And Rural Technologies (DART) website to be made available to education providers world wide. Following the construction of the Gondwana Stars Observatory remote viewing through the Museum's 25" Dobsonian and refrator telescopes will also be available to education providers around the world through scheduled online education tours and demonstrations.

The importance of creating long-term viability through the optimum use of local resources and creating destination competitiveness is essential to future proofing the region. Gondwana Stars Observatory and the free Star Gallery will provide a new social benefit to Central West Queensland residents and school children through access to high-quality telescopes and information packages. It will offer unique astronomy tour experiences to the visiting public and professional equipment with associated toilet and accommodation facilities to university students and professional and amateur astronomers who are looking for the night-sky attributes of an accredited dark-sky sanctuary.

Table 4 *Tourism products, experiences and activities, 2019*

PRODUCT	DESCRIPTION	PRICING	TIMING
GUIDED TOURS			
The Ultimate Dinosaur Pass	Includes a guided tour of the Museum (Fossil Preparation Laboratory, Collection Room and Dinosaur Canyon)	Adult: $55 Concession (seniors, veterans, students): $50 Child: (5–16 years): $30 Family (up to two adults and their children): $115 Infants (0–4 years): Free Wholesale: $40 PAX	3 hours Museum opening times
The Winton Dinosaur Capital of Australia Pass	Includes a guided tour of the Museum (Fossil Preparation Laboratory, Collection Room and Dinosaur Canyon) and Dinosaur Stampede National Monument	Adult: $75 Concession (seniors, veterans, students): $70 Child: (5–16 years): $37 Family (up to two adults and their children): $170 Infants (0–4 years): Free Wholesale: $55 PAX	3 hours 45 minutes Museum opening times
Australia's Dinosaur Trail Pass	Includes the Winton Dinosaur Capital of Australia and entry to Kronosaurus Korner in Richmond and Flinders Discovery Centre in Hughenden	Adult: $95 Concession (seniors, veterans, students): $85 Child: (5–16 years): $50 Family (up to two adults and four children): $215 Infants (0–4 years): Free	Valid for one year Museum and associated attraction's opening times
EXPERIENCES			
Prep-A-Dino	Learn how to prepare real dinosaur fossils including induction and training with a senior Museum technician	Packages start from $189 Single, twin and Honorary Technician packages Participants must be 12 years and above	Min two days Museum opening times
Dig-A-Dino	Join a Museum dig and look for real dinosaur fossils	Packages start from $2,800	Seven days Museum opening times
EDUCATION PROGRAMS			
Education tour	Includes a guided tour of the Museum with a specially trained education Tour Guide	Wholesale: $25 PAX	Museum opening times
Junior Palaeo tour	Explore the Museum and go behind the scenes to participate in hands-on programs and experiences	Wholesale: $50 PAX	Museum opening times
ACTIVITIES			
Dinosaur excavation sandpit	Replica *Diamantinasaurus* dinosaur leg excavation sandpit with dig tools	Free	Museum opening times
The Star Gallery	Designated Star Gallery at the base of The Jump-Up	Free	Open year-round

3.2 ECONOMICALLY SUSTAINABLE

Over the last ten years the Museum has received a total funding contribution of $2,432,000 from state and federal governments to build and develop Stages 1, 2 and 3.1. Following the completion of each of these large-scale infrastructure projects, increased visitation and national profile of the region have led to direct economic growth across the region (refer to Table 5). Given the Museum's remote location, when visitors travel to Winton they must stay overnight or in the nearby town of Longreach.

3.2.1 The statistics

In 2016–17 tourism directly and indirectly employed 7.7% of all workers in Australia. Over the same period the Outback regional economy (4% of the Outback's gross regional product) directly and indirectly employed 9.9% (or 4,480) of all workers. In terms of attracting astro-tourists to the Museum, for every $96,000 in visitor spend in Outback Queensland, one full-time employee is created or supported.

Across the region, overnight visitor numbers and expenditure have been increasing steadily. In 2017 the Outback Queensland region received 875,000 visitors with the tourism industry contributing $355 million of Outback Queensland's GRP. Domestic visitors comprised almost all of Outback Queensland's visitation (98%), the majority of whom were intrastate visitors (688,000), although visitors from interstate are also growing at a three-year trend rate of 8.9%. Visitors to Outback Queensland spent 3,906,000 nights (three-year average, year ending December 2017) in the region.

While domestic visitation is strong, over the next ten years total visitation to Queensland is expected to grow by 30.9%, a figure that is driven primarily by international visitation (54%). This rise in visitation has been forecast to increase consumption by 28.3% – driven by domestic day spend (34%), domestic overnight spend (50%) and international visitor spend (93%). Despite these promising statistics, international visitation to the Outback region currently sits at 21,000 visitors (with an average length of stay of 22.5%) and is predominately comprised of western markets.

To ensure Outback Queensland is recognised as a must-see destination that is interesting and experience-orientated, significant tourism experiences focusing on unique natural resources such as dark skies must be developed and promoted.

3.2.2 The Winton Shire region

The Winton Shire covers a large land area and over the last six years experienced extreme climatic conditions ranging from drought to flood events. These extremes have negatively impacted the pastorally reliant economy, which employs over 26% of Winton residents.

The impact of prolonged, extreme drought on the Winton Shire and nearby regions has meant a significant loss in cash flow into the community and a reduction in employment opportunities and services. The Socio-Economic Indexes for Areas (SEIFA) measures the social and economic conditions of geographic areas across Australia focusing on low-income earners, relatively lower education attainment, high unemployment and dwellings without motor vehicles. Based on these measures, Winton Shire ranked as 44.7% in the most disadvantaged quintile – substantially higher than the entire Queensland region.

3.2.3 Sustainable summer tourism

As summer visitation is historically low in Central West Queensland (due to the reluctance of domestic visitors to travel at the hottest time of the year) the burgeoning international tourist market holds the key to the future of Outback Queensland. However, for it to be developed, the critical mass of tourist attractions in the region must grow significantly. Becoming a certified Dark-Sky Sanctuary is the Museum's first step towards developing sustainable summer tourism that will, combined with building the Gondwana Stars Observatory, increase overnight stays in the region. Sustainable summer tourism in Outback Queensland will drive regional growth and self-sufficiency by meeting the tourism demand for unique and authentic experiences. There are three main ways in which becoming a Sanctuary will promote economic growth in the region.

1. Create and sustain jobs in tourism and other supply chains

- Increasing the Museum's product offering, popularity, visitation and merchandise sales.
- Increasing the Museum's productivity, student and community involvement.

Table 5 *Operating performance to date*

	2013	2014	2015	2016	2017	2018^
Visitation	22,945	22,635	27,414	25,713	32,036	36,345
Revenue						
Revenue from operating activities	$ 927,651	$ 990,778	$1,235,456	$1,315,646	$2,045,391	$2,152,423
Cost of sales	*$ 226,442*	*$ 222,503*	*$ 235,301*	*$ 181,499*	*$ 263,487*	*$ 337,954*
Gross profit	$ 701,209	$ 768,275	$1,000,155	$1,134,147	$1,781,904	$1,814,469
	76%	*78%*	*81%*	*86%*	*87%*	*84%*
Other income						
Contributions and donations	$ 48,873	$ 136,098	$ 139,552	$ 207,693	$ 81,536	$ 91,431
Expenses						
Museum staff employed	10	15	15	18	22	22
Employee costs	*$ 517,353*	*$ 591,973*	*$ 610,063*	*$ 739,361*	*$ 942,806*	*$ 951,642*
Materials and services	*$ 162,789*	*$ 200,027*	*$ 229,080*	*$ 242,297*	*$ 345,379*	*$ 273,477*
Total expenses	*$ 680,142*	*$ 792,000*	*$ 839,143*	*$ 981,658*	*$1,288,185*	*$1,225,119*
Operating contribution	**$ 69,940**	**$ 112,373**	**$ 300,564**	**$ 360,182**	**575,255**	**$ 680,781**
	8%	*11%*	*24%*	*27%*	*28%*	*32%*
Grants, subsidies income – capital	$ 178,934	$ 195,266	$ 66,619	$ 368,200	$ 193,305	$ 50,000
EBITDA*	$ 248,874	$ 307,639	$ 367,183	$ 728,382	$ 768,560	$ 730,781
Depreciation and ammortisation	*$ 108,973*	*$ 135,825*	*$ 140,854*	*$ 161,647*	*$ 138,952*	*$ 145,783*
Interest received	$ 10,320	$ 9,948	$ 5,433	$ 2,039	$ 1,790	$ 2,844
Finance costs	*$ 1,208*	*$ 4,200*	*$ 2,678*	*$ 1,556*	*$ 3,167*	*$ 562*
Contributions and donations	-	$ 195,266	$ 21,697	$ 29,927	$ 193,305	$ 91,431
Net surplus	**$ 149,013**	**$ 177,562**	**$ 229,084**	**$ 567,218**	**$ 628,231**	**$ 587,280**

* **EBITDA** *Earnings before interest, tax, depreciation and amortisation.*
^ *Based on financials from January to November 2018.*
Since opening the Reception Centre in April 2012 and Dinosaur Canyon in April 2017 significant increases in revenue and employment opportunities have occurred.

2. Have flow-on economic benefits for supply chains

- As Museum visitation and direct and indirect employment increase, regional businesses and the necessary supply chains to support them will expand to meet the need.
- Providing ongoing business and opportunities to develop the necessary tourism experiences to support tourism in the region, including accommodation, transportation and excursions, bars and restaurants, handicrafts, food production and waste disposal. Currently there are 46 businesses in Winton that benefit from tourism and, to date, the Museum has contributed over $1,797,000 into the Winton Shire and nearby regional economies.

3. Have cross-regional benefit

As a very remote town, travel to Winton is via other remote and regional locations. Based on the success of the Museum's recently opened Dinosaur Canyon project, it is confidently predicted that becoming a Dark-Sky Sanctuary and building the Gondwana Stars Observatory will have a tangible effect on every regional community from Townsville, to Quilpie, to Cloncurry and Longreach. As travel is a necessity to the region, the cross-regional benefit will be felt through:

- regional employment opportunities
- the development of travel-related support business such as caravan parks, restaurants, mechanic and shopping outlets and
- sustainable practice and culture as communities work together in partnership to improve tourism objectives and awareness.

Astro-tourism represents an opportunity to expand the Museum's current offering to visitors and encourage visitors to actively engage in local celestial activities and, in turn, improve the quality of dark skies in their own communities.

The Museum has received letters from the wider community and all tiers of government expressing their support for its certification as a Dark-Sky Sanctuary and the building of Gondwana Stars Observatory. These include:

From humble beginnings, the Australian Age of Dinosaurs (AAOD) Museum is fast becoming a world-class centre of excellence in education, tourism and scientific research - all while located in Outback Queensland. The development of an International Dark-Sky Park at The Jump-Up and the Gondwana Stars Observatory will further the Museum's mission to promote the fascinating story of Australia to a world-wide audience
—The Honourable Quentin Bryce AD CVO (Former Governor General of Australia)

The Australian Age of Dinosaurs Museum of Natural History is one of Australia's premier outback destination and without doubt, an International Dark-Sky Park and observatory will stimulate direct economic benefits within and beyond the region.
—Outback Queensland Tourism Association, Peter Homan

Additional letters of support can be found in Appendix B.

3.3 ENVIRONMENTALLY SUSTAINABLE

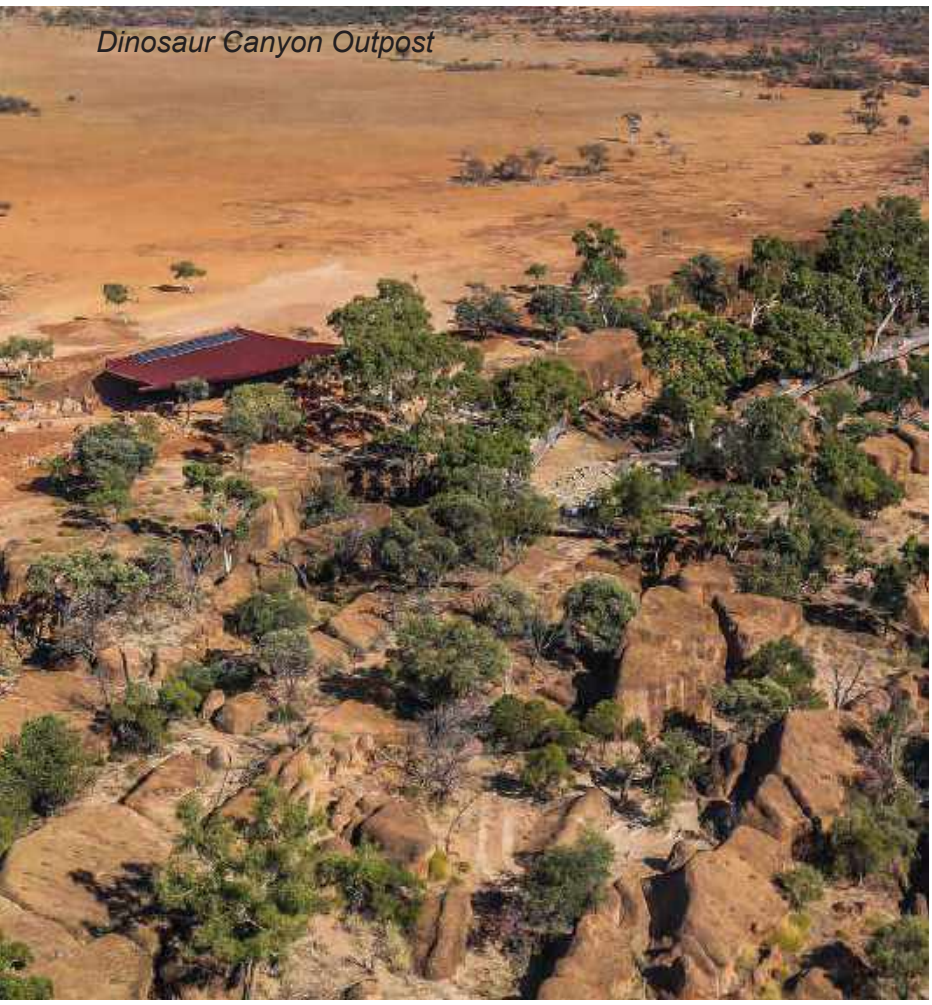
To meet its current needs without compromising environmental sustainment, the Museum is committed to environmental protection and enhancement. Internally, this means that the Museum embraces the best practices of environmental management techniques, such as total quality management, continuous improvement, motivating and empowering people, international benchmarking, social responsibility and environmental awareness. The latter is achieved through:

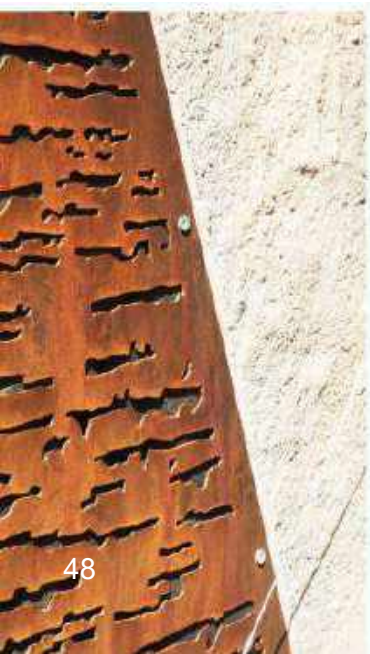
- The Dinosaur to Dunnarts program
  During Museum's tours of The Jump-Up visitors are informed about the Dinosaurs to Dunnarts program, a biodiversity program established by the Museum in 2009. This program encourages staff, visitors and volunteers to take photos of the flora and fauna they encounter on The Jump-Up and send the images to the Museum for identification. As the mesa is still relatively unexplored, the Museum is constantly finding new flora and fauna. A database of all identified flora and fauna found on The Jump-Up is available to the public via the Museum's website.

- Promoting environmentally responsible practices
  The Museum employs an array of different methods to reduce carbon emissions and promote environmentally responsible practices to the public. These methods include using recyclable or biodegradable material in the Cretaceous Café and Museum Shop, purchasing tour materials that can be reused (notebooks and pencils), encouraging visitors to leave their pets in Museum-provided kennels while on tour and asking visitors to take all waste material brought to The Jump-Up away with them.

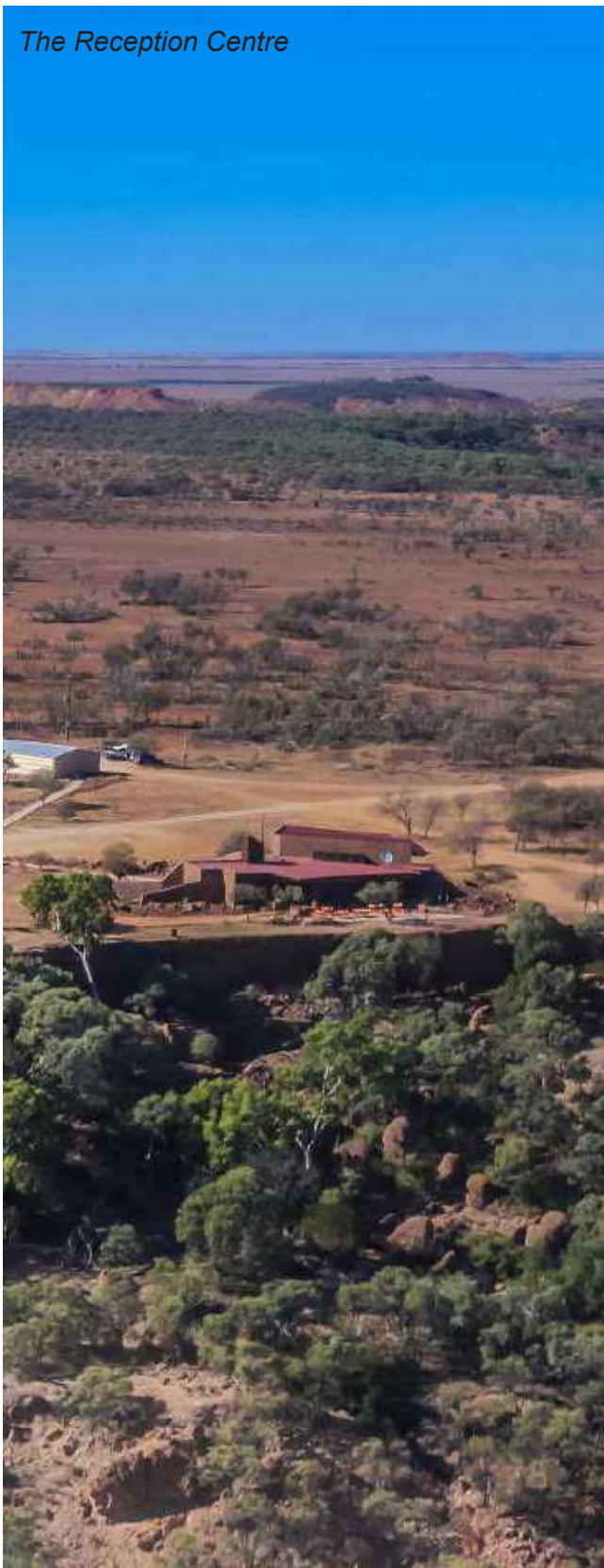
- Infrastructure that captures the essence of an ancient landscape
  The public buildings on The Jump-Up have been designed to fit seamlessly into the environment around them. These buildings on the The Jump-Up appear to taper down into the cap rock through the use of multiple interlocking precast concrete panels and hand-made perforated iron sheets. Designed by Cox Architecture (formerly Cox Rayner Architects), the Reception Centre and Dinosaur Canyon Outpost are the first of several planned buildings that have been inspired by the mesa's deep rock fissures and deep earthy colour scheme.

Dinosaur Canyon Outpost





The Reception Centre



3.3.1 Land designation

Australian Age of Dinosaurs Limited owns the 1,400-hectares of freehold land (The Jump-Up) from which the Museum operates. It was donated to the organisation for the purpose of preserving and promoting Australian natural history for future generations to learn from and find inspiration in. The Museum is guided by its four values:

Shared curiosity
- Inspiring discovery, preservation and knowledge of Australia's unique natural history.
- Inspiring people to explore the possibilities of scientific and educational endeavours.

Fair dinkum integrity
- Outback heritage, founders and embracing hard yakka.
- Recognising our commitment to professionalism and authentic, hands-on experiences.

Passionate customer focus
- Creating a friendly, memorable Museum connection for everyone.
- Creating a loyal and dedicated community of Museum supporters.

Dynamic Evolution
- Motivating a sustainable approach to the environment, the Museum and its growth.
- Motivating future generations to find purpose through connecting with deep-time.

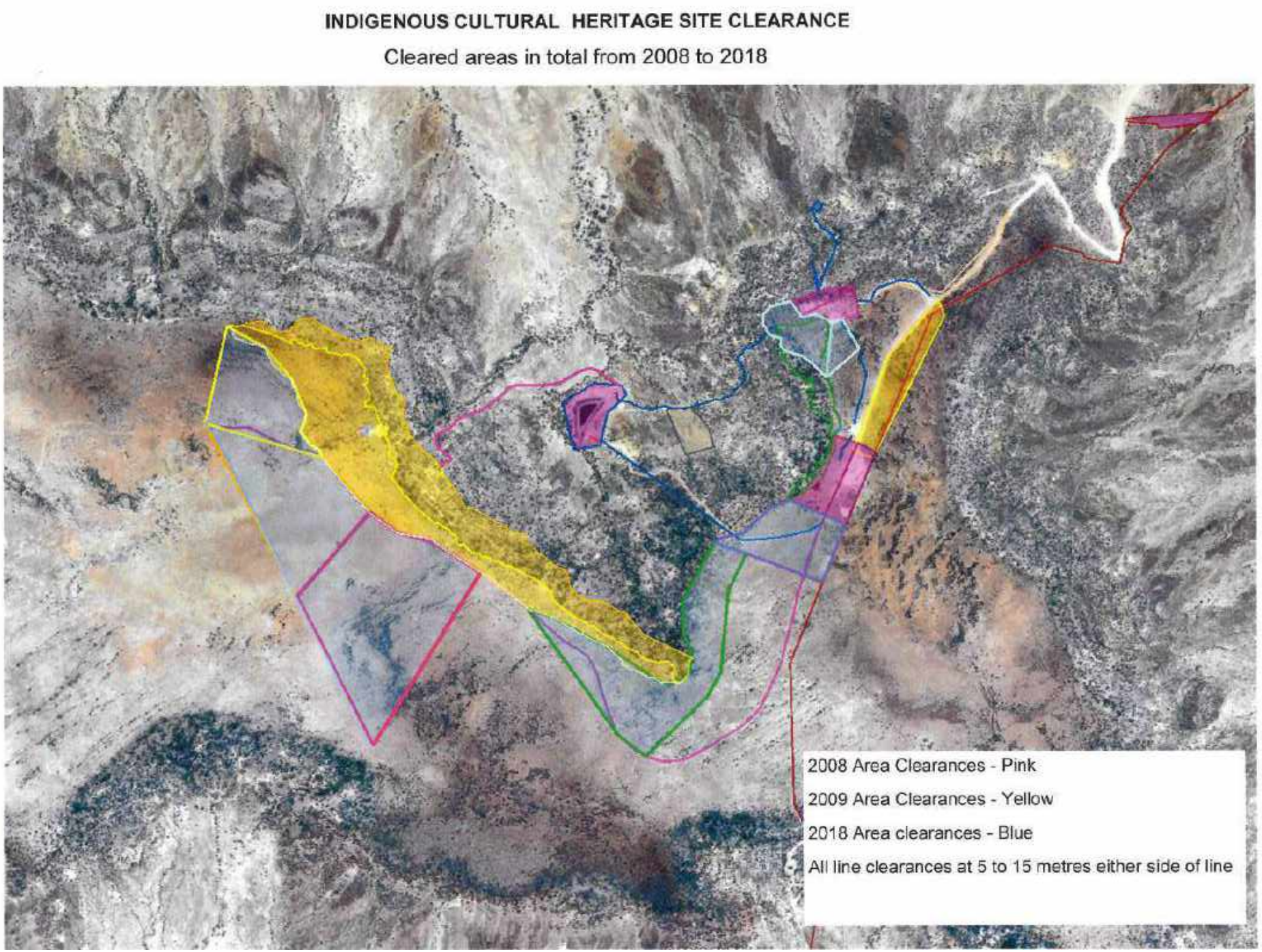
Australian Age of Dinosaurs Limited is an Australian registered charity set up to provide an awareness of local natural history to the world. Under section 3.1 of the company constitution (2013), the objects for which the Company is established are:

1) to encourage, promote and facilitate the discovery, preservation and display of fossil material from the age of dinosaurs within Australia;
2) to further public knowledge on Australian natural history and the evolution of the Australian continent with an emphasis on fossil material from the age of dinosaurs within Australia;
3) to ensure that the fossil discoveries of the Winton district are accessioned into the Australian Age of Dinosaurs collection;
4) to provide a secure, fire safe, climate controlled, museum specific premises to house fossils while making them accessible for scientific research and the public at all times operating in accordance with National Standards for Australian Museums & Galleries and the International Council of Museums Code of Ethics;
5) to further the public knowledge and understanding of Australia's natural history through displays, education programs, scientific research and an Australian Age of Dinosaurs annual journal;
6) to preserve the cultural and natural heritage of Australia through the use of sustainable principles and promote these as best practice to the public;
7) to establish the Australian Age of Dinosaurs Society to coordinate membership and the Australian Age of Dinosaurs Gift Fund;
8) to take over all of the assets and liabilities of Australian Age of Dinosaurs Association Incorporated; and
9) to do all things necessary and incidental in advancing any of the above 8 objects.

3.3.2 Indigenous cultural clearances

Australian Age of Dinosaurs Limited has met the requirements of the Aboriginal Cultural Heritage Act 2003 and the Aboriginal Cultural Heritage Act 2003 'duty of care' guidelines to protect Aboriginal cultural-heritage values. Cultural clearances have been undertaken by Koa Traditional Owners in 2008, 2009 and 2018. Cleared areas are GPS tagged and recorded on maps (refer to Map 14).

Map 14 *Indigenous cultural heritage-site clearance map*



3.4 FUTURE PLANS

The Museum and the Winton community are excited at the prospect of The Jump-Up becoming a certified Dark-Sky Sanctuary. However, the driver for this certification is not only to promote our exceptional dark skies to the world but also to protect the dark-skies into the future. This protection extends to all current and future infrastructure on The Jump-Up by compliance with IDA regulations, the Museum's Lighting Management Plan and state and national regulations for public lighting (refer to Section 4).

3.4.1 Stage 3 (refer to Maps 15 and 16)
Stage 3 of the Museum's overall long-term development is 2km west of the Reception Centre and encompasses Dinosaur Canyon and the future Gondwana Stars Observatory and March of the Titanosaurs exhibition, and Museum of Natural History (MNH) main building. Due to its size and scope, Stage 3 has been divided into three development phases:

Stage 3.1: Dinosaur Canyon – complete.
Stage 3.2: *Gondwana Stars Observatory and March of the Titanosaurs exhibition – shovel ready.
Stage 3.3: Museum of Natural History – concept planning complete, strategic planning underway.

Within the Museum's 2018–2021 Strategic Plan, six mission-critical project objectives have been identified as essential to the construction of Stage 3.3. This includes objective 3: develop new night-visit tourism products. Within this objective the following two activities have been listed:

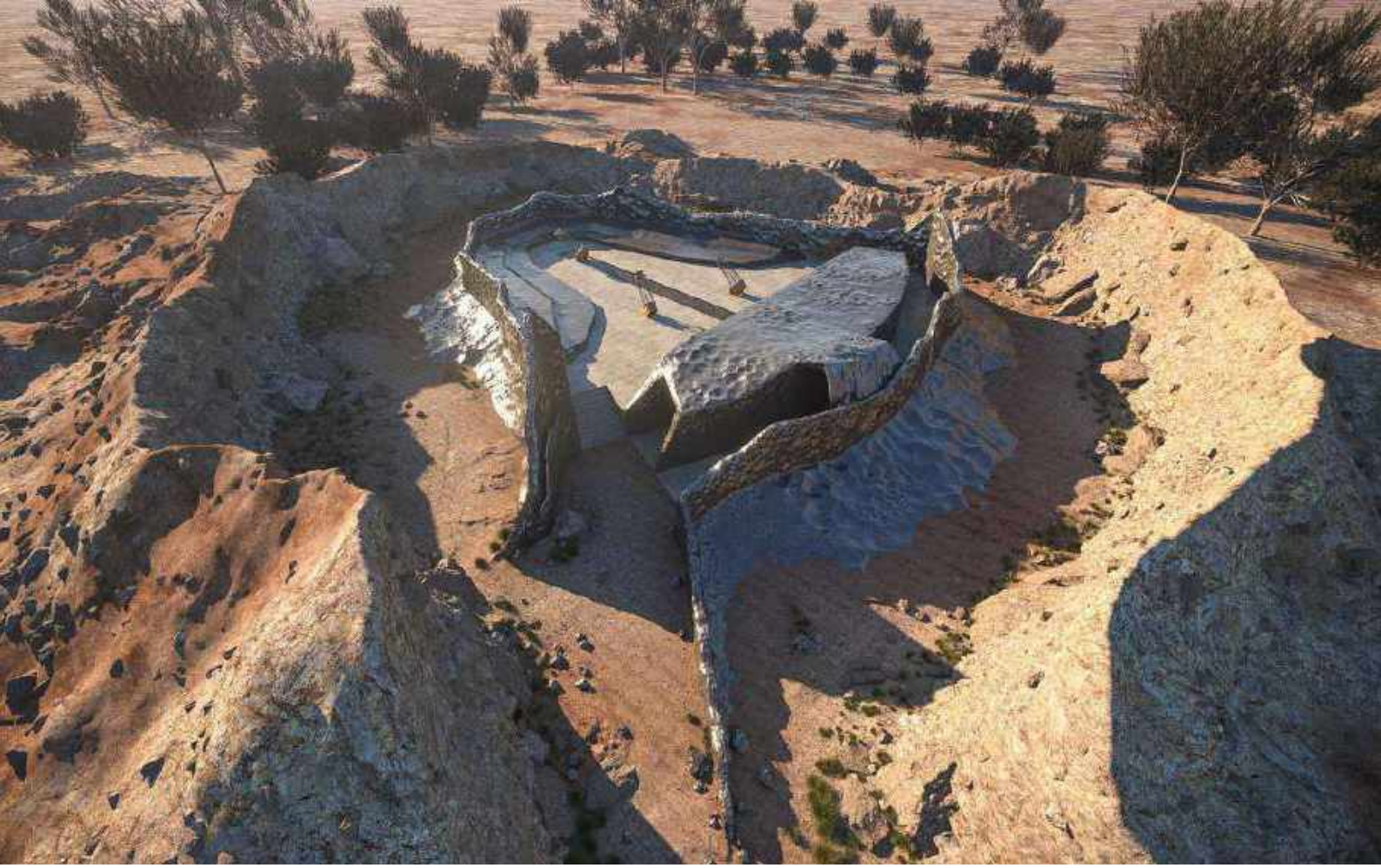
1) Develop The Star Gallery
It is imperative that the Museum increase its public offering in the lead up to the MNH but, more importantly, it must develop programs and products that have wide-reaching benefits to the broader community. The biggest challenge currently facing regional tourism is the low visitation numbers throughout the summer season. While it is expected that the MNH will attract an international summer audience following completion, it is unlikely that domestic visitor numbers in summer will change substantially in the meantime. It is therefore important that maximum visitor spend in the region is achieved in the lead up to opening the MNH. The continued development of facilities at The Star Gallery to include toilets, water station, signage, concrete seating and rubbish bins (maintained by the Museum) is considered mission critical.

2) Stage 3.2 Gondwana Stars Observatory
The Gondwana Stars Observatory will be situated close to the existing Dinosaur Canyon Outpost with access to its barbecue, seating and toilet amenities. Its design is in keeping with the Museum's visual brand and values, incorporating the red rock and rust themes of other public infrastructure on The Jump-Up. The building walls will assume the texture and colours of a meteorite and sit in the middle of a simulated crater, reflecting the bolide impacts that have caused world extinction events throughout deep time. The observatory will be fully equipped to cater for people with disabilities and include a large viewing deck, reclined seating and storage for telescopes and equipment. The telescopes installed at the Observatory will be two 25" Dobsonian and three 15" Dobsonian and refactor telescopes with go-to mounts.

A 3m-wide sealed road from the Reception Centre to the observatory (2.2km) will provide all-weather access and will offer quiet seclusion away from the daytime operations of the Museum. In line with the Museum's sustainability stance, the project also includes the installation of 11-KwH solar power and LED lighting along pathways and safety barriers.

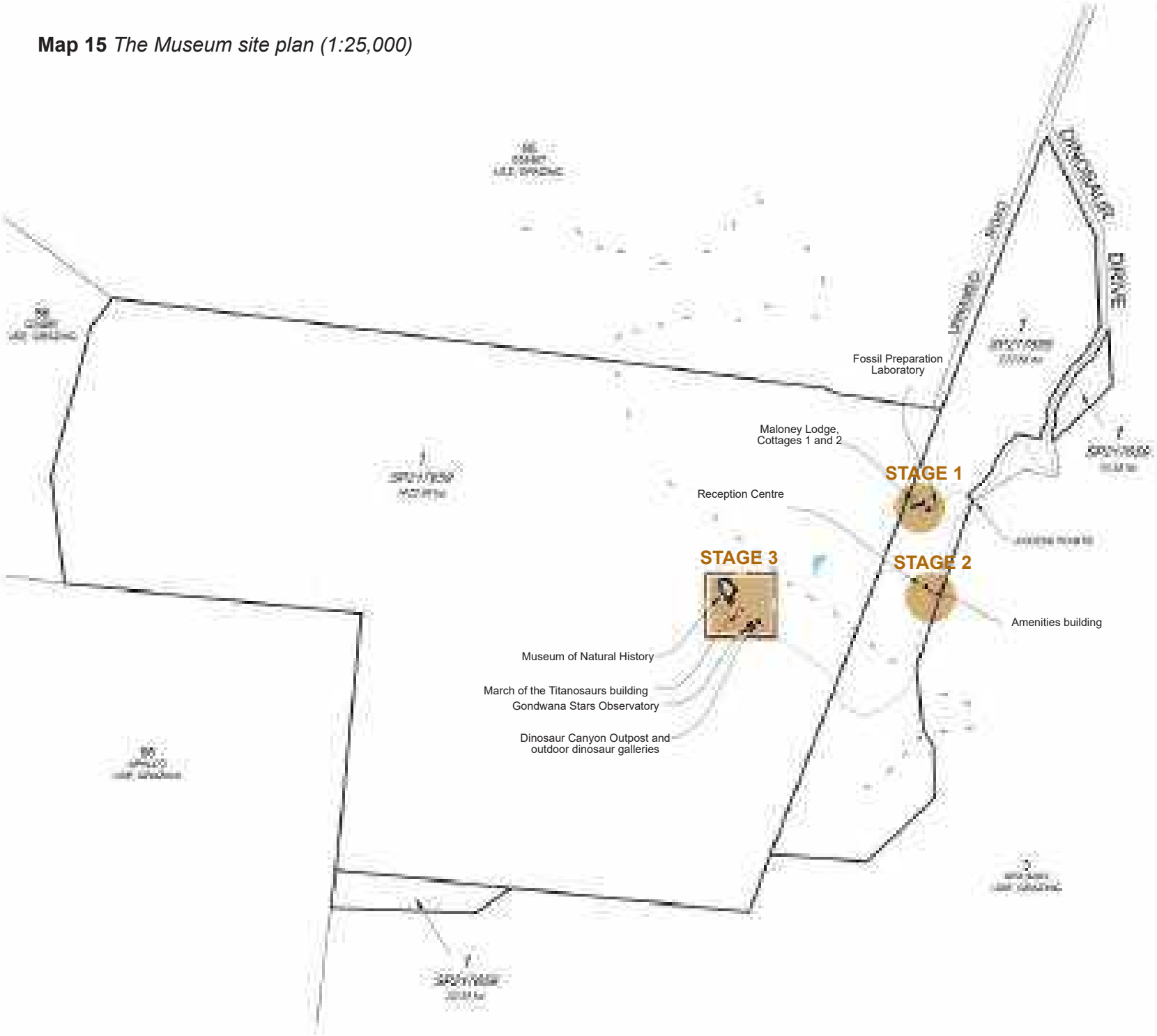
This attraction has been designed to cater for 20 people per tour. The Observatory tours will commence after a dinner and take a total of three hours.

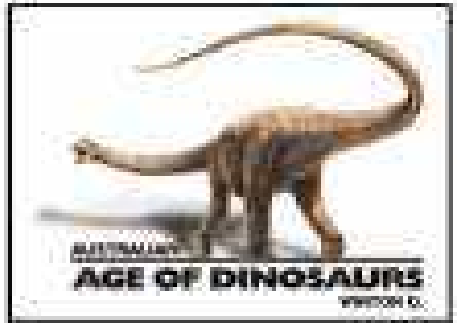
*The Museum has been shortlisted to compile a business case as part of its application to the Queensland Government's Growing Tourism Infrastructure Fund to fund the construction of Stage 3.2. Notification of the outcome of this application will be received in April 2019.



Stage 3.2: Gondwana Stars Observatory concept plan images.

Map 15 *The Museum site plan (1:25,000)*





Legend

Note: All dimensions are in metres and are appropriate

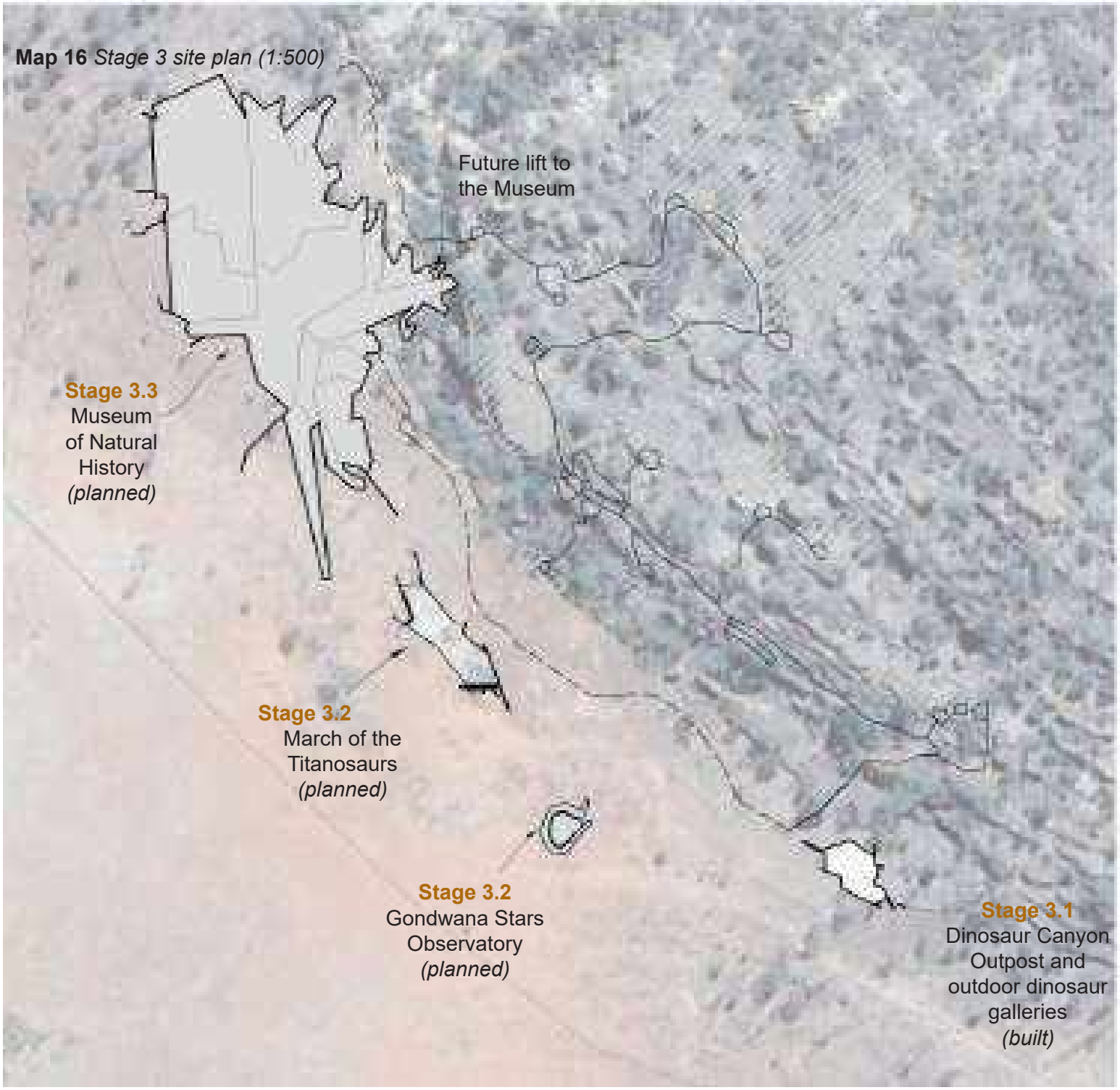
The Museum site plan

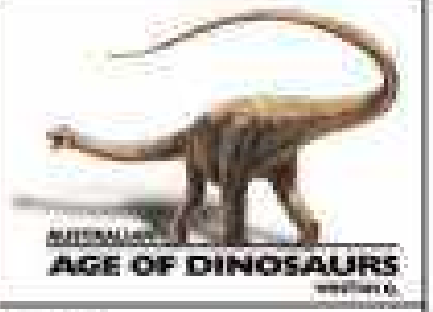
Stage 1
- Fossil Preparation Laboratory
- Maloney Lodge, Cottages 1 and 2

Stage 2
- Reception Centre and Amenities building

Stage 3
- Dinosaur Canyon Outpost and outdoor dinosaur galleries
- Gondwana Stars Observatory
- March of the Titanosaurs building
- Museum of Natural History

Map 16 *Stage 3 site plan (1:500)*





Legend

- Proposed building or structure
- Completed building or structure
- Proposed gravel road/ track
- Completed pathway

Note: All dimensions are in metres and are appropriate

Stage 3 Site Plan

Stage 3

3.1 Dinosaur Canyon Outpost and outdoor dinosaur galleries

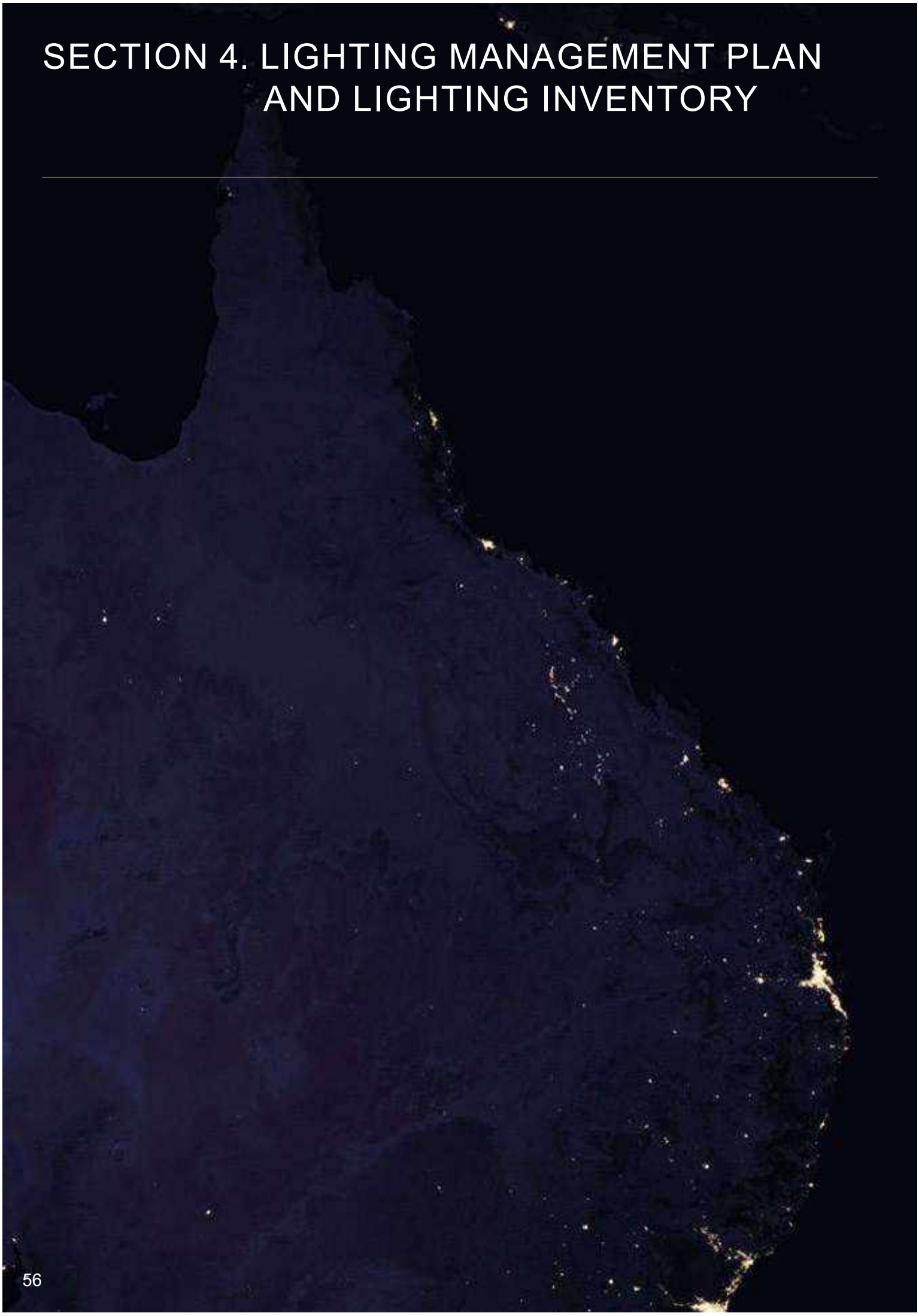
3.2 Gondwana Stars Observatory

3.2 March of the Titanosaurs

3.3 Museum of Natural History

Stage 3.3: Museum of Natural History concept plan images. The building will be 6,000 square metres, of which 1,400 square metres will be exhibitions. The rest will be divided between public space, gift shop laboratory, fossil storage, and staff and volunteer areas.

SECTION 4. LIGHTING MANAGEMENT PLAN AND LIGHTING INVENTORY



david.elliott@aaod.com.au
Lot 1 Dinosaur Drive
Winton, Qld 4735
+61 0428 573 056
australianageofdinosaurs.com

14 January 2019

IDA Board of Directors
International Dark-Sky Association
3225 North First Avenue
Tucson, Arizona 85719-2103, USA

Dear IDA Board of Directors

It is with great pleasure that I write to confirm that on 14 January 2019 the Australian Age of Dinosaurs Limited Board adopted the attached Lighting Management Plan (LMP) to guide the Museum's selection, placement, installation and operation of all new and replacement/retrofitted light on The Jump-Up. As part of this meeting it was agreed that all non-complying external lights would be replaced and 90% of all outdoor lighting will conform to the Museum's LMP within five years of receipt of an IDA certification. The Board will also ensure lighting on The Jump-Up will be 100% compliant against the Museum's LMP within ten years of the certification.

The LMP will be an invaluable reference to ensure the Museum adequately regulates the use of artificial light at night in a way that prioritises the safety of visitors and staff while minimising the impact of such light on protected outdoor spaces and wildlife transverse zones. Artificial outdoor light will only be used:

1. when it is strictly necessary
2. where it is needed
3. in the appropriate amount for a specific task and
4. with the appropriate spectrum.

By adopting these simple principles and LMP guidelines, the spectacular dark night sky above the The Jump-Up will be enjoyed by future generations. Once established the Board is committed to erecting and maintaining appropriate signage indicating the International Dark-Sky Sanctuary certification and photo evidence will be sent to the IDA for your records along with signage location descriptions.

Over the last 17 months Museum staff and volunteers have worked hard to meet the International Dark-Sky regulations and will continue to make appropriate use of adaptive controls to limit the duration, intensity and extent of outdoor lighting.

Yours sincerely

David A Elliott OAM
Executive Chairman
Australian Age of Dinosaurs Ltd

4.1 LIGHTING MANAGEMENT PLAN

Document name	The Jump-Up Lighting Management Plan
Document purpose	To provide regulations for the management of all outdoor lighting on The Jump-Up
Adopted by the AAODL Board	 David Elliott, Executive Chairman 14 January 2019
Distribution list	Executive Chairman Business Development Manager Operations Manager Laboratory Supervisor
Review frequency	Annually

INTRODUCTION

The Jump-Up is the location of the Australian Age of Dinosaurs Museum of Natural History (the Museum), the current site of The Star Gallery and future Gondwana Stars Observatory. The following Lighting Management Plan exceeds the necessary outdoor lighting requirements stipulated in Australian state and national regulations: Queensland Planning Regulation 2017 (QPR), Queensland Environmental Protection Act 1994 (QEPA) and the Australian Standard: *Control of the obtrusive effects of outdoor lighting* (AS 4282). The Museum has adopted established IDA previsions on The Jump-Up to reduce light emissions and ensure new lighting is good lighting and all existing lighting conforms to International Dark Sky standards. Note: The most stringent restrictions apply within a 10km radius of the Museum site.

LOCATION

This Lighting Management Plan (LMP) covers the entire Jump-Up area of 1,400 ha, though a 10km radius from the north-west corner of The Jump-Up (using the Reception Centre as the epicentre) is the focus of the most stringent restrictions.

STATE AND NATIONAL REGULATIONS

The following list summaries the lighting requirements outlined by the QPR, QEPA and AS 4282.

- Queensland Planning Regulation 2017 (QPR): outdoor lighting on the premises does not adversely impact on the amenity of relevant neighbouring premises.

- Queensland Environmental Protection Act 1994 (QEPA): environmental nuisance is unreasonable interference or likely interference with an environmental value caused by aerosols, fumes, light, noise, odour, particles or smoke or an unhealthy, offensive or unsightly condition because of contamination; or another way prescribed by regulation.

- The Australian Standard: *Control of the obtrusive effects of outdoor lighting* (AS 4282): specifically refers to the potential adverse effects of outdoor lighting on nearby residents, users of adjacent roads, transport systems and astronomical observations. However it does not apply to:
  - some parts of public lighting
  - internally illuminated advertising signs

- the obtrusive effects of brightly lit surfaces eg floodlit buildings and externally lit advertising signs
- lighting systems which are of a cyclic or flashing nature and
- environmental impacts associated with the daytime appearance of outdoor lighting systems, including their support structures.

Further the objective of the AS 4282 does not:
- address the requirements that may be necessary for lighting systems to facilitate the activities for which they are designed and
- stipulate compliance when relating to light spillage (although information and guidance is provided).

While the Museum conforms to all state and national regulations relating to outdoor lighting, in the absence of detailed and stringent guidelines to protect the pristine dark-skys above The Jump-Up the following IDA supported Lighting Management Plan will be adhered to.

CERTIFICATION AS AN INTERNATIONAL DARK-SKY SANCTUARY

With increasing skyglow from uncontrolled urban uplight, stars are quickly disappearing in the night sky around the world. However, The Jump-Up's very remote location in Central West Queensland puts it in a unique position to actively preserve some of the darkest sky in the world. The Jump-Up fits the criteria of an IDA International Dark-Sky Sanctuary as it:

- is located on 1,400 ha of freehold land
- possesses an exceptionally dark night sky
- is located on a mesa that is a home to an array of unique flora and fauna reliant on a nocturnal environment
- falls in line with the Museum's objective to promote and preserve Australian natural history for future generations to learn from and
- is very remote with no nearby threats to the quality of its dark night skies.

As an International Dark-Sky Sanctuary the Museum will be able to further the awareness of dark skies and promote its long-term conservation in Australia.

OUR AIMS

This LMP aims to preserve the dark skies of The Jump-Up by ensuring that all new and existing lighting is compliant to the IDA and national standards. The Museum is committed to meeting "...the current and future national environmental legislative and regulatory requirements and continue to work towards attaining international environmental requirements." (AAOD Environmental Plan, 2018).

As the Museum will be taking a leading role in defining best sustainable practice to minimise light pollution within the region, all visitors to the Museum and The Jump-Up will be informed of the Museum's aims as well as how to minimise light pollution in their own lives.

GOALS OF THE LIGHTING MANAGEMENT PLAN

The overarching goal of the LMP is to ensure The Jump-Up remains compliant with its lighting. This will be achieved by maintaining the existing low-light standards across The Jump-Up and actively managing light-control measures in the future.

1. MANAGEMENT OF LIGHT SOURCES

The Museum is committed to preserving the dark skies above The Jump-Up by:
- ensuring that lighting complies with the relevant QPR, QEPA and AS 4282 regulations
- selecting fully shielded/cutoff light fixtures, regardless of their output in lumens, to prevent uplight
- ensuring that the correlated colour temperature of all lighting is 3,000 Kelvins or less
- providing outreach material to visitors to educate them on light pollution and ways to reduce their own
- impact (refer to Section 5.5)

- preventing lights reflecting from white or other surfaces
- limiting light size to requirements and using the minimum number and size of lights
- switching lights off/dimming lights when not in use
- installing time switches or motion sensor switches
- ensuring down lights are deeply recessed with effective low-glare baffles
- ensuing any structural part of the luminaire or the surrounding material is securely and permanently fixed: where the luminaire is bracket mounted from a white or similar highly reflective surface, the light-emitting surface of the light fixture facing the wall must be rendered opaque
- ensuring all future security lights are fitted with a motion-sensor switch to prevent continuous use
- reducing light intensity and using lights with blue-light blocking coating on the inside, LED and compact fluorescent bulbs
- taking measures to ensure lights are switched off no more than five minutes after activation and
- installing blinds, curtains, roller doors or shutters to prevent light escape, particularly if operational requirements demand strong interior lighting (eg the Industrial Laboratory).

2. PROHIBITED LIGHT SOURCES AND ACTIVITIES

The Museum has banned the use of the following light sources on The Jump-Up:

- searchlights and similar high-intensity lights except when needed for operational activities such as spotlighting for pest control and survey or in emergencies by police or fire personnel
- handheld battery-operated laser pointers with a power greater than one milliwatts. (These are considered prohibitive weapons that require reasonable excuse for lawful possession. A person in possession of a laser pointer must be able to provide details of a membership to a recognised astronomical organisation or be personally supervised by a member of a recognsed astronomical organisation, and the person's reason for possession or acquisition of the laser pointer is to take part in activities associated with astronomy; and for astronomical related activity, the power output of the laser pointer must be less than 20 mW)
- floodlights as used for sports lighting and showground activities
- light art performance photography or light painting and
- all illuminated outdoor signage (reflective lighting for wayfinding or information signage is permitted).

3. EXCEPTIONS AND OTHER LIGHT SOURCES

The following types of outdoor lighting installations are permitted on The Jump-Up and are not subject to the other regulations of this LMP:

1. lighting installations required by the relevant local, regional or national legal jurisdiction and
2. lighting installations required temporarily for the safe performance of night-time tasks, such as construction, at the discretion of the Museum Management Team (MMT).

Other light sources with restrictions are set out below.

PRIVATE LIGHTING

- When guests stay on The Jump-Up in their own caravans they must comply with the Museum's lighting regulations and lighting curfew. All guests will receive a copy of the Museum's on-site compendium on arrival, containing this LMP, and asked to comply with the document. A temporary lighting exclusion for the use of spotlighting equipment is in place for flora or fauna surveys carried out by Museum staff or contractors.

EVENT LIGHTING

- Occasionally the Museum will host small events or concerts on The Jump-Up. In this scenario, a written request to the MMT for a short-term exemption from the requirements of the LMP for temporary outdoor lighting may be submitted.
  The request for the exemption must contain, at a minimum, the following information:
  - date, time and length of event (including period of use of proposed event lighting)
  - reason for the requested exemption and what kind of exemption is requested
  - proposed location of all outdoor lighting (including a map to demonstrate each lighting location)
  - details of lights being used, screening and positioning of the lights and

– total wattage and light output.

The MMT may ask for additional information or that event organises use unshielded low-intensity event (one-off) lighting. Notification of the MMT decision will be issued in writing within ten working days.

TEMPORARY LIGHTING

- Allowable installations of outdoor lighting on The Jump-Up for temporary purposes, as exempted above, shall be limited to the minimum number of nights required to complete the task that the lighting illuminates. Museum staff responsible for such installations will follow these guidelines to the greatest practical extent, and will endeavor to limit as much as possible the on-site impacts of such lighting.

RETROFITTING LIGHTING

- Over almost two years the Museum has replaced lighting that is non-compliant with lighting solutions, that are energy efficient and reduce light pollution. No significant private lighting pollution was observed during the lighting inventory survey or on any of the night-sky brightness measurements.

VISITOR AND TENANT LIGHTING

- Lighting of vehicle exteriors, caravans and other personal property belonging to Museum visitors shall be limited to ensure the natural integrity of The Jump-Up is maintained and that other visitors and tenants are not disturbed. All lighting shall be restricted in intensity and extent to provide for the legitimate needs of visitors and be extinguished no later than The Jump-Up curfew (10pm). Inappropriate high-intensity light painting, the use of searchlights, and similar uses of outdoor lighting by visitors, is prohibited.

4. COMPLIANCE REQUIREMENTS

The guiding principle of lighting on The Jump-Up is that light is used only when and where it is needed, and is appropriate for the specific task for which it is intended. In addition, lighting fixtures are required to be fully shielded, with either control timers or motion sensors wherever possible.

The installation of new outdoor lighting on The Jump-Up is permitted only in instances where the MMT has determined that a public safety hazard exists that can only be mitigated through the use of outdoor lighting at night. Where light at night is required for the safe performance of tasks or safe transit between locations, it will be used; otherwise, the default policy on The Jump-Up is not to install additional lighting.

5. SHIELDING

All outdoor lighting fixtures with lamps that have an intensity of equal to or greater than 500 lumens shall be fully shielded. Lighting with lamps that have an intensity of less than 500 lumens may be left unshielded as decided by the MMT. These lights shall not be exempt from the other requirements of the LMP, and must be designed in such a way as to minimise impact to the night-time environment. Further, to the greatest possible extent, the MMT will endeavor to limit the inadvertent or incidental emission of light from indoor spaces to outdoor areas through the use of window coverings, indoor lighting timers/switches and other appropriate measures.

6. SELECTING OUTDOOR LIGHTING FIXTURES

Outdoor lighting used on The Jump-Up must be energy efficient and minimise the emissions of short-wavelength light into the night-time environment. Lighting on The Jump-Up will avoid white light wherever practicable and not exceed 3,000 Kelvins (refer to Section 4.3). The following table gives the maximum outdoor luminance (the amount of luminous flux per unit area) that is allowed on The Jump-Up unless a demonstrated need for larger values exists (refer to 3. Exceptions and other light sources).

Application	Lumens	Lux / m^2	Notes
Recessed path lighting	80	8lx / $10m^2$	1
Motion-sensor lighting	700	28lx / $25m^2$	2
Outdoor path lighting	700	46lx / $15m^2$	3
Fluorescent lighting	1,350	67lx / $20m^2$	4

Table notes

1. *Night-time lighting at Dinosaur Canyon is via a pathway with recessed 2-watt LED lighting powered by solar energy. This light source is only turned on for short periods of time as a safety precaution during evening tours.*
2. *Motion-sensor lighting is available at Maloney Lodge and is fully shielded. Illumination is limited to two minutes.*
3. *Night-time lighting of the pathways at the Reception Centre and Dinosaur Canyon is by fully shielded bollard lights that are only turned on for short periods during evening tours.*
4. *Fluorescent lighting is either used during the day or otherwise fully shielded at night and turned on for limited time by tenants of Maloney Lodge, Cottages 1 and 2 and subject to curfew.*

7. ILLUMINATED SIGNS

Internally illuminated signs and signs illuminated by electronic means such as LEDs and similar lighting are prohibited on The Jump-Up.

8. CURFEW

Dusk-to-dawn lighting is not generally allowed on The Jump-Up. All outdoor lighting must be extinguished from 10pm until one hour before sunrise.

9. LIGHT POLLUTION AWARENESS (EDUCATION AND INTERPRETATION)

The importance of this LMP cannot be understated. By ensuring the dark skies above The Jump-Up remain clear of light pollution through the use of quality and measured lighting sources the Museum is able to promote lighting solutions and night-sky appreciation through the Museum's growing interpretative tours. As well as adoption in the Museum's tours, the following strategies are being developed to further the Museum's education outreach:

1. information relating to Australian night skies in education and public information booklets
2. publication of a Dark-Sky book entitled *Gondwana Stars*
3. inclusion of The Jump-Ups DSS in all marketing material, media kit and information packs
4. articles in the *Winton Herald* and *Longreach Leader* and
5. inclusion of information relating to light pollution, dark-sky appreciation and resources on the Museum's website.

10. RISK IDENTIFICATION

Given The Jump-Up's remote location it faces few current risks to its dark-sky status. Isolation from the nearest urban centre means that light pollution is not noticeable. Public lighting is controlled by the Museum and adheres to the QPR, QEPA, AS 4282 and IDA regulations. The following risk is unlikely, though warrants acknowledging:

PRIVATE DEVELOPMENT

- The majority of private titles in the Winton Shire consist of large blocks of pastoral land, there are minimal development rights and subdivision is notoriously difficult. Although pastoral property homesteads are all located well away from The Jump-Up, property owners wishing to install any infrastructure that requires lighting within 10km of The Jump-Up will be encouraged to adopt IDA regulations, and a revised LMP will be submitted to the IDA.

11. LIGHTING PLAN AND SUPPORTING INFORMATION

A lighting plan must be submitted with any development application by the Museum pursuant to part 2 of the Winton Shire Planning Scheme, assessable against the Rural Zone Code.
The lighting plan should include the:

- location and mounting height of all proposed and existing luminaries
- type of light source with power (watts), light output (lumens) and colour temperature and
- details of all shielding necessary to meet the requirements of this scheme including those incorporated in the luminaire construction.

REPLACING LIGHT FITTINGS

- If any existing non-complying external light fitting is replaced, it must be replaced with a complying fitting. If an existing, non-complying external light fitting can be made to comply by replacing the lamp (light source) with a different type, then this must be done when the lamp fails. Within five years of achieving Dark-Sky Sanctuary certification, 90% of lights will comply with IDA regulations.

12. REPORTING

The Museum will submit an annual report to IDA by each year detailing activities and progress towards fulfilling IDA DSS goals during the previous year.

13. REFERENCES

REGULATIONS, STANDARDS, GUIDELINES

- Environmental Planning and Assessment Act 1979
- Standards Australia (1997) Australian Standard: *Control of the obtrusive effects of outdoor lighting* (AS 4282). Strathfield, NSW: Standards Australia International
- Queensland Planning Regulation 2017
- Queensland Environmental Protection Act 1994

MANAGEMENT DOCUMENTS

- Environmental Policy 2015
- Charter for Sustainability and Responsible Tourism 2015
- Environmental Management Plan 2018

FORMS

- Museum Lighting Plan (refer to Section 5)

14. RESPONSIBILITY

The following table summaries the responsibilities as they relate to the LMP.

Title	Responsibility	Authority level
Business Development Manager	To ensure: • publication of the LMP • roles and responsibilities as they relate to the LMP are clearly communicated • where required, training in the implementation of the LMP is conducted and • the recommended controls and management safeguards are undertaken in accordance with the LMP.	Review and approval
Operations Manager	• To sign off and give authority to the LMP and to ensure its implementation and ongoing acceptance is successful • To ensure the annually review of the LMP	Approval

4.2 LIGHTING INVENTORY

Reception Centre	-22.479008, 143.182705	**Industrial Laboratory**	-22.474285, 143.182137
Laboratory	-22.472552, 143.182787	**Cottage 1**	-22.474224, 143.182456
Dinosaur Canyon Outpost	-22.481184, 143.171960	**Cottage 2**	-22.472462, 143.182247
Amenities building	-22.479680, 143.183570	**Maloney Lodge**	-22.474355, 143.182019

Location	Fixture	Full-shielded?	Operable?	Special purpose (≤500 initial lumens) and ≤3,000k	Application	Conformity with LMP	Image
Reception Centre	8 x recessed in roof (down lights) 7W	Yes	Yes	Yes 680 lumens 3,000 kelvins	Only used during night events	Yes	
	4 x square bollards with recessed LED (down lights) 6W	Yes	Yes	Yes 374 lumens 3,000 kelvins	Only used during night events	Yes	
Laboratory	No external lighting.						
Dinosaur Canyon Outpost	7 x recessed in roof (down lights)13W	Yes	Yes	Yes 825 lumens 3,000 kelvins	Only used during night events	Yes	
	3 x recessed in passage way roof (down lights) 13W	Yes	Yes	Yes 825 lumens 3,000 kelvins	Only used during night events	Yes	
	83 x recessed pathway railing (down lights) 2W	Yes	Yes	Yes 80 lumens 3,000 kelvins	Only used during night events	Yes	
Amenities building	All outdoor lighting has been sealed inside a new storage facility. No external lighting.						

Location	Fixture	Full-shielded?	Operable?	Special purpose (≤500 initial lumens) and ≤3,000k	Application	Conformity with LMP	Image
Industrial Laboratory	All outdoor lighting has been sealed behind roller doors. No external lighting.						
Cottage 1	1 x LED wall (down light) 36W	Yes	Yes	Yes 240 lumens 3,000 kelvins	Used only when required by tenant	Yes	
Cottage 2	1 x LED wall (down light) 36W	Yes	Yes	Yes 240 lumens 3,000 kelvins	Used only when required by tenant	Yes	
Maloney Lodge	4 x LED wall (down lights) 36W	Yes	Yes	Yes 240 lumens 3,000 kelvins	Motion sensors - when required by tenants	Yes	
	2 x undercover florescent lights (down lights) 36W	Yes	Yes	No 3,350 lumens 4,000 kelvins	Used only when required by tenants	No - refer to 4.3 lighting replacement plan	
	1 x undercover florescent light (down light) 36W	Yes	Yes	No 3,350 lumens 4,000 kelvins	Used only when required by tenants	No - refer to 4.3 lighting replacement plan	

ON-SITE ACCOMMODATION RETROFITTING

The only location on The Jump-Up that has the potential for light clutter or sky glow is Maloney Lodge and Cottages 1 and 2. Most buildings have now been retrofitted with IDA compliant lighting.

Photo 1 Outside view of on-site accommodation taken with an IPhone 8 at 8.08pm, 20 November 2018 prior to lighting retrofit.
Photo 2 Outside view of on-site accommodation taken with an IPhone 7 at 10.36pm, 22 January 2019 after lighting retrofit.
Photo 3 At Cottage 1 the floodlight was removed.
Photos 4 and 5
At Maloney Lodge four LED Riga 9417 wall lights were installed (240 lumen, 3,000 Kelvins, 36W lighting, down lights with shielding).
Photo 6 At Cottage 1 the fluorescent outdoor light has been replaced with a LED Riga 9417 wall light.
Photo 7 At Cottage 2 the fluorescent outdoor light has been replaced with a LED Riga 9417 wall light.

Photo 1

Photo 2

Photo 3

Photo 4

Photo 5

Photo 6

Photo 7

4.3 LIGHTING REPLACEMENT TIMELINE

In accordance with the Museum's LMP all future fluorescent lighting tubes will be replaced with low-temperature LED lights (under 3,000K). The following non-complying external light fittings will be replaced within 12 months of achieving the Dark-Sky Sanctuary certification to ensure 90% of lights comply with IDA regulations.

Location	Fixture	Issue	Solution to conform to the Museum's LMP	Timeframe
Maloney Lodge	3 x undercover florescent lights (down lights) 36W	While this light is shielded it is 4,000K	Lights to be replaced by 3,000 kelvins florescent LED lights	Ordered and will be replaced by 28 February 2019

The Museum is self-funding the replacement of all non-compliant lighting over the next twelve months to achieve 90% compliance – whether the lights fail or not.

OTHER LIGHTING CONDITIONS

- **Hosted dark-sky dinners**

Hosted dark-sky dinners are specialised tours for wholesale groups that include an evening tour and BBQ. These tours are conducted at the Reception Centre where lighting is turned off by no later than 10pm. Outdoor lighting is turned off for dark-sky tours following the dinner.

- **The Reception Centre**

Internal lighting is turned off at 5.30pm daily. During hosted dark-sky dinners (once a week during peak season) only compliant outdoor lighting is used.

- **Amenities building**

All outdoor lighting has been sealed inside a new storage facility, no external lighting is visible.

- **Fossil Preparation Laboratory and Industrial Laboratory**

Internal lighting in both facilities is turned off prior to 5.30pm daily, no external lighting is visible.

- **Maloney Lodge**

Rooms are fitted with curtains and sensor-operated LED lights along both sides of the building.

- **Cottages 1 and 2 (private lighting)**

All cottage windows have external downward-facing metal slats reducing light in and out of the building. In addition, all windows are fitted with internal blinds and curtains.

- **Events**

Occasionally the Museum will host small events or concerts on The Jump-Up, in accordance with the LMP organisers must submit a completed Lighting Plan in writing to the MMT.

SECTION 5. MANAGEMENT AND SUPPORTING DOCUMENTS

5.1 ENVIRONMENTAL POLICY

10 Administration

10.8 Environmental Policy

10.8.1 Objective

As a responsible and forward-thinking member of the regional community, and as a potential influencer of visitors' understanding of the Earth's fragility and ever-changing nature, to commit to both sound sustainability practices through environmental performance and to deliver responsible tourism through exhibition and program messaging.

10.8.2 Application

The Museum, through its Staff, Volunteers, Program Participants and Contractors, will continuously assess its commitment to meeting the needs of its visitors, collections and structures, without compromising future generations, by being an environmentally responsible organisation and implementing, as far as practicable, best practice care for biodiversity and the natural environment, waste reduction, energy efficiency, water efficiency and environmental procurement initiatives throughout all our activities.

10.8.3 Policy statements

In all its activities the Museum will, as far as practicable, commit to:

- taking a positive role in defining and implementing environmental best practice
- setting appropriate and challenging environmental improvement targets by regularly reviewing progress and continually improving upon minimising our operational environmental impact
- implementing the requirements of relevant environmental legislation and regulations and aiming to exceed any relevant minimum requirements
- monitoring the use of resources, both non-renewable and renewable, and maximising the efficiency and effectiveness with which these are used, with a view to minimising environmental impacts
- providing appropriate environmental awareness induction training for Staff, Volunteers, Program Participants and Contractors, and encouraging them to apply sound environmentally sustainable practices at work, at home and within the wider community
- purchasing the most environmentally sustainable goods and services and supporting suppliers that have environmental policies and practices
- continuously, in its exhibition and program development, considering the opportunities available to provide visitors with knowledge about environmental and biodiversity care on The Jump-Up, the evolution and fragility of the planet and the need to protect the world's resources for future generations
- monitoring progress and reporting on our environmental and information-sharing performance through our Annual Report, electronic newsletter and other relevant publications
- setting out our commitment in a Charter for Sustainability and Responsible Tourism to be located in a public area.

Policy adopted by the Board of Australian Age of Dinosaurs Limited
on 20 July 2015 for immediate implementation
Recommended for review in 2018

Charter for Sustainability and Responsible Tourism

July 2015

The Australian Age of Dinosaurs Museum of Natural History (the Museum) is a relatively young museum which intends to become, quietly, a sustainability champion within the museum sector. Sustainability is central to the way we operate and develop the Museum. We are committed to contributing to responsible tourism and to the economic, social and environmental wellbeing of Winton and outback Queensland. Working sustainably is a way of thinking for our Board, Staff and Volunteers and underpins everything we do.

The Museum has been established since 2002 and exists to protect and make accessible its wealth of natural history collections.

We have a clear long-term purpose and will ensure the collection is cared for safely and is accessible to current and future generations.

We are mindful of the environmental conditions required for the long-term preservation of collections and implement these where possible and appropriate.

We will ensure that sustainability principles are a prime driver of the Museum's development project and that energy efficiency options are considered thoroughly.

Museum Management will ensure principles of sustainability are woven into every aspect of the Museum's work.

We will work with external agencies to ensure best practice in the management of our resources and ensure Staff and Volunteers have an understanding of the environmental factors that affect us.

We will continue to develop Staff and Volunteer awareness of sustainability practices and encourage the recycling of used materials, passing as many re-usable items as possible to other museums or community organisations.

We will contribute responsibly to the social, cultural and economic vitality of the local area and ensure materials and supplies for all activities are sourced from local sustainable suppliers or local suppliers where possible.

We will identify Key Performance Indicators to monitor and measure our sustainable practices.

We will ensure that we are a sustainable tourist attraction and inform and educate our visitors about the local environment and Australia's natural history.

We will provide enjoyable experiences for our visitors and provide information about our history and our local environment through our displays, our public programs and our research outputs.

We will use our collections for research, and make them available to scientists and other researchers as appropriate.

The exhibitions developed for the Museum main Stage 3 building will tell the story of the Australian continent's 4.5-billion-year evolution through deep time, the land and its biota, including the effects of the six major extinctions. Visitors will be encouraged to reflect on how everything in nature is inter-connected, how Mankind has altered the Earth's natural rhythms, our reliance on water and minerals taken from the Earth for survival, and the need to protect the world's resources for future generations. The final message will be that the Earth is fragile and ever-changing, and that life is ever-evolving.

We will work with other museums and like-minded organisations where a partnership is mutually beneficial to achieve each organisation's long-term objectives and enhance visitor experiences.

Members of the public, Staff and Volunteers are invited to make comments or submit ideas about how the Museum can improve its commitment to sustainability. Address comments and ideas to Trish Sloan, Operations Manager, Australian Age of Dinosaurs.

5.3 EXCERPT FROM THE MUSEUM'S ENVIRONMENTAL MANAGEMENT PLAN

OUR ENVIRONMENTAL AIMS AND **OBJECTIVES**

The Museum's environmental aims and objectives are based on the Museum's Environmental Policy (refer to *appendices*) as adopted by the Board of Australian Age of Dinosaurs Limited in 2015.

OUR AIMS
The Museum aims to take a leading role in defining best sustainability practice to minimise the environmental impacts of the Museum's operations and will set its own appropriate and demanding standards where none exist.

OUR OBJECTIVES
To meet our environmental aim the Museum will:

- meet the current and future national environmental legislative and regulatory requirements and continue to work towards attaining international environmental requirements
- adopt best operational practices to reduce environmental impacts of museum programs and activities
- measure and take action to reduce the carbon footprint of the Museum's programs and activities; ensure all Museum buildings (present and future) are suited to the climate and have the ability to adapt to environmental change
- monitor, manage and minimise the use of energy and water on The Jump-Up
- minimise the environmental impact of associated travel with our venues and business (where possible)
- minimise the amount of waste produced by the Museum and promote greater reuse and recycling to staff, visitors and volunteers
- ensure there are no long-term environmental or cultural impacts from the operation of the Museum
- ensure environmental (including climate change) criteria are taken into account in the procurement of goods and services (eg bulk purchasing)
- consider environmental factors in the Museum's decision making including giving due consideration to environmental issues and energy performance in the construction, refurbishment and the use of buildings on The Jump-Up and
- encourage and develop our staff, visitors, volunteers and stakeholders to conduct their activities in an environmentally responsible manner.

ENVIRONMENTAL **IMPROVEMENTS**

Current environmental improvements

Solar panels

The Museum is working towards installing solar panels on all its buildings. currently solar panels are installed on the Amenities building, Dinosaur Canyon Outpost and the Noble Express shuttle buses.

Rainwater tanks and dam water

The Museum, including Maloney Lodge, is not connected to mains water supply. Potable water is taken from rainwater tanks located at each facility and non-potable water from the Museum dam for showers, cleaning etc.

Planned environmental improvements

In the next 12 months the Museum's main environmental objective is to acquire a Dark-Sky Sanctuary accreditation for The Jump-Up through the International Dark-Sky Association. While many people are familiar with air, water and land pollution, light pollution or the excessive use of artificial light can also have a serious environmental consequence to wildlife and the climate. According to the 2016 study *World Atlas of Artificial Night Sky Brightness*, 80% of the world's population lives under skyglow. In the United States and Europe 99%, of the public can't experience a natural night. This widespread use of artificial light is having a lasting impact on wildlife, particularly nocturnal animals, as predators use light to hunt and prey species use darkness as cover. Near urban centres, cloudy skies are now hundreds, or even thousands, of times brighter than they were 200 years ago. Glare from artificial lights can also impact wetland habitats that are home to amphibians, such as frogs and toads whose nighttime croaking is part of the breeding ritual. Artificial lights disrupt this nocturnal activity, interfering with reproduction and reducing populations. Lastly, lighting that emits too much light or shines when and where it's not needed is wasteful. Wasting energy has huge economic and environmental consequences.

Under the Dark-Sky Association criteria only areas that have exceptional quality of starry nights and a nocturnal environment (that is protected for its scientific, natural or educational value, its cultural heritage or public enjoyment) can qualify as a Dark-Sky Sanctuary.

A sanctuary differs from a Dark-Sky Park or Dark-Sky Reserve in that it is typically situated in a very remote location with few nearby threats to the quality of its dark night skies and it does not otherwise meet the requirements for designation as a park or reserve. The typical geographic isolation of Dark-Sky Sanctuaries significantly limits opportunities for public outreach, so a sanctuary designation is specifically designed to increase awareness of these fragile sites and promote their long-term conservation.

The Jump-Up night skies are exceptionally clear and dark as there is no light pollution from human activity or urban centres – as substantiated through extensive light readings of the night sky taken over the last two years. Sky-quality measurements have averaged between 20 and 22 MPSAS, and over 64 nights the data recorded exceeded 21.75 MPSAS. The Jump-Up is on par with the recently certified International Dark-Sky Sanctuary of Aotea / Great Barrier Island in New Zealand.

MUSEUM LIGHTING PLAN

This Lighting Plan must be submitted with any development application by the Museum pursuant to part 2 of the Winton Shire Planning Scheme, assessable against the Rural Zone Code. This Lighting Plan must comply with the Museum's Lighting Management Plan and be approved by the Business Development Manager prior to implementation.

Sketch proposed lighting locations and types

Location of lighting _____ Date _____

Mounting height of all proposed and existing luminaries.

Describe the type of light source planned including power (watts), light output (lumens) and colour temperature.

Detail all light shielding for compliance against the Lighting Management Plan.

PUBLIC NIGHT SKY VIEWING AREA

In a world where you are more likely to see a movie star than Alpha Centauri come and enjoy an Outback starry night on The Jump-Up.

The Public Night Sky Viewing Area is the perfect place to enjoy some of the **darkest skies** in the world.

The viewing area is free, open year round and located at the base of The Jump-Up. Bring your telescope, picnic and enjoy our spectacular **southern skies!**

australianageofdinosaurs.com


NO BOUNDARIES
AUSTRALIANAGEOFDINOSAURS.COM
Pisces
Cetus
Aquarius
Sculptor
Piscis Austrinus
Eridanus
Capricornus
Phoenix
Grus
Macroscopium
Eridanus
Indus
Aquila
Tucana
Sagittarius
Reticulum
Hydrus
Pavo
Lepus
Caelum
Scutum
Dorado
Orion
Octans
Canis Major
Pictor
Volans
Chamaeleon
Serpens
Ara
Scorpius
Puppis
Musca
Triangulum Aus.
Ophiuchus
Circinus
Lupus
Monoceros
Crux
Vela
Centaurus
Libra
Pyxis
Hydra
Corvus
Sextans
Crater
Virgo
PRISTINE SKIES IN A UNIQUE LOCATION
THE STAR GALLERY
A FREE DARK-SKY VIEWING AREA
AUSTRALIAN AGE OF DINOSAURS, THE JUMP-UP

WHAT IS **LIGHT POLLUTION?**

Light pollution is excessive, misdirected or obtrusive artificial (usually outdoor) light. This inappropriate or excessive use of artificial light can have serious environmental consequences for humans, safety, wildlife and our climate.

TYPES OF LIGHT POLLUTION

LIGHT TRESPASS
Light falling where it is not intended or needed.

SKYGLOW
Brightening of the night sky over inhabited areas.

GLARE
Excessive brightness that causes visual discomfort.

LIGHT CLUTTER
Bright, confusing and excessive groupings of light sources .

While artificial lights disrupt the natural day-night pattern there are practical solutions everyone can implement, to combat light pollution.

4 WAYS YOU CAN MAKE A DIFFERENCE

1. **INSTALL** lighting only when and where it is needed.
2. **USE** energy-saving features such as dimmers and motion sensors on outdoor lights.
3. **SHIELD** your lighting so light shines down, not up.
4. **EDUCATE** your friends and colleagues about the importance of good lighting for our health, economy and environment.

13.8 Ga (billion years) ago
THE BIG BANG
Beginning of space and time

13.3 Ga (billion years) ago
MASS STAR FORMATION

11 Ga ago
STAR FORMATION RATE PEAKS

10.4 Ga ago
UNIVERSE BECOMES HABITABLE
First life-friendly star systems emerge

7.5 Ga ago
MOST POWERFUL GAMMA-RAY BURST EVER OBSERVED BY HUMANS

4.4 Ga ago
OCEANS FORM ON EARTH
Asteroids bring water to Earth

3 Ga ago
CYANOBACTERIA DEVELOP TRUE PHOTOSYNTHESIS
Life begins to produce oxygen

2.5 Ga ago
GREAT OXYGENATION EVENT
Bacterially produced oxygen starts to accumulate in the atmosphere

1.4 Ga ago
POPULATION OF STROMATOLITES RAPIDLY RISE

540-529 Mya ago
CAMBRIAN EXPLOSION
Exponential diversification of life

225 Mya ago
FIRST MAMMALS

66 Mya ago
CRETACEOUS EXTINCTION EVENT
75% of all species go extinct

2.2 Mya ago
FIRST MEMBERS OF GENUS HOMO APPEAR

13.5 Ga ago
FIRST BLACK HOLES FORM

13.2 Ga ago
FIRST GALAXIES FORM

11 Ga ago
UNIVERSE STARTS TO COOL
Temperatures average around 13,000 K

8.8 Ga ago
MILKY WAY'S THIN DISK STARTS TO FORM

5.5 Ga ago
MILKY WAY BECOMES A SPIRAL GALAXY

4.2 Ga ago
LIFE EMERGES ON EARTH

3.1 Ga ago
FIRST LAND BACTERIA

2.5 Ga ago
MOVEMENT OF THE TECTONIC PLATES COMMENCES

1.6 Ga ago
MITOCHONDRIA ASSIMILATE INTO EUKARYOTIC CELLS

850 Mya (million years ago)
POPULATION OF STROMATOLITES STARTS TO DECLINE

445 Mya ago
ORDOVICIAN EXTINCTION EVENT

231 Mya ago
FIRST DINOSAURS

80 Mya ago
AUSTRALIA SPLITS FROM ANTARCTICA

2.5 Mya ago
CURRENT ICE AGE BEGINS

AUSTRALIAN AGE OF **DINOSAURS**

MUSEUM OF NATURAL HISTORY

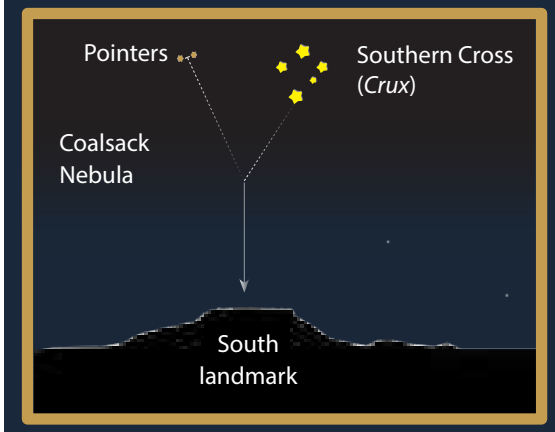
Looking to the STARS

ENJOY THE DARKNESS

It can take your eyes a while to adjust fully to the darkness. It is best to get comfy and turn off mobile phones, car lights and flashlights. If you have to use a light use a red light as this will not impact vision as much as white. The galaxy that contains our own solar system, the **MILKY WAY,** is especially easy to see in Australia. The galaxy appears from Earth as a band of light formed from stars that cannot be individually distinguished by the naked eye.

FINDING SOUTH

THE SOUTHERN CROSS or *Crux* comprises circumpolar stars that are visible from most locations in the Southern Hemisphere year-round. To find south draw a line perpendicular to the halfway point between the two pointer stars. Where that line meets the line formed by the two most widely separated stars in the Southern Cross is the south point in the sky. From the pole drop a line straight down to the horizon.



australianageofdinosaurs.com

THE MOON is the Earth's only permanent natural satellite, and formed around 4.51 billions years ago – not long after the Earth.

Next to the Southern Cross, **THE EMU** is one of the few night-sky features made up of darker patches of sky rather than the stars themselves. These patches are created by the dust of the Coalsack Nebula and other dark dusty trails obscuring the light of stars that exist behind them.

The Steering Wheel

Looking to the Stars

The Gondwana Stars committee are preparing the Museum's application for The Jump-Up to become an International Dark-Sky Sanctuary (IDSS). To become an IDSS the Museum must provide evidence that The Jump-Up has exceptionally dark-skies as recorded by the Sky Quality Meters in place on The Jump-Up. For more information, have a chin-wag with Kate!

Ways to celebrate Dark-Sky Week

1. During International Dark-Sky Week, get together with friends and family and go outside at night. A lot of us don't take the opportunity to experience the night-time environment. Go outside, look up and look around. Lots of interesting stuff is happening during the night hours. Go explore! Better yet, visit one of our International Dark-Sky Places!

2. Help spread the word about light pollution and the importance of dark skies. This week is a great excuse to talk with friends, family, neighbours, your homeowner's association or government representatives about why protecting our night environment is so crucial. We have Dark-Sky Week resources to help start the conversation.

3. Become a citizen scientist and collect data about the night sky in your neighbourhood for Globe at Night. It's fun, easy and you'll be helping scientists across the globe better understand the threat of light pollution to our planet. The April campaign has already started, so check it out now.

4. Stopping light pollution isn't just about seeing the stars. There are other important things at stake too. Use this week to take the time to learn more about the effect of artificial light at night on human health, the environment, energy waste, crime and safety, and our heritage of night skies.

STAFF AND VOLUNTEER *photos of The Jump-Up night-sky to feature in the IDSS application. If you'd like to contribute towards making the application AMAZE-BALLS!, then talk to Trish to arrange access to The Jump-Up after hours.*

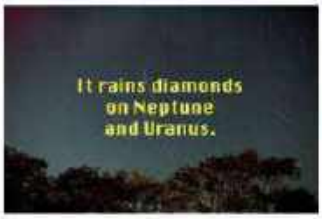
EXCERPTS FROM THE MUSEUM'S STAFF NEWSLETTER: THE STEERING WHEEL (JUNE 2018)

The Steering Wheel

Outback Driving Tips!

When driving on roads in the Outback please take plenty of water and delicious snacks. You never what will happen eg flat tyres or car break downs. Send a text or leave a message at home and let someone know where you are going, just in case. ***Outback Queensland has claimed lives!***

Setting it straight!



Did you ever wonder if this was true? Thanks to Kate, our Starry Guru, we discover the truth!

In 2017 a team from the USA, the UK and Germany recreated conditions found deep inside the icy giant planets of Uranus and Neptune and watched as tiny diamonds formed. To create the 'diamond rain', scientists used a sheet of polystyrene which contains similar intense quantities of carbon and then shocked it with extreme soundwaves to recreate the high pressure of the outer planets.

The diamonds form in the hydrocarbon-rich oceans that cover the gas giants' solid cores. Scientists have long speculated that the extreme pressures in this region might split those molecules into atoms of hydrogen and carbon, the latter of which then crystallise to form diamonds.

From these experiments it is likely that the extreme high pressures on Neptune and Uranus create diamond rain, that then collects in glittering masses around the core.

The roster has changed!

Trish keeps going cross-eyed when completing the roster, so it has now changed!

Each department will have its own colour.

It's on trial for August!

C
Q
DC
L
R

FUN FACTS

In the Café ~ 65 loaves of bread were used over 10 days

The Noble Express shuttle drivers have completed ~96 tours in six days

From 23 June to 11 July Dinosaur Stampede hosted 2,896 visitors

From 23 June to 11 July the Museum hosted 6,502 visitors

WOW!

The Café went through 60 litres of milk in two days!

Photo by Tom Beeston

EXCERPTS FROM THE MUSEUM'S STAFF NEWSLETTER: THE STEERING WHEEL (JULY 2018)

The Steering Wheel

Starry goodness with Kate...

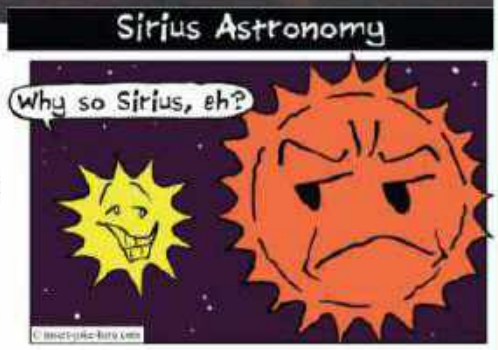
The pale blue dot of Earth

This image of Earth is one of 60 frames taken by the Voyager 1 spacecraft on 14 February 1990 from a distance of more than 6 billion kilometres and about 32 degrees above the ecliptic plane. In the image the Earth is a mere point of light, a crescent only 0.12 pixel in size. Our planet was caught in the centre of one of the scattered light rays resulting from taking the image so close to the Sun. This image is part of Voyager 1's final photographic assignments which captured - family portraits of the Sun and planets.

Look again at that dot. That's here. That's home. That's us. On it everyone you love, everyone you know, everyone you ever heard of, every human being who ever was, lived out their lives. The aggregate of our joy and suffering, thousands of confident religions, ideologies, and economic doctrines, every hunter and forager, every hero and coward, every creator and destroyer of civilization, every king and peasant, every young couple in love, every mother and father, hopeful child, inventor and explorer, every teacher of morals, every corrupt politician, every "superstar," every "supreme leader," every saint and sinner in the history of our species lived there --on a mote of dust suspended in a sunbeam.

The Earth is a very small stage in a vast cosmic arena. Think of the rivers of blood spilled by all those generals and emperors so that, in glory and triumph, they could become the momentary masters of a fraction of a dot. Think of the endless cruelties visited by the inhabitants of one corner of this pixel on the scarcely distinguishable inhabitants of some other corner, how frequent their misunderstandings, how eager they are to kill one another, how fervent their hatreds.

Our posturing's, our imagined self-importance, the delusion that we have some privileged position in the Universe, are challenged by this point of pale light. Our planet is a lonely speck in the great enveloping cosmic dark. In our obscurity, in all this vastness, there is no hint that help will come from elsewhere to save us from ourselves.

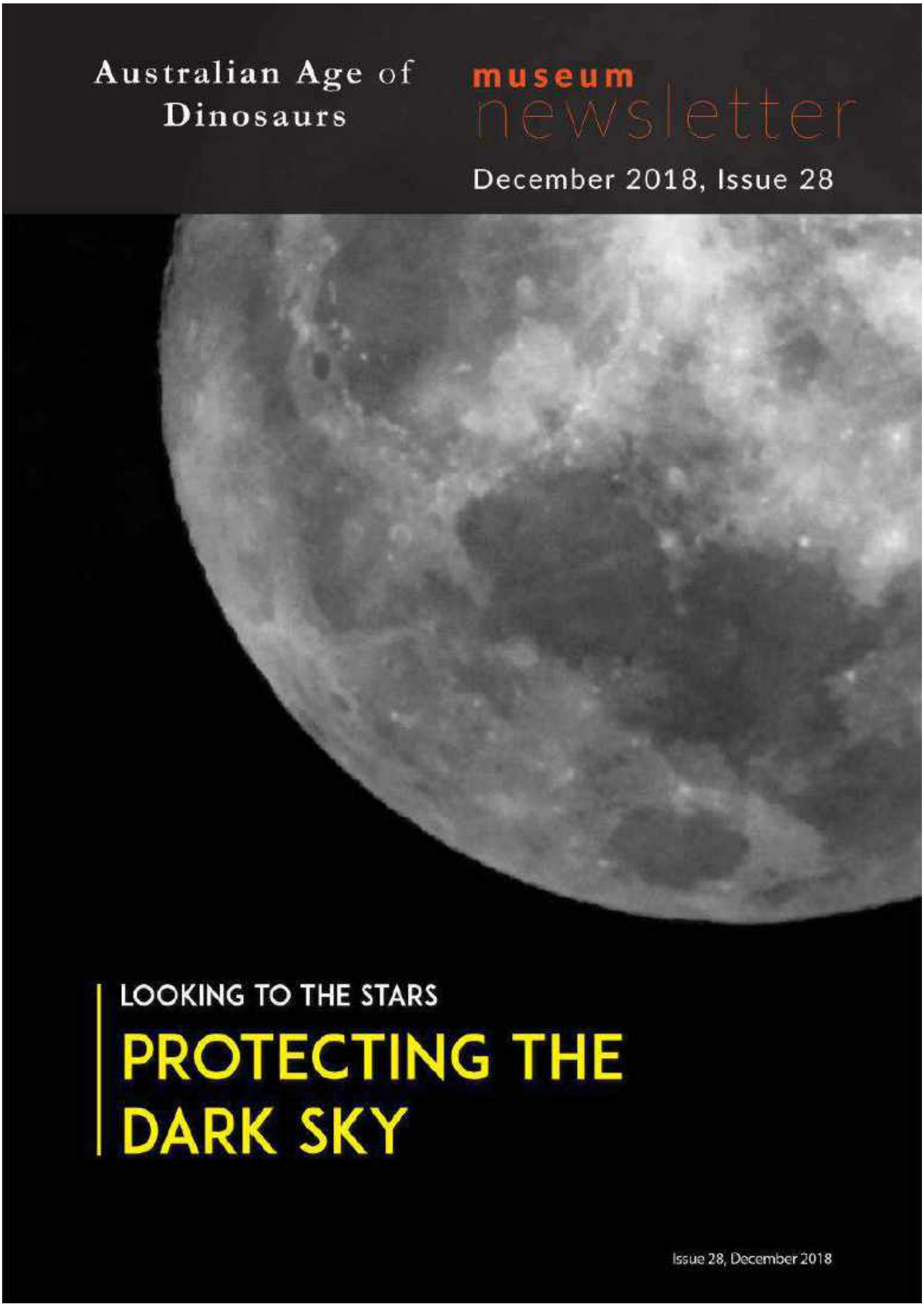


The Earth is the only world known so far to harbor life. There is nowhere else, at least in the near future, to which our species could migrate. Visit, yes. Settle, not yet. Like it or not, for the moment the Earth is where we make our stand.

It has been said that astronomy is a humbling and character-building experience. There is perhaps no better demonstration of the folly of human conceits than this distant image of our tiny world. To me, it underscores our responsibility to deal more kindly with one another, and to preserve and cherish the pale blue dot, the only home we've ever known.

-- Carl Sagan, *Pale Blue Dot*, 1994

EXCERPT FROM THE MUSEUM'S MEMBERSHIP NEWSLETTER: LOOKING TO THE STARS: PROTECTING THE DARK SKY (DEC 2018)



EXCERPT FROM THE MUSEUM'S MEMBERSHIP NEWSLETTER: LOOKING TO THE STARS: PROTECTING THE DARK SKY (DEC 2018)

OUR MISSION

The Museum has been operating on The Jump-Up for almost ten years and is focused on scientific research, education and conservation of Australian Natural History. The Museum is working towards becoming a sustainability champion to build a dynamic destination within Outback Queensland that will be the catalyst for ongoing growth and development across the region. As a tourism operator in natural areas, the Museum is committed to providing and developing well-managed sustainable practices and high-quality nature-based tourism experiences, now and into the future.

PUBLIC NIGHT-SKY VIEWING AREA

To this end, the Museum has set aside an area at the base of The Jump-Up, called the Public Night-Sky Viewing Area as the perfect place to enjoy some of the darkest skies in the world. The viewing area is free and open year-round (though camping is prohibited). The viewing area is one of many initiatives the Museum plans to implement to create sustainable summer tourism products that increase visitation, as well as appreciation for the natural beauty found only within Central West Queensland.

PROTECTING THE DARK SKIES

The extraordinary dark skies above The Jump-Up are an important natural resource that have been included in the Museum's policy development for several years. This includes the Environmental Policy (2015) statement to commit to "setting appropriate and challenging environmental improvement targets by regularly reviewing progress and continually improving upon minimising our operational environmental impact." Within the Museum's Charter for Sustainability and Responsible Tourism (2015) the Museum stated that "we will

WHAT IS LIGHT POLLUTION?

Light pollution is excessive, misdirected or obtrusive artificial (usually outdoor) light. This inappropriate or excessive use of artificial light can have serious environmental consequences for humans, safety, wildlife and our climate.

TYPES OF LIGHT POLLUTION

LIGHT TRESPASS
Light falling where it is not intended or needed.

SKYGLOW
Brightening of the night sky over inhabited areas.

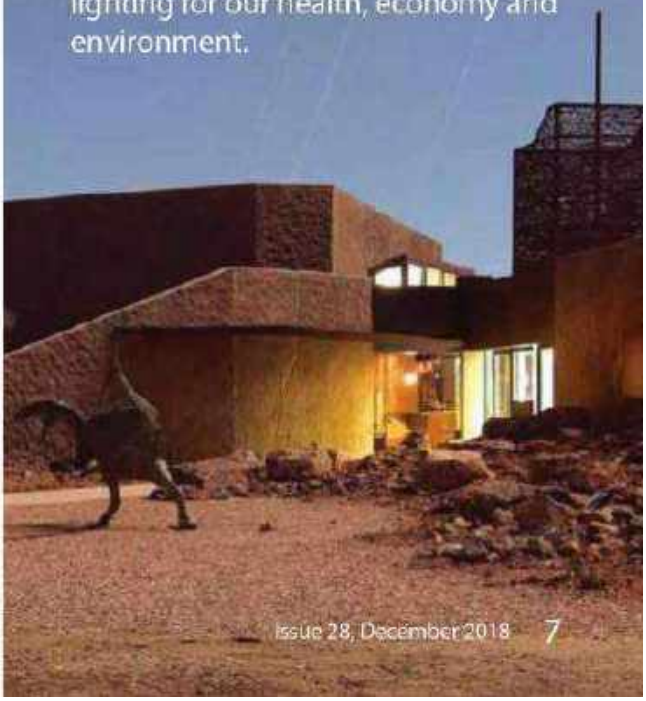
GLARE
Excessive brightness that causes visual discomfort.

LIGHT CLUTTER
Bright, confusing and excessive groupings of light sources.

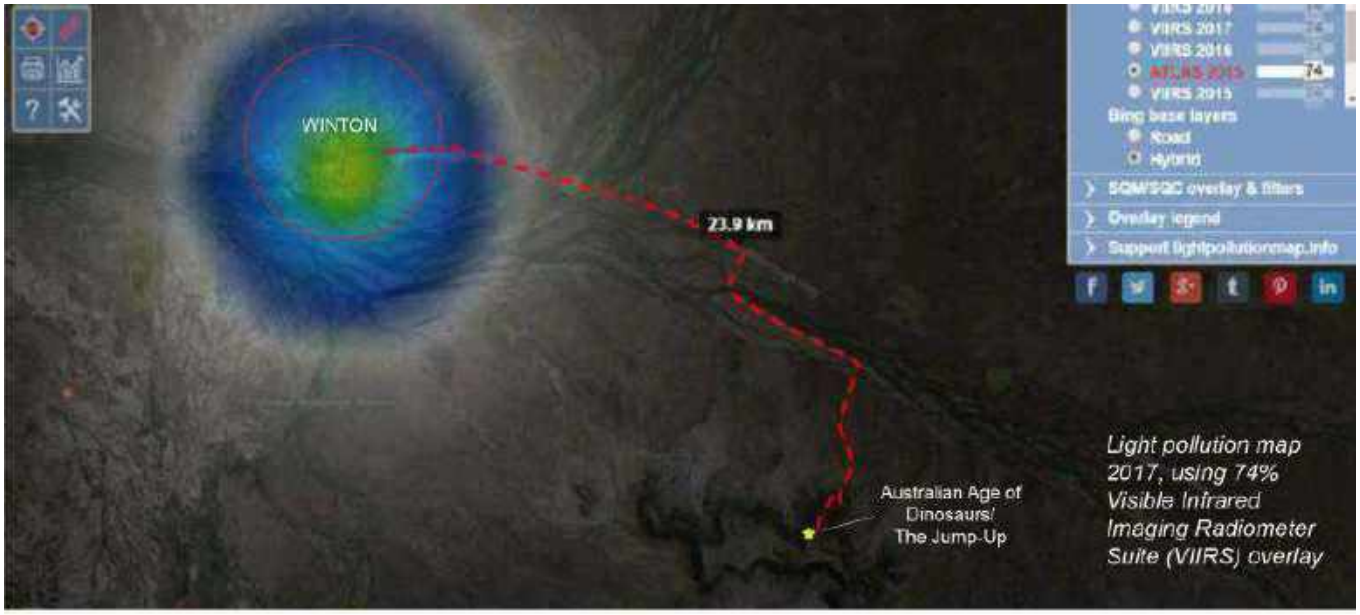
While artificial lights disrupt the natural day-night pattern there are practical solutions everyone can implement, to combat light pollution.

4 WAYS YOU CAN MAKE A DIFFERENCE

1. INSTALL lighting only when and where it is needed.
2. USE energy saving features such as dimmers and motion sensors on outdoor lights.
3. SHIELD your lighting so light shines down, not up.
4. EDUCATE your friends and colleagues about the importance of good lighting for our health, economy and environment.



EXCERPT FROM THE MUSEUM'S MEMBERSHIP NEWSLETTER: LOOKING TO THE STARS: PROTECTING THE DARK SKY (DEC 2018)



Light pollution map 2017, using 74% Visible Infrared Imaging Radiometer Suite (VIIRS) overlay

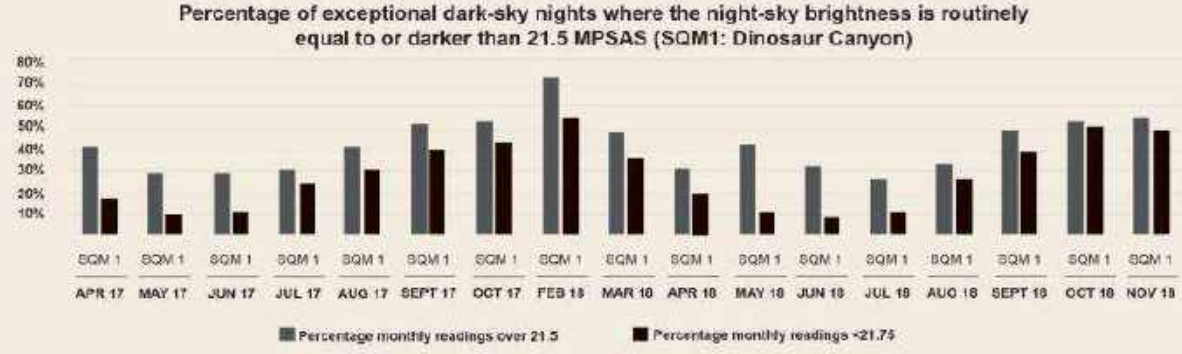
ensure that sustainability principles are a prime drive of the Museum's development project and that energy efficiency options are considered thoroughly." Within this Charter the Museum went on to pledge to "... work with external agencies to ensure best practice in the management of our resources and ensure Staff and Volunteers have an understanding of the environmental factors that affect us."

From these documents the practical requirements necessary to protect the dark skys above The Jump-Up have been implemented through the identification of activity risks, mitigation measures, emission reduction plans, best-practice initiatives and improvements (including the planned accreditation of The Jump-Up as a Dark-Sky Sanctuary) within the Museum's Environmental Management Plan (2018).

LIGHT READINGS

Light readings from Dinosaur Canyon and the Public Night-Sky Viewing Area have been recorded since 2017. Sky quality measurements have been averaged from 21:00 and 04:00 each night into monthly results. Over 17 months the percentage of dark-sky nights with results equal to or darker than 21.5 magnitude per square arcsecond (MPSAS) are displayed in the graph below. The darkest recorded night at Dinosaur Canyon occurred on 20 October July 2017 at 22.46 MPSAS. These results indicate that The Jump-Up is on par with the recently accredited International Dark-Sky Sanctuary, the Great Barrier Island in New Zealand.

To read more information about preserving the dark skies in your region, click here.



THE DARK-SKY WEBPAGE: australianageofdinosaurs.com

HOME / AUSTRALIAN AGE OF DINOSAURS | THE DARK SKY

THE DARK SKY

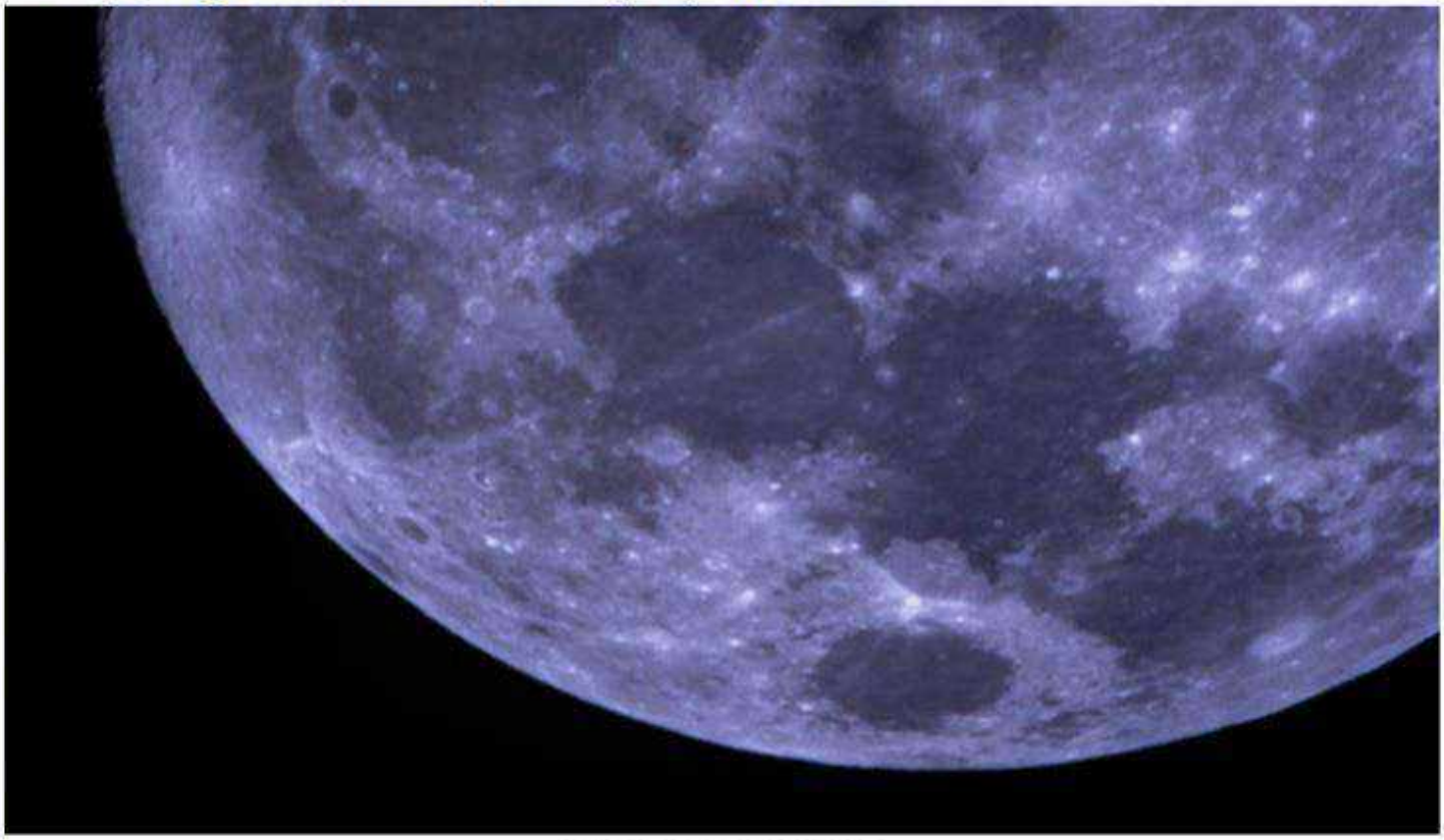
Outback Queensland draws visitors from all over the world to admire the natural environment, from the flat plains of the Channel Country to the mesa formations of the Vindex Ranges. As the Museum's position atop The Jump-Up is bereft of population and light pollution it is the perfect spot to stargaze.

Our galaxy has hundreds of billions of stars and stretches 100,000 light years across. When viewing the Milky Way from The Jump-Up what you are actually seeing is the breadth of our spiral galaxy. Earth is located about two-thirds of the way out from the centre of the galaxy in one of the spiral arms known as the Orion Arm.

When on The Jump-Up take time to find the parts of the Milky Way which are dark, areas where stars have been blocked out by dark nebula's. These nebula's are accumulations of gas and dust so thick that we can't see through them. These regions are important because, eventually, the dust will collapse in on itself and become a stellar nursery where new stars are born. Come and see the beauty of the southern night sky, on show in the dark skies above The Jump-Up.

Go stargazing and love astronomy at the Museum's Star Gallery!

The Star Gallery is the perfect place to enjoy some of the darkest skies in the world. The viewing area is free, open year-round and located at the base of The Jump-Up. Bring your telescope, binoculars, picnic and enjoy our spectacular southern skies!



Download our poster or brochure for more details:

NEXT - OUR HISTORY

SECTION 6. CONCLUSION

The Jump-Up is a truly exceptional location. As a sprawling and ancient mesa in very remote Australia it is home to a diverse array of fauna and flora as well as unobstructed views of the surrounding Channel Country. The geographical location, the absence of densely populated areas and light pollution make The Jump-Up the perfect place to admire the thousands of stars in the night sky. While The Jump-Up is very remote it is easily accessible and within range of facilities while also being sufficiently removed from the Winton township to ensure the integrity of the night sky. Regular night-sky talks are held on The Jump-Up as part of the Museum's commitment to dark-sky outreach, in 2018 this equated to 40 groups comprised of 811 visitors.

Through the compilation and adoption of a formalised Lighting Management Plan the Museum has committed to the long-term integrity and protection of the dark skies above The Jump-Up. To this end a public night-sky viewing area, The Star Gallery, has been made available to visitors year-round and the future Gondwana Stars Observatory will be developed and expanded into the future. The Museum will continue to develop relevant tours and educational programs focused on understanding the benefits of truly dark skies to the environment and our own wellbeing.

The Night-Sky Brightness Study demonstrates The Jump-Up's exceptional dark-sky conditions with daily and monthly average measurements equal to or greater that the requisite 21.5 mpsas in the visual band as well as demonstrable measurements equal to or greater than 21.75 mpsas. The Jump-Up night sky will continue to be monitored and reported annually via the Museum’s website, through posts on the Globe at Night website and the Museum’s annual report to the International Dark-Sky Association. Additional Sky Quality Meters have also been purchased to better catalogue the entire jump-up site and these results will also be monitored and reported.

By accepting this proposal for The Jump-Up Dark-Sky Sanctuary in Central West Queensland, the IDA Committee will greatly assist the Museum in protecting The Jump-Up's dark skies, promoting their protection through unique tourism products and creating a catalyst for other astro-tourism products in Queensland.

APPENDICES

Australian Age of Dinosaurs Limited

Our Milky Way is ablaze with dust. When light reflects off surfaces or particles it can become polarised which, means that its electric fields line up together in the same direction.

CONTENTS

6 EXHIBITIONS & TOURS

6.6 Tour Procedures – Dark-Sky Interpretation

6.6.1 Introduction

In our current age of science and technology it is easy to forget that a mere hundred years ago computers didn't exist and space travel was considered science fiction. As a science, astronomy is unique as amateurs can work alongside professionals to further our knowledge of the universe.

6.6.1.1 The basics

Just as the Earth is an ordinary planet, so the Sun is an ordinary star. All the stars you can see on a clear night are themselves suns, some of them far larger, hotter and more luminous than ours. Different stars appear as certain colours, based on their spectral types (like a Bunsen burner) – red/orange stars are considered 'cool' (with a surface temperature from 2,600°C–4,000°C) and blue/white stars are considered 'hot' (with a surface temperature from 25,000°C–80,000°C).

Star distances are so great that ordinary units of measurements, such as a kilometre, are too short. But, there is a solution. As light does not move instantaneously and flashes at ~299,000km per second in a year it can cover around 9,500,000 million kilometres. It is this distance that is termed the light year. As this is a measurement of distance not time it follows that beyond our solar system our view of the universe becomes 'out of date'. For example, we see Rigel as it used to be 900 years ago as the light that is being emitted is received on Earth, so if it was suddenly extinguished we would not know for another 900 years. Hence, technically, when you look up at the night sky, you are looking up into the past.

An important fact to remember is that stars in any particular constellation may not actually be associated with each other but merely happen to lie in a similar direction, as seen from Earth. For example, in the constellation of Orion, out of the two leading stars (Betelgeuse and Rigel), Rigel is actually closer to Earth than to Betelgeuse.

6.6.2 Best viewing features in the Southern Hemisphere

SUMMER (Dec, Jan, Feb) Dark-Sky Tour start time from 8.15pm
Canis Major, Crux (comes up late in Dec from 10:30pm), Orion, Pisces, Pleiades (M45), Taurus

AUTUMN (Mar, Apr, May) Dark-Sky Tour time from 7.00pm–7.45pm
Cancer, Canis Major, Crux, Gemini, Leo, Orion, Taurus (not in May), zodiacal light to the east

WINTER (Jun, Jul, Aug) Dark-Sky Tour time from 6.45pm–7.15pm
Aquila, Boötes, Crux, Libra, Magellanic clouds, Sagittarius, Scorpio, The Emu, Virgo

SPRING (Sept, Oct, Nov) Dark-Sky Tour start time from 7.15pm–8pm
Aquarius, Capricorn, Crux (Sept–Oct), Cygnus, Lyra, Pegasus (Andromeda Galaxy, Oct–

Nov), Sagittarius, Scorpio (Sept–Oct), the Emu

6.6.3 A Dark-Sky Sanctuary

The Museum is in the process of applying for The Jump-Up to become an International Dark-Sky Sanctuary (IDSS) through the International Dark-Sky Places (IDSP) program. The program is focused on protecting and promoting places with exceptional or distinguished quality of starry nights and a nocturnal environment that is protected for its scientific, natural or educational value, its cultural heritage and/or public enjoyment. Certification through this program will encourage other communities, parks and protected areas around the world to preserve and protect dark sites through responsible lighting polices and public education on public or private land.

There are SIX types of designations offered by the IDSP program:

1. **International Dark-Sky Communities** (cities and towns)
2. **International Dark-Sky Parks** (publicly or privately owned spaces)
3. **International Dark-Sky Reserves** (dark core zone surrounded by a populated periphery)
4. **International Dark-Sky Sanctuaries** (the most remote and darkest)
5. **Urban Night Sky Places** (site surrounded by large urban environs)
6. **Dark-Sky Friendly Developments of Distinction** (master planned communities that promote natural night skies)

6.6.3.1 Lighting compliance

In accordance with the IDSP program, all lighting at the Museum is compliant with the requirements necessary for an IDSS. Lighting is low impact, meaning it is low temperature and has minimal effect on the environment. On-site lighting is either low wattage, colour specific, shielded and/or time-specific. The Museum has a Lighting Management Plan (adopted by the AAODL Board, 2019), an AAOD Environmental Policy (adopted by the AAODL Board, 2015), a Charter for Sustainability and Responsible Tourism (2015) and an Environmental Management Plan (2018). These documents detail the Museum's lighting guidelines and overall approach to sustainable practices on The Jump-Up.

SPOTLIGHT: Light Pollution

Light pollution is excessive, misdirected or obtrusive artificial (usually outdoor) light. This inappropriate or excessive use of artificial light can have serious environmental consequences for humans, safety, wildlife and our climate.
Types of light pollution include:

a) Light trespass Light falling where it is not intended or needed.
b) Skyglow Brightening of the night sky over inhabited areas.
c) Glare Excessive brightness that causes visual discomfort.
d) Light clutter Bright confusing and excessive groupings of light sources.

To combat these types of light pollution there are four ways you can make a difference:

1. Install lighting only when and where it is needed.
2. Use energy saving features such as dimmers and motion sensors on lights.
3. Shield your lighting so lights shine down and not up.
4. Educate your friends and colleagues about the importance of good lighting for our health, economy and environment.

6.6.4 Time is relative

One lap around the galaxy is 250 million years. So, 95 million years (around the time dinosaurs roamed prehistoric Winton) is plenty of time for stars to shift positions in a very substantial way.

6.6.4.1 Past

Earth formed around 4.54 billion years ago (Ga). Volcanic outgassing created the primordial atmosphere and the ocean, although the early atmosphere contained little oxygen. While Earth was in its earliest stage, a massive collision with a developing planet the size of Mars, named Theia, threw up debris that eventually came to form the Moon. Over time the Earth cooled, causing the formation of a solid crust and liquid water on its surface.

After a few hundred million years star clusters were formed and began to disband. While the Earth would have originally been part of an open-star cluster, over time our Sun would have come to stand on its own. The sky from this point on would have looked similar to what it does today.

Around 95 million years ago, when dinosaurs roamed prehistoric Winton, the Moon was around 381,585km away from the Earth or 2,415km (0.8%~) closer to the Earth than it is today resulting in a day-night cycle of less than 23 hours. However, the Moon would not really appear much larger than it is today.

The Moon is gradually slowing down the spin of the Earth while the length of time the Moon takes to orbit the Earth is increasing. The Moon is also gradually moving away from the Earth at about 2–4cm per year.

6.6.4.2 Future

In the future stars will continue to die and new stars will appear. Sirius, the brightest star in the night sky, is moving closer to Earth and in the next 60,000 years will be a lot brighter. In fact it will be one of Earth's brightest stars for the next 210,000 years. The Moon will gradually move further away from the Earth, and as a result the Earth will become a little dimmer and the day-night cycle will increase. In the next thousand years the increase in greenhouse gases will cause the Earth's temperature to rise long after fossil fuels have been depleted.

The tilt of the Earth (caused by the gravity of the Moon and Sun) will decrease over the next 8,000 years resulting in the poles becoming less radiated and allowing more ice to form on the poles. As more ice forms the reflective surface will begin to cool the Earth.

The nearly circular orbit of the Earth around the Sun is smoothing out, so over the next 10,000 years there will be less variation in the seasons on Earth.

In about a billion years the Sun will turn into a giant red star, increasing energy output and pushing out into our solar system, evaporating all the water from the Earth.

6.6.5 The Moon

The Moon formed shortly after the Earth – around 4.51Ga. As the developing planet Theia collided with early Earth, the broken fragments formed a disk around the Earth (accretion disk) and the rubble eventually joined together, held in place by Earth's gravity, to form the Moon.

6.6.5.1 About the Moon

The Moon is the Earth's only permanent natural satellite and the largest planetary satellite (relative to planet size) that orbits a planet in the solar system.

The Moon does not emit its own light; the light we see is a reflection of the Sun's light.

Instead of a dark side of the Moon there is a far side, as the Moon is only visible to us from one side. This is due to the rotation of the Moon around the Earth, coinciding with the Earth's rotation.

The Moon is composed of two surface types:

1. Maria (Latin for 'seas'): The dark and relatively featureless lunar plains, clearly seen with the naked eye and once thought to be filled with water, are in fact vast solidified pools of ancient basaltic lava.
2. Lunar highlands: Higher than most maria and are the older, lighter-coloured regions of the Moon.

Maria
The maria are younger than the highlands at 3.8–3.2Ga and were formed from basaltic lava flows. These basalt lava flows occurred after the major crater-forming impact events that affected the highlands. They could have still been forming up to 0.8–1.0Ga. Some of the flows go for hundreds of kilometres, however the source is still a mystery as there are no obvious volcanoes on the Moon. One theory to explain this is that when the lava came to the surface it exited out of cracks and fissures rather than ruptures in the crust.

Lunar highlands
The lunar highlands are about 2.75km above the maria, and are older with an age of 4.4–4.5Ga. This high surface material formed by rising to the surface of an ancient magma ocean following accretion. Both maria and the lunar highlands have craters.

6.6.5.2 Craters on the Earth and the Moon

As the Earth travels around the Sun so do other planets and celestial bodies such as asteroids and comets. There are around 10,000 objects that travel across or near to the Earth's orbit and at least 850 of these objects are larger than 1km wide. While the Earth is only hit by two or three of these large objects every million years or so, these impacts, particularly from larger objects, can leave craters and lasting effects.

Impact cratering has significantly affected the Earth's surface and environment. Impacts that produce craters on terrestrial planets occur at hypervelocity, typically at speeds of several kilometres per second. Hypervelocity is over 3,000 metres per second (11,000km/h) and an impact at this speed can make even metals act like fluids.

Today there are very few obvious craters that can be seen on Earth, whereas the Moon has an abundance of impact craters covering its surface. On Earth the atmosphere may help to slow the break up, or else burn up, meteors before they reach the surface. The Moon, however, has very little atmosphere and less protection and is unable to slow objects as they approach the surface. Many of the craters on Earth are young, very large or were formed on stable continents that have not experienced much geological change.

6.6.5.3 Where are all the craters?

While there are at least 200 terrestrial impact structures on Earth, visual evidence of craters is minimal as the Earth is active with geological processes that alter its surface. These include:

Erosion through weathering and sedimentation means the Earth's landscape is in constant change. This is evident at the Museum as the top of The Jump-Up represents the Earth's surface millions of years ago before the low-lying country eroded away. Over time all that remained was the hard caprock surface, a reminder of the height of the Earth's surface. The Moon, on the other hand, has no atmosphere and no weather and therefore little erosion.

Volcanic activity such as lava flows and deposition of volcanic ash can also cover craters on Earth. This activity has covered at least 70% of the Earth's surface in basalt lava in the last 200Mya with most of this in the oceans. While the Moon originally had some volcanic activity that helped shape its surface it has been at least 3Ga since any volcanic activity occurred.

Tectonic plates cause buckling and deformation of the Earth's surface that can form mountains and move land masses. Sometimes dinosaur footprints are uncovered on the side of a rock wall or upside down; this is due to the movement of Earth's tectonic plates. The Moon has not had tectonic movements for billions of years.

6.6.6 Meteors and meteorites

A meteor is an asteroid or other object that burns and vaporizes upon entry into the Earth's atmosphere; meteors are commonly known as "shooting stars." If a meteor survives the plunge through the atmosphere and lands on the surface, it's known as a meteorite.

Impacts play a big part in the formation and evolution of our solar system. With the exception of stars that are made from gas and dust, everything else is formed due to impacts and accretion (gathering and joining) of solid objects. After dust and rock began to circle the Sun, over time they joined together to make bigger and bigger objects. Eventually, these objects would become protoplanets and later planets. Protoplanets tend to have hundreds of collisions with each other before becoming planets. One region of our solar system where accretion was not possible (due to the gravitational pull from the nearby planet Jupiter) is the rocky belt between Mars and Jupiter known as the asteroid belt.

6.6.6.1 Where do meteorites come from?

The majority of our meteorites come from the asteroid belt located between Mars and Jupiter. While it is rarer, meteorites also come from comets, the Moon and Mars.

Asteroids from the asteroid belt get sent into the inner solar system after collisions and gravitational interactions with Jupiter. If an asteroid strays from its orbit, it can be captured by the Earth's gravity.

6.6.6.2 Asteroid belt

This main asteroid belt (located between Mars and Jupiter) holds more than 200 asteroids larger than 100km in diameter. Scientists estimate the asteroid belt also contains between 1.1 million and 1.9 million asteroids larger than 1 km in diameter and millions of smaller ones. The asteroids are mainly planetary bodies that continuously smash into each other as a result of the gravitational effect from Jupiter and this is preventing them from becoming planets.

Ceres, a dwarf planet, is also located in the asteroid belt and at 950km in diameter makes up around a third of the mass of the asteroid belt. In the past decade, scientists have also identified a class of objects known as main belt asteroids, small rocky objects with tails. However, even if all the asteroids were combined they would still be smaller than the Moon.

6.6.6.3 Near Earth Asteroids (NEA)

There are over 9,000 Near Earth Asteroids (NEA) with an orbital trajectory that passes near to or over the Earth's orbit. As of 2018, asteroid 2010 RF12 is listed with the highest chance of impacting Earth, at 1 in 20 in 2095. At only 7m across, the asteroid does not pose a serious threat.

6.6.6.4 How many craters are on Earth and how many meteorites have hit the Earth?

Most meteors will burn up in the Earth's atmosphere before they even hit the ground. Calculating how many meteorites hit the Earth each year is difficult to determine. On a daily basis more than 100 tonnes of tiny particles hit the Earth and around once a year a car-sized meteor will enter the atmosphere, making an awesome fireball before burning up.

Every few million years a meteorite more than 1.5km in diameter will hit the Earth, threatening its inhabitants.

Approximately once every twenty million years a meteorite more than 5km in diameter will hit the Earth. The last known impact of an object of ~10km in diameter was at the extinction event 66 million years ago.

Large meteorites that hit Earth often leave an impact crater, though many have been covered over due to weathering processes. Australia has 27 confirmed impact craters.

6.6.6.5 Asteroids

Not all asteroids are the same. Asteroids are categorised according to their composition based on their thermal, physical and chemical formation.

The majority of asteroids in the asteroid belt are made up of rock and stone with a small percentage containing iron and nickel. The remaining asteroids contain a mix of these components along with carbon-rich materials.

6.6.6.6 Encounter velocity

The average encounter velocity is 19 kilometre per second (km/s) for asteroids and 70km/s for comets at the top of the Earth's atmosphere. The minimum speed a meteorite could reach Earth is 11km/s as encounter velocity is equal to escape velocity – the speed required for something to exit Earth and Earth's gravitational pull. This minimum speed is the same speed necessary for a rocket to launch from Earth. Note the speed of a bullet is about 1km/s.

While the Earth's atmosphere slows meteorites, celestial bodies with little gravity, like the Moon, are unable to slow the impact and the encounter velocity stays the same, at hypervelocity.

6.6.6.7 Comets

Comets originate from the Kuiper belt near Pluto or further out in the Oort cloud

and are made of ice and silicates. The giant outer planets have to potential to disturb a celestial body in the Kuiper belt and these interactions may result in the comet being projected into the inner solar system. Celestial bodies in the Oort cloud are too far out for our planets to be affected, but as the solar system travels around the galactic centre the gravity of other stars can affect celestial objects in the Oort cloud.

We have never observed the Oort cloud and the first confirmed observation of a body in the Kuiper belt only occurred in 1992.

It is quite hard to work out but it is estimated that about 10% of impacts on Earth are from comets.

Comets are typically only a few kilometres across. As a comet gets closer to the Sun the heat begins to vaporise the ices releasing gas and dust particles. This produces a fuzzy, luminous ball called a coma, typically one million kilometres in diameter. This can then extend behind the comet in a tail that can reach lengths of more than 100 million kilometres (almost the entire distance from the Earth to the Sun).

6.6.6.8 Fall vs find

Meteorites found after their fireball has been witnessed are called ‘falls’. Meteorites found long after their arrival, with an unknown origin, are called ‘finds’.

6.6.6.9 Why are meteorites important?

Meteorites are extremely important to science as they help us to understand the origins, composition and formation of the solar system. They are our major source of extraterrestrial material apart from Moon rocks retrieved during space missions. The Museum has five stone meteorites and one iron meteorite in its collection.

SPOTLIGHT: Space rocks

Meteor	The solid particle (meteoroid) that enters the atmosphere prior to burning up or landing on Earth as a meteorite. The burning trail is caused by melt ablation of the meteor's surface as it burns in the Earth's atmosphere.
Asteroid	A small rocky body orbiting the sun. Large numbers of these, ranging in size, are found between the orbits of Mars and Jupiter, though some have more eccentric orbits.
Bolides	Large meteoroids that form a fireball. Bolides usually explode or break up in the atmosphere creating a sonic boom.
Comet	A celestial object consisting of a nucleus of ice and dust and, when near the Sun, a ‘tail’ of gas and dust particles pointing away from the Sun.
Meteorite	Larger meteoroids that survive the Earth’s atmosphere and land on the Earth’s surface.

6.6.6.10 Desert Fireball Network

The Desert Fireball Network (DFN) is a network of cameras located across the Australian interior designed to track meteors entering Earth’s atmosphere with the aim of recovering meteorites. The program is based at Curtin University in Perth and has the support of NASA. So far 50 cameras are in use, covering 2.5 million km^2.

Images of the night sky are captured at intervals and the DFN team are alerted when a possible meteorite is detected. The images are then analysed to determine an approximate landing point and the mass of the meteorite.

The Museum aims to become part of this network forming a triangle with two neighbouring locations in Outback Queensland.

6.6.6.11 Mass extinction

Around 66Mya 85% of all species on Earth disappeared including dinosaurs (with the exception of modern-day birds). This extinction event is the boundary separating two geological time periods; the Cretaceous (when the majority of the Museum's dinosaurs are from) and the Tertiary (age of mammals).

In fossil records there is generally a slow evolution of simple to more complex species over a long period of time. There are also gaps in the fossil record where one group of fossilised species gives way to another species over a short period of time. For example, dinosaurs gave way to mammals from the Mesozoic to the Cenozoic Era.

Each era (such as the Mesozoic) is separated by the species found during this time (we are currently in the Cenozoic). So each era represents quite a different set of species. Each era is broken down into periods, eg the Mesozoic Era is broken down into Triassic, Jurassic and Cretaceous periods each representing smaller changes in the fossil records.

A buried impact crater, dated to 66Mya, was discovered in Mexico in 1980 and called the Chicxulub (CHICKS-uh-lub) crater. This crater measures180km in diameter and is believed to have been caused when a 10km-wide meteorite crashed into the Earth. An analysis of the soil revealed a layer of iridium-rich clay supporting the theory that a meteorite, of asteroid origin, hit the Earth 66Mya causing the mass extinction of all non-avian dinosaurs.

6.6.6.12 Did this wipe out the dinosaurs?

The meteorite that caused the Chicxulub crater would have hit the Earth at around 30km/s (or 40,000km/hr). On impact, masses of dust, rock and meteorite would have been thrown up into the atmosphere. The material would have then become heated so that the sky around the world was covered with fireballs (moving energy converts to explosive energy – the energy would have been a billion times that of the atomic bomb dropped on Hiroshima). An impact this size would have strewn debris all over the world, not just above the impact site. Alone, this debris would have heated the Earth's surface sufficiently to kill many plants and animals, while some more sheltered species would have survived, such as those in the ocean or underground. Once the fireballs returned to Earth fires would have erupted across the world.

The same soil layer that the iridium clay was found in also contains 70 billion tonnes of soot from millions of trees burnt down during the blazes that swept the Earth. So much dust entered the atmosphere that it blocked sunlight for months and possibly years, limiting the survival of species either directly (such as plants) or via the food chain.

When the dust and soot settled it blanketed the Earth and the surviving animals gave rise to the age of mammals. Humans may owe their very existence to an asteroid from space.

Many asteroids have their orbits passing through the inner solar system and across Earth's orbit. The majority are smaller than the one that impacted the Earth 66Mya. A meteorite impact like the one that caused the Chicxulub crater is very rare – around one in every 100 million years.

6.6.7 Star life cycles

6.6.7.1 How a star is born

Stars are born from nebulas or massive clouds of gas and dust. This occurs when small pieces of space dust start to join together and the massive clouds collapse in on themselves creating heat and attracting more particles, condensing the core to form a protostar.

A disk of dust forms around the young star and eventually, if enough density, pressure and temperature are present, starts emitting hydrogen fusion and a baby star is born.

The lifetime of a star depends on its size. Large stars burn their fuel quickly and have a shorter lifespan. Smaller stars burn much slower and can have a lifespan of several billion years.

Once the fuel has been used up stars expand and cool to become red giants. After this the size of the star will determine its end point. A typical star will have a peaceful ending throwing out its outer layers in a planetary nebula before becoming a white dwarf.

Massive stars will end in a supernova explosion and, depending on their size, become a neutron star and, for the more massive stars, a black hole.

6.6.7.2 We are made of star stuff

The elements that are produced in the core of a star are sent out into the universe at the end of a stars lifespan. Larger stars send out the heavier elements such as carbon, nitrogen, silica and oxygen. Hence humans, animals and dinosaurs are literally all made from stars.

6.6.7.3 Brown dwarfs

A brown dwarf is a protostar that does not have enough mass to start the nuclear fusion process.

6.6.7.4 White dwarf

A white dwarf is the stellar core remnants of an average-sized star that has used up all its nuclear energy. Eventually white dwarfs will cool and fade. This will be our Sun’s final life phase.

6.6.7.5 Red giant

A red giant is an expanded, cool-temperature star moving towards the end of its lifespan.

6.6.7.6 Supernova

A supernova occurs following a massive explosion, usually at the end of a giant star's lifespan. A supernova emits as much energy as a whole galaxy and lights up the sky (millions to billions times brighter than our Sun).There are two types of supernovas:

Type I This occurs in binary star systems in which gas from one star falls on to a white dwarf reigniting nuclear fusion and causing it to explode.

Type II This occurs in massive stars when the core collapses under

gravity leading to a massive explosion. This kind of supernova will leave behind neutron stars and black holes.

6.6.7.7 Neutron star

A neutron star is the end stage of a star's life after it explodes in a supernova. It is composed of mainly neutrons (combined protons and electrons) and is typically very dense ie a teaspoonful would weigh a million tonnes.

6.6.7.8 Pulsar

A pulsar is a type of neutron star that rotates rapidly and emits a beam of electromagnetic radiation. The beam is like a lighthouse and you can only see it when it is rotated towards Earth, creating a pulse of light.

6.6.7.9 Black hole

A black hole occurs at the end of a massive star's life after a supernova explosion. Following the explosion the gravity is so intense it overcomes physical forces ensuring nothing escapes, not even light.

6.6.8 The constellations of the Southern Hemisphere

6.6.8.1 Orion

Orion is a familiar constellation on the celestial equator and is often called the Hunter or, in Australia, the Saucepan (although this makes up only a part of the entire constellation).

Orion's Belt is formed by the stars Alnilam, Mintaka and Alnitak. The right shoulder of the Hunter is marked by Betelgeuse a bright red star (a red supergiant nearing the end of its life). Betelgeuse, is one of the largest stars we know of. It is about 1,000 times the mass of the Sun and 1,400 times larger. If we were to put Betelgeuse where the Sun is, it would extend out and engulf the first five planets (Mercury, Venus, Earth, Mars and Jupiter), although Saturn would be safe.

Betelgeuse is expected to end its life soon through a massive explosion (supernova). This supernova may have already happened as the star is 640 light years from us meaning that the light of an explosion will take another 640 years to arrive at Earth. The left shoulder of the Hunter is Bellatrix. The brightest star in Orion is Rigel (bright blue-white star) and is the Hunter's – left knee. The constellation is 'upside down' in the Southern Hemisphere.

All the stars in Orion are bright, young blue giants or supergiants (with the exception of Betelgeuse). These stars are typically hot, bright, fast-burning stars with a short (relatively speaking) lifespan.

The Orion Nebula is a star-forming region or a stellar nursery. The gas appears to us as beautiful colours of reds and greens (the ionised gas of stars forming green = oxygen, red = hydrogen). To find the Orion Nebula look straight up (Rigel direction and away from Betelgeuse) from Mintaka (middle belt star) and about halfway up is the sword with three brighter stars. The centre star is not a star – this is the Orion Nebula. There are four stars within the nebula, called the trapezium.

6.6.8.2 Canis Major

Canis Major, or Sirius – the dog star is host to the brightest star in our sky due to its proximity to Earth. Originally, Canis Major consisted of just two bright blue stars: Sirius A and Sirius B, the latter being the larger of the two.

Sirius is only 8.6 light years away from Earth and has a radius of 1.2 million km, which is roughly 71% greater than the radius of the Sun and 25 times brighter. Sirius is slowly moving closer to Earth and will gradually increase in brightness over the next 60,000 years, before it starts to recede again.

As the larger star, Sirius B used up all its fuel supply quickly and evolved into a red giant star before expelling its outer shell and becoming a white dwarf star around 120 million years ago. It is now considered to be a small companion dwarf star to Sirius A and is the nearest white dwarf star to Earth.

Every 50 years Sirius A and Sirius B approach each other causing huge magnetic storms between them, and spinning them faster as a result of their tidal forces getting stronger.

6.6.8.3 Crux (the Southern Cross)

Crux is probably the most recognisable constellation in the southern night sky and is also known as the Southern Cross. From Earth it is circumpolar as the constellation is visible to observers south of the latitude 25^{o}N. It is the smallest of all the constellations.

The four main stars that form the asterism (pattern of stars) are Alpha Crucis, Beta Crucis, Gamma Crucis and Delta Crucis, however, there are about 49 stars within the entire area of the constellation.

The brightest star in Crux is Alpha Crucis. This is a multiple or triple star system composed of two B class stars (hot blue stars) and a B class dwarf star (small blue star). There is a fourth star in this system but it is more distant and could just be in the line of sight. Lots of the stars we look at are actually double or multi-star systems where the stars are held together by a common centre of gravity.

The second-brightest star in Crux is Beta Crucis, or Mimosa, which is a blue giant. It was thought that this was a binary system – one in which two stars orbit around a common centre of mass. Beta Crucis is about 359 light years away.

Gamma Crucis is a red giant star and the third brightest in the constellation. It is an optical double star. It appears as though the component stars are located close together but they are actually nowhere near each other. The primary star is a red giant star 88 light years away and the secondary star is an orange giant star 228 light years away.

Delta Crucis is the fourth-brightest star in the constellation. It is a constellation and a subgiant.

6.6.8.4 Centaurus (the pointers)

The centaur's front legs are marked by two of the brightest stars in the sky: Alpha Centauri and Beta Centauri, also known as the pointers.

Alpha Centauri is a multiple-star system containing Alpha Centauri A, the third-brightest star seen from Earth, after Sirius and Canopus in Carina. This primary star is a yellow-white main sequence star belonging to the spectral type G2V, and is about 10% larger than the Sun. Alpha Centauri and Beta Centauri are believed to be about 4.85 billion years old, making them about 250 million years older than the Sun.

Alpha Centauri is about 4.37 light years away, or 41.5 trillion kilometres. By jet plane travelling at 966km/hr, it would only take us five million years to get there.

Alpha Centauri is one of the best multi-star systems that can be seen through binoculars.

SPOTLIGHT: Finding south

To find south draw a line perpendicular to the halfway point between the two stars of the pointers. Where that line meets the line formed by the two most-widely separated stars in the Southern Cross constitutes the southern point in the sky. From the pole drop a line straight down to the horizon – this is south.

6.6.8.5 Boötes

Boötes is a constellation that consists of five stars known to have planets.

Arcturus is the brightest star in Boötes and the brightest star in the Northern Hemisphere but the fourth brightest in the Southern Hemisphere (after Sirius, Canopus and Alpha Centauri). The name Arcturus dates back to around 750 BC and means 'Guardian of the Bear'.

Arcturus is an old orange disk star that is part of the Local Interstellar Cloud. Arcturus is actually just a hydrogen-concentrated area of the interstellar medium.

Arcturus appears to be travelling with a group of 52 other old disk stars, commonly known as the Arcturus Stream. These stars have low metallicity, meaning they would have had to form very early in the formation of our universe before heavier metals began to form. Arcturus was formed around 7Ga, just after the formation of our universe.

You can find Arcturus by following the arc that forms the three bright stars of the Big Dipper handle, although this may be hard to do from the Southern Hemisphere.

6.6.8.6 Aquila

Aquila has two stars very close to Earth, the brightest of which is Altair at only 16.77 light years away. Aquila has nine stars that have planets.

To find Aquila look north. On the horizon will be the bright star Vega in the constellation of Lyra, a little lower is the bright star Deneb in Cygnus and a little above the horizon will be the bright star Altair. Altair, Vega and Deneb form what is sometimes called the Summer Triangle.

6.6.8.7 Pegasus (Andromeda Galaxy)

The Great Square of Pegasus is home to the Andromeda Galaxy which is more familiar in the Northern Hemisphere than the Southern Hemisphere. Pegasus has nine stars with confirmed planets and the brightest star is Enif.

6.6.8.8 Cygnus

Cygnus has ten stars with exoplanets. The brightest star in the constellation is Deneb which is one of the brightest stars known as it is 60,000 times brighter than the Sun. Deneb is also one of the largest white stars we know of but, as Deneb is nearing the end of its life, it is expected to explode as a supernova within the next few million years.

To find Cygnus look low in the north sky and locate Vega. Deneb is a bright blue-white star in the constellation of Lyra, slightly beneath Vega.

6.6.8.9 Lyra

The brightest star in the Lyra constellation is Vega, the fifth-brightest star in the night sky. Vega was the first star (besides the Sun) to be photographed in the 1850s and the first to have its spectrum recorded. In 12,000 BCE it was the pole star and will be again in 14,000CE.

Vega is believed to have a rotational velocity of 274km/s at the equator and a circumstellar disk of dust. There is also a possibility it may have at least one planet the size of Jupiter in its orbit.

SPOTLIGHT: Astrology

The path the Sun travels across the sky is an imaginary line called the ecliptic. The twelve constellations that follow this path are known as the zodiac. The Sun travels through the signs in the same order they appear through the year in horoscopes.

Astrology does not match with what actually happens in the sky as the Sun does not stay in each sign for exactly one month, as with star signs. So, if you are a Leo, you're probably really a Cancer.

6.6.8.10 Aries

Aries has five stars with known planets and is not a bright constellation. The brightest star is Hamal, followed by Sheratan, which is a binary star system.

Aries is located between the constellations of Taurus and Pisces.

6.6.8.11 Taurus

The Taurus constellation looks like a big A in the sky. Within this constellation is a major star cluster, the Pleiades (or the Seven Sisters). This is an open star cluster (loosely held together by gravity) that are all the same age (~100 million years old). The Pleiades are seven prominent stars that we can see with the naked eye, although it's estimated there are a total of 500 stars. It is thought the cluster will dissipate in another 250 million years, drifting apart to become individual stars.

6.6.8.12 Gemini

To find the constellation of Gemini find Orion's Belt, then from Rigel (bright blue star) draw a line to Betelgeuse (bright red-orange at the other end of constellation) and the line will get you to the location of Pollux and Castor in the constellation Gemini.

6.6.8.13 Cancer

Cancer is found between the constellations of Leo and Gemini along the ecliptic. Cancer contains the famous beehive star cluster (an open star cluster) and is one of the nearest to our solar system, containing more stars than other nearby clusters. On dark nights you can see the cluster as a small, faint cloud. Through binoculars it appears as a ‘city of stars’.

6.6.8.14 Leo

Part of the constellation of Leo looks like a question mark and at the base of the question mark is Leo’s brightest star, Regulus. In February and March Leo appears low in the northeastern sky from around 9pm, but by April to June it starts moving towards the northwest horizon.

6.6.8.15 Virgo

The constellation Virgo is home to the bright star Spica. Virgo has dozens of known exoplanets and was the first exoplanet ever detected in 1988. In the constellation of Virgo there have been 35 confirmed exoplanets and 29 stars identified.

Virgo is home to the Virgo galaxy cluster containing thousands of galaxies (over 3,000). Some of these are visible as faint smudges through a telescope. The Virgo cluster of galaxies is around 65 million light years from Earth.

6.6.8.16 Libra

Libra is the only zodiac constellation that represents an object (scales) and not an animal or mythological character. Libra houses the oldest star we know of in the universe – HD 140283.

The two brightest stars in Libra are about halfway between Spica (Virgo constellation) and Antares (Scorpio).

6.6.8.17 Scorpio

The brightest star in the Scorpio constellation is Antares which is around 604 light years away. Antares is an evolved star nearing the end of its life and is burning the heavier elements in its core, before running out of fuel to collapse and explode in a brilliant supernova. This could happen today or a million years from now and will leave behind either a tiny neutron star or a black hole. The event will be a spectacular sight from Earth and will be as bright as the rest of our galaxy put together.

6.6.8.18 Sagittarius – galactic centre

The easiest way to find Sagittarius is via Scorpio, just across from the tail. It is in the Milky Way and roughly points to the centre of our galaxy.

Sagittarius resembles a teapot and towards the tip of the teapot is the centre of our galaxy where the clouds of the Milky Way appear thickest.

6.6.8.19 Capricornus

The constellation of Capricornus is often called the ‘sea-goat’ as it used to be depicted with a goat’s head and fish tail.

The brightest star in Capricornus is Deneb or Delta Capricorni. This is a four-star system. The second-brightest star is Beta Capricornus, which is actually two stars that both form binary systems.

To find Capricornus look for the Summer Triangle, make a line from Vega (Lyra constellation) through Altair (Aquila constellation) to Capricornus, which makes a small triangle at the head of the constellation.

6.6.8.20 Aquarius

Aquarius is rich with stars that have exoplanets and are very close to us (the closest exoplanet is only 15 light years away).

Aquarius houses the first-known system containing seven Earth-sized planets around a singular star. Three of these are in the Goldilocks zone (habitable zone): not too warm, not too cold, and just right to have liquid water (in relation to distance from their Sun). This system is about 40 light years away.

Aquarius lies in the part of the sky often referred to as the sea because the constellations are water related (Pisces: fish, Cetus: whale, Eridanus: river).

6.6.8.21 Pisces

Pisces is a fairly dim constellation and requires a dark sky to be seen. It is found between the north-east of Aquarius and northwest of Cetus. Fortunately, Pisces can be found easily by referring to the signpost known as the Great Square of Pegasus.

6.6.9 Deep-sky objects

6.6.9.1 The Milky Way

Our galaxy has hundreds of billions of stars and stretches 100,000 light years across. When viewing the Milky Way from Earth what we are actually seeing is the breadth of our spiral galaxy. Earth is located about two-thirds of the way out from the centre of the galaxy in one of the spiral arms known as the Orion Arm.

Parts of the Milky Way appear dark as the stars have been blocked out by dark nebulas. These nebula's are accumulations of gas and dust so thick that we can’t see through them. These regions are important because eventually the dust will collapse in on itself and become a stellar nursery, where new stars are born.

The group of galaxies that comprise the Milky Way are called the Local Group. The Local Group forms part of the Virgo Cluster of over 1,000 galaxies and is 60 million light years away. The Local Group, the Virgo Cluster and around 100 other galaxies form the Virgo Supercluster.

6.6.9.2 Indigenous astronomy: the Emu

The Emu in the Sky, recognised by Aboriginal groups across Australia, is composed of the dark spaces in the Milky Way. The rising of the celestial emu at dusk informs observers about the bird’s breeding behaviour. Across the Pacific, the indigenous Tupi people of Brazil see the same shape as a rhea, a large flightless bird that is native to South America and related to the emu. The rhea’s behaviour is nearly identical to that of the emu and the Tupi and Aboriginal traditions are remarkably similar.

6.6.9.3 Magellanic Clouds

Visible to the naked eye and appearing as clouds in part of the Milky Way, the Magellanic Clouds are visible from December to April. The Magellanic Clouds are nearby galaxies that orbit the Milky Way (just as the planets orbit the Sun). The Large Magellanic Cloud (LMC) is 170,000 light years away and the Small Magellanic Cloud (SMC) is around 210,000 light years away.

Use Sirius and Canopus (the two brightest stars in the sky) to find the clouds. Drawing a line from Sirius, move across to Canopus and keep going in a slightly downward angle.

6.6.9.4 The Andromeda Galaxy

The Andromeda Galaxy is the closest galaxy to Earth and is travelling towards us at around 100–140km/s (400,000km/hr). It is expected to merge with our own galaxy in four Ga, although it will not be the first time the Andromeda Galaxy has collided with a galaxy. It previously collided with M32 about 200 million years ago leaving the Andromeda Galaxy with rings and a double nucleus.

The Andromeda Galaxy is the most distant object visible to the naked eye and one of only ten galaxies. It is the largest galaxy in our Local Group with about a trillion stars (twice as many as the Milky Way).

To find the Andromeda Galaxy look between Cassiopeia's W shape and Pegasus. The brightest star in Andromeda is Alpheratz which is one of the stars that form the Great Square of Pegasus. The three bright stars between the square and Cassiopeia are the most prominent in the constellation of Andromeda.

6.6.9.5 47 Tucane

47 Tucane is a globular cluster found in the constellation of Tucana. It can be seen with the naked eye as a fuzzy star and is only visible in the Southern Hemisphere. It is the most massive globular cluster near the Milky Way and the second brightest with at least 500,000 stars.

6.6.9.6 Eta Carinae

Eta Carinae is a stellar system containing at least two stars with a combined luminosity greater than five million times that of the Sun. It is the most luminous and massive stellar system close to Earth.

Eta Carinae is known for its surprising behavior, erupting twice in the 1800s for reasons scientists are yet to understand. It is located in the Carina constellation between Canopus and Crux.

SPOTLIGHT: How do we know so much about the universe?

Historically, astronomy has focused on observations of heavenly bodies and is closely related to astrophysics. Astrophysics involves the study of the physics of astronomy and concentrates on the behaviour, properties and motion of objects in the universe. Modern astronomy includes many elements of the motions and characteristics of these bodies, and the two terms are often used interchangeably today.

Modern astronomers tend to fall into two fields: the theoretical and the observational.

- Observational astronomers focus on direct study of stars, planets, galaxies and so forth.
- Theoretical astronomers model and analyse how systems may have evolved.

6.6.10 The planets

The inner planets

Mercury, Venus and Mars are the three planets that, together with the Earth, make up the inner part of the solar system. While these planets are our closest neighbours, they are not at all like the Earth – Mercury is similar to the Moon, Venus is intolerably hot and Mars is not a place where humans could survive under natural conditions.

6.6.10.1 Mercury

One Mercury year = 88~ Earth days

Mercury is the closest planet to the Sun and is very small, being only 4,875km in diameter. Mercury never comes closer than 80 million km to the Earth and is not glaringly conspicuous as it can't be seen against a dark background and very few telescopes on Earth will show much in the way of surface detail. The surface does look similar to the Moon although there are mountains, valleys, craters and ridges. One striking feature is a huge impact basin, 1,545km across and surrounded by plains. The structure has been named the Caloris Planitia because an observer there would see the Sun directly overhead when Mercury is at the point of orbit closest to the Sun and the temperature would be around 430°C (hence the name *caloris* meaning heat). Mercury is virtually airless and life there seems impossible.

6.6.10.2 Venus

One Venus year = 225~ Earth days

Sometimes called a sister planet to Earth, Venus is the second-brightest object in the night sky after the Moon. The atmosphere of Venus is so dense and so cloud laden that it hides the surface permanently – meaning there is no such thing as a sunny day on Venus. It is this thick cloud cover that reflects and scatters sunlight making Venus appear so bright.

Venus has what is known as a 'runaway' greenhouse effect which is when heat becomes trapped by thick atmosphere and water evaporates. Due to this thick atmosphere, Venus sits at a constant year-round temperature of 465°C – hot enough to melt lead and hotter than Mercury (despite it being closer to the Sun). As well as high temperatures, Venus has an atmosphere composed of mainly carbon dioxide and clouds of sulfuric acid.

Venus and Uranus are the only planets in the solar system that rotate in a counterclockwise direction. This retrograde rotation is thought to be the result of the planet forming from a solar nebula with a different rotation period and obliquity, reaching its current state because of chaotic spin changes caused by planetary perturbations and tidal effects on its dense atmosphere – a change that would have occurred over the course of billions of years. This unusual rotation means the Sun would rise in the west and set in the east.

A day doesn't equal one day-night cycle like it does on Earth. As the rotation is slow and a day and a year are so similar, a day-night cycle takes 117 days. The Sun rises twice in a day on Venus. As Venus has a very small axial tilt it also does not experience seasons.

Recent research using climatic modelling techniques suggest that Venus may have had oceans of liquid water and temperatures suitable for sustaining life for up to two billion years. However, the heat from the nearby Sun would have gradually evaporated the oceans and the ultra-violet radiation broken apart water vapour molecules.

6.6.10.3 Mars

One Mars year = 687~ Earth days
Mars is about half the size of Earth.

The surface of Mars has an orange-reddish color because its soil has iron oxide or rust particles in it. The sky on Mars often appears pink or light orange because the dust in the soil is blown into Mars' thin atmosphere by winds. Mars has the largest mountain in the solar system: the shield volcano, Olympus Mons. Mars has two natural satellites, or moons: Phobos and Deimos.

Mars has water ice at the polar regions, some permafrost and some sub-surface water. Mars has many gullies and channels that are believed to have had water flowing in them at some time.

Methane has been found on Mars. As methane has a short lifespan and can only exist for a limited time there has to be some source for the methane. Is this source biological? Possibly, but not necessarily. Methane can be produced by reactions of rock with water which is a process common on Mars.

The outer planets
Far beyond Mars, and well beyond the main belt of asteroids, are the outer planets of the solar system. They are the 'gas giants' Jupiter and Saturn and the 'ice giants' Uranus and Neptune.

6.6.10.4 Jupiter

One Jupiter year = 12 Earth years
Jupiter is the largest planet in the solar system with faint and hard rings made up of fine dust.

The Great Red Spot on the surface of Jupiter is a storm that is twice the size of Earth and has been raging for at least 150 years. Scientists don’t know the cause of the storm but, due to Jupiter’s gaseous nature, it is not slowed by solid ground.

Jupiter has 67 confirmed moons and four of these named the Galilean Moons after Galileo Galilei. The outer moons orbit in the opposite direction to Jupiter and are thought to be captured asteroids.

6.6.10.5 Saturn

One Saturn year = 29 Earth years
Saturn is most famous for its spectacular ring system which was first seen by Galileo. The rings extend for 282,000km from the planet’s surface and range from 10 metres to 1km thick. Sometimes Saturn’s rings cannot be seen from Earth as a result of the viewing angle. This is called a ring-plane crossing and occurs every 14–15 years.

In size and mass Saturn is second only to Jupiter. Saturn's overall mass is 95 times greater than that of the Earth and the surface gravity is less than 1.2 times greater. The surface is gaseous and hydrogen is the main constituent, with most of the rest of the atmosphere being made up of helium. The core temperature may be as high as 15,000°C but the outer clouds are bitterly cold at around -180°C.

Saturn has 62 confirmed moons. There are many interesting and varied features of the moons, including weird shapes (like flying saucers) and many

are shepherd moons that work to keep ring material in their orbits.

6.6.10.6 Uranus

One Uranus year = 84 Earth years
Uranus rotates counter clockwise as well as on its side. Uranus experiences continuous sunshine for 84 Earth years and then cold and dark for 84 years. When transitioning from dark to light the Sun will heat up the atmosphere and trigger storms about the size of Australia.

The name of Uranus references the ancient Greek deity of the sky, Uranus – the father of Cronus (Saturn) and grandfather of Zeus (Jupiter). Consensus on the name was not reached until almost 70 years after the planet's discovery.

The chemical composition of the upper cloud bank of Uranus was only determined in 2017 when researchers found hydrogen sulfide, a component not found in planets closer to the Sun. The lower atmosphere consists of hydrogen, helium and methane. Methane absorbs red wavelengths of light and reflects blue hues giving Uranus its distinctive blue-green colour.

Uranus is host to 27 moons. Uranus is the coldest planet even though it is closer to the Sun than Neptune. This is because Uranus does not generate any internal heat.

6.6.10.7 Neptune

One Neptune year = 165 Earth years
Neptune was predicted to exist by mathematicians prior to its first actual observation. Its existence was predicted due to irregularities in the orbit of Uranus.

Neptune is the only planet that cannot be seen from the Earth without binoculars. The planet has 14 moons and six rings. The largest and only spherical moon of Neptune, Triton, travels around the planet in the opposite direction to the planet's rotation and could be a dwarf planet that has been captured by Neptune. Neptune’s gravity is drawing Triton closer to the planet and the moon will eventually be torn apart.

Neptune has clouds of frozen methane that are blown around the planet at speeds of 2,000km/hr making Neptune the planet with the fastest winds. A vortex was discovered in the atmosphere of Neptune, appearing as a dark spot.

6.6.11 Dark-sky calendar guide, 2019

The best time to go stargazing is when there is no bright moon at night and when the Sun has set enough so that twilight does not affect observations. The dark sections on the calendar indicate when the skies are truly dark and where you will be able to see the most stars. The yellow sections indicate when the sky is not dark due to moonlight.

JAN	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
FEB	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29		
MAR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
APR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
MAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
JUN	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
JUL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
AUG	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
SEPT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
OCT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
NOV	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
DEC	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31

2019 scripts	Dark-sky night tours	Bright-night/lunar tours	In the event of bad weather
	Gondwana Stars Observatory tour	Gondwana Stars Observatory tour	Outback weather tour
	Dark-sky tour	Outback lunar tour	

6.6.12 Quick reference

CONSTELLATION	PRONUNCIATION	NICKNAME	COMMENTS
Andromeda	an-DRUM-mih-duh	The Chained Maiden	Ancient, daughter of Cepheus
Antlia	ANT-lee-uh	The Air Pump	18th century
Aquarius	uh-QUAIR-ee-us	The Water Bearer	Ancient, in zodiac
Aquila	ACK-will-uh, uh-QUILL-uh	The Eagle	Ancient
Boötes	bo-OH-teez	The Herdsman	Ancient, also called Bear Watch
Cancer	CAN-ser	The Crab	Ancient, in zodiac
Canis Major	CANE-iss (CAN-iss) MAY-jer	The Great Dog	Ancient
Canis Minor	CANE-iss (CAN-iss) MY-ner	The Lesser Dog	Ancient
Capricornus	CAP-rih-CORN-us	The Keel	Ancient, in zodiac, fish-goat hybrid
Carina	cuh-RYE-nuh, cuh-REE-nuh	Of the ship Argo	The Keel
Centaurus	sen-TOR-us	The Centaur	Ancient
Crux	CRUCKS	The Southern Cross	Carved out of Centaurus
Cygnus	SIG-nus	The Swan	Ancient
Gemini	JEM-uh-nye, JEM-uh-nee	The Twins	Ancient, in zodiac
Leo	LEE-oh	The Lion	Ancient, in zodiac
Libra	LEE-bruh, LYE-bruh	The Scales	Ancient, in zodiac
Lyra	LYE-ruh	The Lyre	Ancient kind of harp
Orion	oh-RYE-un, uh-RYE-un	The Hunter	Ancient, a mythological hunter
Pisces	PICE-eez, PISS-eez	The Fishes	Ancient, in zodiac
Perseus	PER-see-us, PER-syoos	The Hero	Ancient, Andromeda's rescuer
Sagittarius	SAJ-ih-TARE-ee-us	The Archer	Ancient, in zodiac
Scorpius	SCOR-pee-us	The Scorpion	Ancient, in zodiac
Taurus	TOR-us	The Bull	Ancient, in zodiac
Virgo	VER-go	The Maiden	Ancient, in zodiac

B. LETTERS OF SUPPORT

A.B. PATERSON COLLEGE

INDEPENDENT CO-EDUCATION PREP TO YEAR 12

6 December 2017

To Whom It May Concern

I write to offer my strongest support for the Australian Age of Dinosaurs Museum (the Museum) regarding their application to the Federal Government's Building Better Regions Fund, Infrastructure Projects Stream, Round 2.

It is my understanding that the Executive Chairman: Australian Age of Dinosaurs Ltd, Mr David A Elliott OAM, has made application to build an open-air observatory named the Gondwana Stars Observatory. The observatory will house a 25" Dobsonian telescope with go-to tracking system, along with a range of medium and small telescopes that will enable the public to observe a wide range of celestial objects in a single evening. The project includes the installation of power and a bitumen road to the site, as well as a researcher's cottage to provide university students with easy access to the observatory at all hours of the night and isolated accommodation away from the noise of day-to-day operations at the Museum.

Background

A.B. Paterson College is a co-educational Prep-Year 12 College in Arundel on the Gold Coast. Founded in 1991, the College has a strong and proud connection to our National heritage. Since 1994, A.B. Paterson College has sent approximately 110 Year 6 students and 10 staff/parents each year to Winton. The purpose of this camp is to connect our broadly city-raised children to 'Outback' Australia; to meet the people, learn our unique history, and to study the geology and palaeontology of the region.

The region possesses many unique educational opportunities for students which are articulated in both the ACARA and QCAA Curriculum syllabi. There is, however, a learning that goes beyond the classroom, and prescribed syllabi, and I believe Winton is indeed unique in its offerings.

A.B. Paterson College is so committed to the development of Winton, our connection with this historic town, and our belief in the region's educational offerings, that we have recently purchased land in Winton with a view to developing dormitory facilities for our College and other schools who may wish to use them. Should the Gondwana Stars Project proceed, I see it entirely possible that a partnership between the Australian Age of Dinosaurs and A.B. Paterson College may indeed assist in bringing many schools to Winton for years to come.

Project Value

Apart from the addition of another tourism facility that adds to the critical mass in Western Queensland, there are a great many educational benefits and broad-ranging possibilities for this offering.

The study of astronomy has many benefits, including that of the physics of celestial bodies, the composition of our universe and of stars, understanding the concept of deep time, and an appreciation of our place in history, time and location in the universe. These are indeed very difficult concepts for students to comprehend, and are best approached through an examination of the stars through such a facility.

...../2

PO Box 460, Helensvale Qld 4212
Phone (07) 5594 7947
Fax (07) 5594 7650
Email abpat@abpat.qld.edu.au
Web www.abpat.qld.edu.au
ABN 38 010 596 997 CRICOS PROVIDER NO. 00502F
A.B. Paterson College Limited trading as A.B. Paterson College

While it would be wonderful for all Queensland students to visit the facility, it may be possible in time to set up robotic options that would enable schools, researchers and others to book time on the telescope and undertake their own research from anywhere in the world. It would also be possible to undertake spectral analysis that would help identify the specific 'fingerprint' of each element as found in celestial bodies. Finally, students would be able to study and understand deep time, the movement of celestial objects, and gain a much better appreciation of our place in the universe. These are complex studies and wonderful projects for secondary students.

Many of our young people in Australia are growing up very differently to those of years ago. They do not have a connection with animals, have little concept of farm life or the challenges presented by life in primary industry, they have never seen the wide open plains of Australia, nor have they seen the many wonders in our night skies. They are growing up sheltered from much of our natural environment and without understanding the delicate balance that exists.

A facility like this one, as proposed, opens many doors to young people and gives them an understanding of the universe and a wonder that will unlikely be forgotten. Further, a quick examination of educational curriculum would highlight numerous connections to both the ACARA and QCAA syllabi, and there is always the possibility of remote connectivity and the opportunity for our best and brightest minds to undertake genuine research.

I am in full support of this proposal and would be delighted to partner and support in the development of educational curriculum and opportunities to engage our young people -- bring both our young to the outback and the outback to the young.

I am happy to offer my support and willing to be contacted should you require further discussion.

Yours faithfully

BRIAN GRIMES BSc Dip Ed MEd MACE, MACEL, FAIM
PRINCIPAL / CHIEF EXECUTIVE OFFICER

The Honourable Quentin Bryce AD CVO

8 December 2017

Re: Australian Age of Dinosaurs Museum funding application – Federal Government Building Better Regions Fund

I am thrilled to be able to offer my strong support for the application to fund the ***Gondwana Stars Project***. From humble beginnings, the Australian Age of Dinosaurs (AAOD) Museum is fast becoming a world-class centre of excellence in education, tourism and scientific research - all while located in Outback Queensland.

The development of an International Dark Sky Park at The Jump-Up and the Gondwana Stars Observatory will further the Museum's mission to promote the fascinating story of Australia to a world-wide audience. This observatory will further promote visitation to the Museum, both domestically and internationally, which will, in turn, create economic flow-on effects throughout regional Queensland.

The unique shape of the observatory will enable it to become a well-known landmark in Australia. It is a marvellous way to present astronomy to visiting school children and university groups. The inclusion of high quality telescopes and supporting infrastructure such as a reliable all-weather road and student accommodation will make the Dark Sky Park and observatory a much sought after experience. It will inspire a wide range of people through the delivery of science, education and tourism, and provide a valuable asset to western Queensland.

Having visited AAOD on a number of occasions since I became Patron in 2008, I have seen first-hand the remarkable impact that passion, vision and practical determination can have on a regional community. The Museum is a place of community engagement, connection to country and inspiring knowledge. Since opening its doors in 2009, every milestone that AAOD has set itself has been achieved.

GPO BOX 2434 BRISBANE QLD 4001
Telephone: +61 7 3138 8970 Email: officebryce@qut.edu.au

Blake Repine
Associate Vice-Chancellor (Central Highlands Region)
CQUniversity Australia
Capricorn Highway
Emerald QLD 4720
07 4980 4140
b.repine@cqu.edu.au

David Elliott
Executive Chair
Australian Age of Dinosaurs Ltd
PO Box 139
Winton QLD 4735
07 4657 0414
David.elliott@aaod.com.au

6 December 2017

Dear David,

Re: Letter of Support for the Australian Age of Dinosaurs Museum application to Federal Government's Building Better Regions Fund for the Gondwana Stars Project

CQUniversity is regarded by the Australian Higher Education Sector as Australia's most engaged and inclusive universities. It has more than 30,000 students spread across 25 campuses and locations Australia-wide. It is one of the largest universities based in regional Australia. A pioneer in the delivery of distance education, CQUniversity continues to be a leader in this area, with almost half of the current student cohort being made up of students studying off-campus, many of whom are based in rural and remote areas.

In 2014, the University merged with CQ TAFE, bringing together more than 175 years combined experience in the delivery of education and training, and establishing Queensland's first dual sector, comprehensive university.

CQUniversity is officially recognised as Australia's only Changemaker Campus by global social innovation group Ashoka U. The Emerald Campus is situated in the heart of rural and regional Australia and is a major service centre for Central Western Queensland.

Central West Community Options Program

Winton Neighbourhood Centre
75 Elderslie Street / PO Box 232
WINTON QLD 4735

Telephone: 07 4657 2680
Fax: 07 4657 1141
Email: wintonch@winton.qld.gov.au

4th December, 2017

To Whom It May Concern

I would like to express my support for the Australian Aged of Dinosaurs Museum re application to the Building Better Regions Fund, Infrastructure Programs Stream, round 2 for the Gondwana Stars project.

The Australian Age of Dinosaurs (AOD) project which commenced in 2006 has evolved into a unique and state of the art attraction enjoyed by locals and visitors from afar. This was recently reflected by the 2017 Outback Queensland Tourism Awards who awarded Winton Australian Age of Dinosaurs Museum the Major Tourist Attraction award for the most people through its doors. The AOD is a great asset and attraction for the Central West Qld and Winton community in an area seeped with fossils and history and since its inception has implemented additional stages of the project. Recent works to improve and develop road accessibility to the area will create better access and opportunities for this thriving venture set upon a mesa plateau, offering spectacular views and opportunities.

Central West Community Options provides in home services to frail, aged and disabled clients in the Winton community through funded programs including Commonwealth Home Support Program and Packaged Care. Our program regularly take clients to this local attraction for social support adventures and encourage visitors to experience this one of a kind experience and always receive positive feedback.

The AOD is a major tourist attraction enhancing our local community and the development of the Gondwana Stars project is an exciting new medium of astronomy which will attract an international audience. The tourism industry is a vital part of our local community which assists in keeping our local businesses, providing employment and supports new economic opportunities in our area.

I would like to wish the AOD every success with their funding application.

Yours Sincerely

Vanessa Howard
Coordinator.

Queensland Government

Department of
State Development

Our ref: DGC17/1396

6 DEC 2017

Mr David Elliott OAM
Executive Chairman
Australian Age of Dinosaurs Ltd
Email: david.elliott@aaod.com.au

Dear Mr Elliott

Thank you for your email of 24 November 2017 requesting a letter of support for the Australian Age of Dinosaurs Museum's (the Museum) application for funding under the Australian Government's Building Better Regions Fund, Infrastructure Projects Stream, Round 2.

As you know, I visited Winton in August this year and gained an understanding of the opportunities and challenges for economic growth of the region. I also visited the Museum and was shown the plans to develop the International Dark Sky Park and the Gondwana Stars Observatory. I understand this project, once completed, would enhance the Museum's facilities, support new economic development opportunities and contribute towards growing the region's economy.

I recognise that the Museum's development is a priority for western Queensland to grow and expand the tourism industry and broader regional economy. It also links to the strategic objectives of the Department of State Development (DSD) to advance regional communities by facilitating collaboration and the delivery of regional economic infrastructure to strengthen the region.

As you are aware, DSD has committed to work with your team to support the Museum's expansion. This will include developing an overarching strategy and supporting materials, including a bankable feasibility study, to realise the full potential of this unique and highly regarded attraction.

I am pleased to provide my support for the Museum's application for funding to conclude stage 3.2 of the project which will deliver outcomes for Winton and Queensland.

If you require any further information, please contact Richard Austin, Regional Director, Regional Economic Development, Department of State Development, on (07) 4924 2901 or richard.austin@dsd.qld.gov.au, who will be pleased to assist.

Yours sincerely

Michael Schaumburg
Director-General

1 William Street
Brisbane QLD 4000
PO Box 15009 City East
Queensland 4002 Australia
Telephone +61 7 3452 7100
www.statedevelopment.qld.gov.au
ABN 29 230 178 530

ELITE
AVIATION SERVICES
Excellence in Aviation

OUTBACK FROM ABOVE

6th December 2017

Letter of Support: Gondwana Stars Observatory Project

I am a small business tourism operator based in Winton, Queensland. My aviation company has recently launched with the offer of helicopter and aeroplane services for tours and transfers around the region. In September 2017, I was appointed Chair of the Winton Business Tourism Association.

I am delighted to put my support firmly behind the **Gondwana Stars Observatory** project. It is exactly this type of world class tourism product that brings benefits to all stakeholders by growing the 'pie' and bringing more visitors to our region while enticing them to stay longer.

The project is well thought out and supported by excellent research. Some of the many benefits it will bring include:

- International recognition as an important **Dark Sky Reserve.** This is an area that is kept free of artificial light pollution, in order to promote astronomy appreciation,
- Increasing the critical mass of attractions in Western Queensland,
- Reaching new market demographics to bring more visitors,
- Strengthening existing reputation for astro-tourism,
- An off-season summer experience - can be enjoyed in the cool of the evening rather than during the extreme temperatures of day,
- New jobs for locals.

I urge you to support this project with the required funding and resources to bring the project to fruition. Please don't hesitate to contact me should more information be required.

Your sincerely,

Hylton Ward
CEO – Elite Aviation Services

Winton Base: Winton Airport PO Box 317 Winton Q 4735 0467 735 483 hylton@eliteaviationservices.com.au

6 December 2017

Letter of Recommendation

To whom this may concern,

I am writing to express my support and recommendation for the Australian Age of Dinosaurs in their application for funding to establish the Gondwana Stars Observatory at their site in regional QLD.

As the founder of Fizzics Education, a science outreach company that reaches over 300,000 students a year via science shows, workshops and video conferencing technology across Australia and beyond, I've see first-hand the tremendous impact that a first-class observatory can bring to a museum. The establishment of an astronomical observatory at the Australian Age of Dinosaurs site not only will create an avenue for students and the general public to view celestial objects in high detail, its combination with accommodation facilities on-site will make for a unique educational offering that can be integrated into an overnight teaching curriculum that will drive increased visitation to the Museum and as well as to the township of Winton.

The creation of an observatory at the Australian Age of Dinosaurs will also create an opportunity for digital outreach, as the Australian Age of Dinosaurs is in the process of establishing video conferencing technology at their site. The imagery created by the telescope as well as the infrastructure itself can be shared with audiences across the world, with educators interacting with remote sites in real-time. As such, by utilising digital infrastructure and the correct hardware the Australian Age of Dinosaurs will be able to amplify the impact of the observatory and will therefore fit within a broader science communication strategy that has been shown to be effective and sustainable in the museums and science centres across North America that I visited during my Churchill Fellowship investigating best practice in science education via video conferencing.

The ability to create attractive educational content on-site is paramount for a regional museum. The application by Australian Age of Dinosaurs for funding to establish an astronomical observatory is forward thinking, aligns with the common purpose of science communication and is realistic in terms of market realities. The opportunity to increase science literacy both onsite and beyond is immense and is one that we are proud to be an educational partner.

I wish David Elliott and all the team at Australian Age of Dinosaurs the very best and trust that this letter of recommendation supports them in their endeavours.

Yours sincerely,

Ben Newsome
Managing Director
Fizzics Education

Fizzics Education Pty Ltd www.fizzicseducation.com.au Ph: 02 9674 2191
ABN: 79 117 115 563 Fax: 02 9624 1988
ACN: 117 115 563 10/55 Fourth Ave, Sydney NSW, AUSTRALIA 2147

FUN OVER 50

Travel in style, service with a smile

funoverfifty.com.au

5 December 2017

David A. Elliott OAM
Executive Chairman
Australian Age of Dinosaurs Ltd
PO Box 139
WINTON QLD 4735
EMAIL: david.elliott@aaod.com.au

Dear David,

RE: Federal Government's Building Better Regions Fund, Infrastructure Projects Stream.

Fun Over Fifty is delighted to support your Federal application for funds in this upcoming round of the Building Better Regions programme for your **'Gondwana Stars Project'.**

As a national multi-award winning tour operator, recently taking out Gold at the Australian Tourism Awards in February this year, Fun Over Fifty is constantly sourcing new and innovative product to enhance our guest experience whilst on tour.

We are delighted that we may soon be able to offer our guests a visit to the **'Dark Sky Park and Observatory'** incorporating a full evening of entertainment, including a barbecue dinner at Dinosaur Canyon Outpost followed by a sound and light show through the Dinosaur Canyon exhibitions while waiting for the sky to darken.

We understand that the **'Gondwana Stars'** experience will commence once the sky is sufficiently dark to see the stars clearly. We value that the Gondwana Stars experience will be quite different to conventional astronomy experiences as it will follow the Museum's theme of paleontology and deep time. It will be great to have your experienced guides present the night sky from a Gondwanan point of view and cover meteorite impacts, meteors, the asteroid belt, impact craters on the moon and anything else relating to how our planet has been affected through deep time by astronomic forces.

I know our Fun Over Fifty guests will thoroughly enjoy such an experience, particularly now we are extending our touring programme in the Summer months and needing product during the cooler parts of the day/night.

As someone whose origin began in a regional Queensland community, I understand and appreciate the enormous value a project of this size will contribute to the long-term viability and economy of the region as a whole. Investment of this kind assists in stimulating interest in and desire to travel to wonderful destinations such as Winton, increasing visitor length of stay and daily expenditure.

Just as importantly, is the sense of pride the community will have to have such an outstanding international standard product to offer.

On behalf of all my team at Fun Over Fifty, we wish you all the very best in your application.

Yours sincerely,

Toni Brennan

DAVID LITTLEPROUD MP

FEDERAL MEMBER FOR MARANOA

Mr David Elliott
Executive Chairman
Australian Age of the Dinosaurs Museum of Natural History
PO Box 139
WINTON QLD 4735

By email: david.elliott@aaod.com.au

Dear Mr Elliott,

I am writing to support the Australian Age of the Dinosaurs Museum of Natural History's (the Museum) application for funding to develop an International Dark Sky Park and an open-air observatory (herein referred to as the Gondwana Stars project) under the Federal Government's Building Better Regions Fund (BBRF) Infrastructure Projects Stream, at the Museum site near Winton, Queensland.

The history of the Museum is unique and a true example of innovation and enterprise in Australia's outback. In 2002 the discovery of dinosaur fossils in Winton commenced a journey to establishing a Museum, which now displays the most significant dinosaur deposits in Australia's history. Needless to say, the Museum is part of the Central West's vitally important outback tourism ecology, attracting more than 31,000 tourists and directly contributing over $1m to the local economy per year. This contribution, combined with the flow-on effects created by increased visitation to the region, provides substantial socio-economic benefits to western Queensland's isolated communities.

The Gondwana Stars Project aligns with the Museum's current operations, as they have been recording night sky data since September 2016. I understand the results of this data monitoring confirm the location as an ideal dark sky location, with readings exceeding the International Gold Standard accreditation criteria. This would diversify the Museum's current operations and attract higher numbers of tourists, students and experts to the area. It would also strengthen the identity of Winton as a major domestic tourism location.

The Museum informs me that if successful, they would use the funding to install electricity infrastructure and bitumen the road to the site, and construct a researcher's cottage to allow university students and academics to utilise the site for research purposes. As part of this phase, the Museum will also construct the observatory, if successful.

I would also like to note as part of a drought-affected region, the expansion of the Central West's tourism industry is essential to their economic sustainability. While this project is likely to immediately and directly benefit the Museum and the township of Winton, I also believe it will provide a number of indirect economic benefits to many other communities across the Central West and Queensland.

PARLIAMENT HOUSE: R1.82, Parliament House, Canberra ACT 2600 P 02 6277 2276
DALBY ELECTORATE OFFICE: PO Box 641, Dalby QLD 4405 P 07 4662 2715
ROMA ELECTORATE OFFICE: PO Box 115, Roma QLD 4455 P 07 4622 7166
WWW.DAVIDLITTLEPROUD.COM.AU

Having visited the Australian Age of Dinosaurs Museum's *Dinosaur Canyon* project when it was under construction in 2016, I firmly believe the applicant possesses the prerequisite project management and financial administration skills to ensure this project is a success and of great benefit to the community. Accordingly, I strongly support the Museum's proposal and wish them all the best in its funding application for this unique and exciting project.

Yours sincerely,

DAVID LITTLEPROUD MP
5 December 2017

LONGREACH REGIONAL COUNCIL
ABN: 16 834 804 112 Email: assist@longreach.qld.gov.au
Phone: (07) 4658 4111 Fax: (07) 4658 4116
Address all correspondence to:
Chief Executive Officer, PO Box 144 Ilfracombe QLD 4727

Main Office:
96a Eagle Street, Longreach
Phone: (07) 4658 4111

Isisford Branch Office:
20 St Mary Street, Isisford
Phone: (07) 4658 8900

Ilfracombe Branch Office:
1 Devon Street, Ilfracombe
Phone: (07) 4652 5400

24 November 2017

David Elliott
Executive Chairman
Australian Age Of Dinosaurs
PO Box 139
WINTON, QLD 4735

Dear David

Re: Letter of support for the Australian Age of Dinosaurs Museum

Longreach Regional Council is proud to support the Australian Age of Dinosaurs Gondwana Stars project. As a regional transport hub for travelers entering and leaving the region the flow on benefit will further stimulate positive economic growth across the whole region.

During the summer season our regions visitor numbers are very low. This exciting new addition to an exceptional tourism attraction will increase visitation through our region during a time where the experience can be ultimately enjoyed at a cooler temperature.

The overall benefit of this additional tourism product is that other local businesses and tourism operators will be able to operate profitably during the tourist low season and the Gondwana Stars project will additionally provide the general public and school children with an enhanced educational experience.

Should you require further assistance in relation to our support for this project, please do not hesitate to contact Russell Lowry, Economic Development and Tourism Manager on (07) 4658 4117.

Yours faithfully

Ed. Warren

Cr. Ed Warren
Mayor

LONGREACH SCHOOL OF DISTANCE EDUCATION
Providing Excellence in Education for Isolated Children

1 December 2017

Mr D Elliott
Executive Chairman
AAOD
P.O. Box 139
Winton, Qld, 4735

Dear David,

RE: Gondwana Stars Observatory

It is with pleasure I offer my support and the support of the Longreach School of Distance Education to the Observatory project.

As well as being an educational facility, we also are heavily involved in the tourism industry through our school tours program. Tourism is such an important part of the economy of the Central West that anything that we can do to encourage more visitors and getting them to stay longer is vital.

The Gondwana Stars Observatory is a natural extension to the AAOD precinct. The clear western skies are ideal for taking a close up look at stars and planets. The idea of offering a different astronomy experience by relating the observations to how our planet has been affected through time by astronomical forces from around the universe is particularly exciting. The opportunities for school children will be great.

Congratulations on the plans for the Observatory. Good luck with the application. You have the full support of the Longreach School of Distance Education Community, in your grant application.

Yours Faithfully,

Des Deighton
Principal

PO Box 600, Sir James Walker Drive, Longreach Q 4730 Telephone (07) 46584222 Facsimile (07) 4658 4200
Email: the.principal@longreacsde.qld.edu.au

Lachlan MILLAR MP
Member for Gregory

27th November 2017

LETTER OF SUPPORT

I write to lend my strongest possible support towards The Australian Age of Dinosaurs Museum's application to the Federal Government's Building Better Region Fund, Infrastructure Projects Stream Round 2. This funding application involves the development of an International Dark Sky Park and construction of an open-air observatory.

The Australian Age of Dinosaurs Museum is a not for profit museum that was incorporated in Winton in 2002 following the discovery of dinosaur fossils on Belmont Station in the Winton Shire. This is a world-class museum and cultural display and houses the largest collection of Australian dinosaur fossils in the world. This museum eloquently tells the story and recognizes that the Winton formation is Australia's most significant dinosaur deposit. These fossils are a national treasure and worthy of national representation. As such, it has become a major tourist attraction in Winton, drawing visitors from across Australia and around the world.

The track record of the Museum is such that you can have every confidence in the quality and longevity of this project. Importantly, it will strengthen Winton's tourism sector at a time when this has become a life-line due to drought.

Ensuring the preservation and future development of this world-class piece of heritage infrastructure is so very important and I have no hesitation in requesting your most positive consideration for this project.

Yours sincerely

Lachlan Millar MP
Member for Gregory

Longreach Office
Shop 2, Studio Exclusive Arcade, 120A Eagle Street, Longreach QLD 4730
PO Box 180, Longreach QLD 4730
P 07 4521 5700 F 07 4521 5709 E gregory@parliament.qld.gov.au

Emerald Office
Shop 1, 93 Clermont Street, Emerald QLD 4720
PO Box 444, Emerald QLD 4720
P 07 4913 1000 F 07 4913 1009 E gregory@parliament.qld.gov.au

f Lachlan Millar MP @Lachlan_Millar W www.lachlanmillarmp.com

Monday, 4 December 2017

Letter of Support

To Whom It May Concern:

As the Owner/Operator of Outback Aussie Tours, I am writing to show support for the New Observatory and Dark Sky Park proposed by the Australian Age of Dinosaurs in Winton, Queensland.

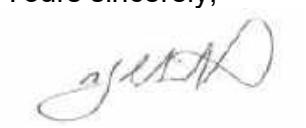
The New Observatory and Dark Sky Park has full support of the Shire Councils, full support of our organisation, and the wider community. The Observatory will have a community focus which will benefit all user groups. It will create many jobs, educational and employment opportunities for Central Western Queensland, and the greater economic and social benefits for our towns, region, and state will be significant.

The project will provide a new tourist attraction to draw visitors from all demographics to our region all year round. Examples of these are the large jet capacity air strip and the accommodation facilities that have peaks and troughs through the busy season May to September and the off-season October to April. These seasons can be targeted now due to the experience being offered in the cool of the evenings offering more jobs, more business development and more cultural advancement for regional communities.

We look forward to working with the Australian Age of Dinosaurs to ensure this facility is funded and built by building into our current itineraries this new exciting product. We confirm that Outback Aussie Tours is currently working with the Australian Age of Dinosaurs to further develop the events program and to package these events maximising opportunities into new markets.

Please don't hesitate to contact me for any further information.

Yours sincerely,



Alan Smith
Outback Aussie Tours

Longreach Railway Station, PO Box 448, LONGREACH QLD 4730
PH: +61 7 4658 3000 FAX: +61 7 4658 3350 E-mail: info@oat.net.au www.oat.net.au

Outback Queensland
Tourism Association

27 November 2017

Re: Australian Age of Dinosaurs Museum of Natural History Stage 3.2 Gondwana Stars Project.

Outback Queensland Tourism Association (OQTA) wholeheartedly supports the Australian Age of Dinosaurs Museum of Natural History, Stage 3.2 Gondwana Stars Project.

The Australian Age of Dinosaurs Museum of Natural History is one of Australia's premier outback destination and without doubt, an International Dark Sky Park and observatory will stimulate direct economic benefits within and beyond the region.

An International Dark Sky Park and observatory will provide a destination with a real competitive advantage by offering what is truly unique, memorable, educational and engaging 'tourism experience'.

Yours sincerely

Peter Homan
General Manager
Outback Queensland Tourism Association
0438394492 | gm@outbackqld.com.au

PO Box 351
Winton QLD 4735
E: vicki@reddirttours.com.au
ABN: 64 213 127 139

To Whom It May Concern

RE: Letter of Support for Australian Age of Dinosaurs, Gondwana Stars Project

It is with great enthusiasm that I write in support of the Gondwana Stars Project at the Australian Age of Dinosaurs Museum of Natural History Museum (AAOD).

Red Dirt Tours is a local Winton tour operation providing day tours and extended tours to visitors to our local area. Current tours include to the Australian Age of Dinosaurs Museum and to the Dinosaur Stampede (Lark Quarry Conservation Park) which AAOD manage as an attraction. I have worked closely with the team at AAOD to provide an exceptional experience to our visitors. Red Dirt Tours is an accredited Savannah Guides Enterprise (as is AAOD) with a commitment to a high standard of professional guiding and visitor experiences.

The Gondwana Stars observatory will bring another level of experience to Winton and Outback Queensland as a whole – this calibre of observatory is currently available in one of the best places for it – and will bring benefits to the tourism industry and to the local community.

Our tourism season in Winton runs from April to the end of October, as a general rule, and over the past five years we have been working to extend this season and encourage more visitors through the region in the months outside of this time. As a night time activity, this Observatory will provide options for visitors in the cooler hours of the day during the warmer months and will be a valuable attraction for visitors.

Having this observatory available for visitors will assist Red Dirt Tours to achieve its goals of expansion and the ultimate extension of the tourism season past October. RDT already offers packages through March and November to extend the season but unfortunately there is little available for inclusion as a night time activity during these months so progress to extend the season to date has been slow. The observatory will be of great benefit by adding a night time attraction. This will also extend the range of tours RDT can offer.

In conclusion, I whole heartedly support for the Dark Sky Observatory project of AAOD and believe there will be great community and economic benefits to the local region and Red Dirt Tours will benefit as a local tourism operator.

I look forward to working with the Australian Age of Dinosaurs Natural History Museum for many years to come!

Yours sincerely

Vicki Jones
Owner Operator
Red Dirt Tours

30 November 2017

Regional Development Australia
FITZROY AND CENTRAL WEST INC

Mr David Elliot
Executive Chairman
Australian Age of Dinosaur
david.elliot@aaod.com.au

Dear David

On behalf of Regional Development Australia Fitzroy and Central West (RDAFCW), I am pleased to support Australian Age of Dinosaur's (AAOD) application to the Building Better Regions Fund, for funding the '*Gondwana Stars Project'* (the Project).

This project involves the development of an *International Dark Sky Park* and construction of an open-air observatory, to be named **Gondwana Stars Observatory**. As only the 2nd one of its kind in Australia this dark park will be an amazing asset to the regions tourism offering. The observatory will house a 25" Dobsonian telescope with go-to tracking system along with a range of medium and small telescopes that will enable the public to observe a wide range of celestial objects in a single evening. The project includes the installation of power and bitumen road to the site and a cottage to provide accommodation for both university students as well as premium guests with easy access to the observatory at all hours of the night and isolated accommodation away from the noise of day-to-day operations at the Museum.

The benefits of this project include an increase in tourist numbers and a flow on impact of increased employment opportunities for residents. This will happen through not only an additional tourist attraction, but one that will extend the tourism season by offering activities in the cool of the early morning and evening. In addition, I understand that AAOD is accessing newly established internet connectivity to establish education programs around the globe, again increasing the earning capacity of AAOD outside of the tourism season. With the extension of the tourism season and new online education components AAOD will then employ staff year-round, rather than only in the tourism season. This will directly benefit the community through increased employment and the flow on effect of spending within the community.

I understand that this project will further promote tourism within Central Australia utilising The Outback Way Art Drive (utilising the billboards to showcase and promote art and artists of Central Australia). This will add another dimension to the Outback Way, as people journey through the heart of Australia.

Congratulations to the Australian Age of Dinosaurs, for the innovation within this project and the development of the '*Gondwana Stars Project'*. The long-term job and tourism sector growth from this project will positively impact economic growth within Western Queensland and I look forward to seeing the results.

Yours faithfully

Graeme Kanofski
Chair
RDA Fitzroy and Central West

RAPAD
Incorporating Central Western Regional Organisation of Councils

27 November 2017

David Elliot
Executive Chairman
Australian Age of Dinosaurs Museum of Natural History
PO Box 139
Winton 4735

Subject: Australian Age of Dinosaurs support

Dear David

I am writing further to our discussion and your recent presentation on the exciting proposed new stages of the internationally acknowledged Australian Age of Dinosaurs (AAOD) museum.

The Remote Area Planning and Development Board (RAPAD – www.rapad.com.au) is Central Western Queensland's (CWQ) regional economic development agency and regional organisation of councils owned by and representing the seven local governments of CWQ. RAPAD has recently endorsed its new strategic plan, which draws on extensive community consultation, some of which was conducted by Professor John Cole OAM from the University of Southern Queensland's Institute for Resilient Regions. As a foundation member, RAPAD, along with our council members hold the AAOD museum in high esteem. The AAOD museum, your leadership and vision all reflect and epitomises so many elements of our strategic plan such as:

Leadership and Capacity Building
Outcome: Leading the region to capitalise on current assets and capabilities, to fundamentally transform its social, economic and professional potential.
Tourism
Outcome: The RAPAD region's tourism industry grows and reaches its potential as a global destination.
Innovation and Entrepreneurship
Outcome: Globally connected ecosystems; and provision of hard and soft infrastructure that fosters innovation, creativity and entrepreneurship across the RAPAD region.
Investment Attraction
Outcome: Actively seeking out and partnering with great companies and people who can make a real difference to our regional economy.
Regional Narrative
Outcome: A regional narrative of 'Team Central West' that embeds and demonstrates the region's vision, values, culture and history, its strengths, and potential; and capacity to attract and support new and expanded investment opportunities

In your presentation and information package you have outlined a truly remarkable list of achievements to date. Many of our current directors can remember when in 2003, AAOD built a small fossil display in Winton and published the first *'Australian Age of Dinosaurs'* journal. Soon after, and with new excavation techniques, large deposits of dinosaur bones were found and from there came a temporary preparatory laboratory in 2006.

From these beginnings, AAOD is now a significant regional, state and national scientific and tourism asset housing the largest collection of Australian dinosaur fossils in the world.

(07) 4652 5600
info@rapad.com.au
117 Eagle Street | PO Box 592
Longreach Q 4730
@RAPADCWQ
Like us on Facebook
rapad.com.au

With the recent completion of Stage 3.1, RAPAD and our region are looking forward to the next stage, being the completion of the Gondwana Stars Observatory, which will allow AAOD to achieve 'International Dark Sky Park' accreditation.

This project has direct links to our strategic plan but more importantly it will bring immense benefits to our region.

- It will be an additional tourism product that increases the critical mass of attractions for our Central West and wider Outback region,
- It will add a new interest group to current visitor demographics and strengthening existing interest in astronomy,
- It will be an additional experience to offer visiting school children as well as (long term) video conferencing direct from the observatory to schoolchildren overseas. (This has many links to our recent Advance Regional Innovation Program which were successful in and are currently completing the project planning),
- It will bring an increase in summer tourist offerings by adding an experience that can be enjoyed in the cool of the evening rather than during the extreme temperatures of day,
- There will be flow on benefits to the local service industry, businesses from increased stop-over rates in the Winton and Central West communities during the summer season when visitor numbers to the region are historically low,
- It will be a new product for regional tour operators to promote and sell, enabling them to operate more profitably during the summer down season,
- Enhance the financial sustainability of the AAOD museum, and bring an increase in museum staff, particularly in summer, which has flow on effects to the regional community.

On behalf of the board of RAPAD, vis-à-vis the regions seven mayors, we wish you every success with your project funding applications and project planning.

Yours Sincerely

Cr Rob Chandler
Chairman

RICHMOND SHIRE COUNCIL

Our Ref.:

Your Ref.:

07 December 2017

Australian Age Of Dinosaurs Museum Of Natural History
PO Box 139,
WINTON QLD 4735

email: david.elliott@aaod.com.au

To Whom it May Concern - Letter of Support

Kronosaurus Korner Board wish to formally acknowledge their support for the Australian Age of Dinosaurs Museum of Natural History (MNH) application for the Federal Government's Building Better Regions Fund, Infrastructure Projects Stream, with their Stage 3.2 Gondwana Stars Project.

In any regional or remote location, tourism is a vital component of any community. This Gondwana Stars tour will provide many benefits to the town of Winton and neighbouring towns and regions. These include:

- Filling a niche market for all year round, night time attraction – particularly during the summer months, when the cool evenings are a refreshing contrast to the hot days.
- Encourage sustainable summer tourism and increase visitation to the region year-round, with a flow on to local service industry businesses from increased stop-over rates
- Increased employment opportunities in a resilient community facing the challenges of living in a remote part of Queensland - limitations of distance, drought, education, health and financial and the impact it has.
- Provision of a science-focused teaching resource that offers visiting school children as well as (long term) video conferencing direct from the observatory to school children overseas, adding a new dimension to existing astronomy offerings in Australia. This will provide the public, including school children, with a fascinating, educational experience.
- Flow on benefits to other attractions in the region such as Kronosaurus Korner would include increased visitation and enabling a more profitable summer down season.

RICHMOND SHIRE COUNCIL

We wish the Australian Age of Dinosaurs Museum of Natural History (MMH) every success with their Gondwana Stars Project, and this Grant application.

Yours sincerely,

Regards

Chairman – Kronosaurus Korner Board

John Wharton AM
Mayor
Richmond Shire Council

Telephone: (07) 4719 3377
Mobile: 0427 777 668
Facsimile: (07) 4719 3372
Email: mayor@richmond.qld.gov.au

65 Goldring Street
Richmond N.Q. 4822
P.O. Box 18
Richmond N.Q. 4822

YOU'LL DIG RICHMOND
OUTBACK QUEENSLAND

Clondooroo Street, Winton QLD 4735
P: (07) 4657 1652 E: wnto@spwtsv.catholic.edu.au
spwtsv.catholic.edu.au

St Patrick's Catholic School
WINTON

Wednesday, 6 December 2017

To Whom it May Concern

RE: Australian Age of Dinosaurs
Federal Government's Building Better Regions Fund, Infrastructure Projects Stream,Round 2 Application

I, Cathryn Cornish, Principal of St Patrick's Catholic School, Winton, write to urge you to consider granting the Australian Age of Dinoscaurs museum funding for their Gondwana Stars Observatory.

As an educator in this remote, rural region, I can unequivocally attest to the quality of educational experiences that the Age of Dinosaurs museum offers. I can also announce that by including a dark sky observatory, the museum will be able to target further Australian Curriculum content. I feel that by offering these new experiences, additional schools will visit on a more regular basis.

With this addition, the Age of Dinosaurs will be able to attract multiple year levels across Science, HASS and Maths curriculum subjects. Schools and educators seek out these brilliant examples of real-life lessons to excite and engage their students at the beginning or at the culmination of their units of work. Schools like us will be able to visit yearly for a multitude of excursion topics rather than once every three years when the content descriptors align. A larger number of attractions at the museum means more subjects and units could be covered, attracting more year levels, more subject areas and hopeful more schools.

Attracting schools and tourists to the region is vital to the Winton economy. It creates jobs, filters funds through the businesses and keeps drought stricken families in our town. Offering these experiences to the youth of Queensland, Australia and (with technology) the world, may entice them to bring their families back years later to experience the same opportunities therefore keeping our town sustainable well into the future.

If you would like further clarification on any of the points I have put forward, please do not hesitate to contact me.

Yours sincerely,

Mrs Cathryn Cornish
(Principal)

For God and Australia

Letter of Support for AAOD Gondwana Stars Project

To Whom It May Concern,
This letter is to support the application of David Elliott on behalf of the AAOD in applying for funding to assist in constructing the proposed Gondwana Stars Observatory.

My Name is Grant Salmond, I teach Physics, Chemistry and Mathematics at Spinifex State College in Mount Isa. I believe the proposed Gondwana Stars development at the AAOD in Winton will provide many benefits. Some of those benefits will be:

- Local access for surrounding area school students and teachers who may visit the observatory for viewing and educational sessions.
- Unrivalled access to dark skies, viewing conditions and telescopes that are not available elsewhere in regional Queensland.
- Exceptional and engaging educational experiences on the night sky and astronomy provided by AAOD trained guides and staff.
- International Dark Sky Park status which will preserve the darkness of the surrounding night sky to ensure visitors and locals will enjoy dark sky viewing into the future.
- The successful application for a Dark Sky Park will make Winton a tourist destination for astronomy enthusiasts from around the world.
- The AAOD will have the opportunity to host star fest viewing parties for amateur astronomers from around the world.
- An observatory at the AAOD with excellent equipment and knowledgeable staff will create a centre for regional Queensland to direct astronomical queries.
- Surrounding families will have local access and connections to astronomical knowledge.
- The Gondwana Stars observatory can provide remote access to online viewers during special events such as lunar eclipses, conjunctions and comet appearances.
- An astronomy presence in Winton, along with the Dark Sky Park will provide opportunities for the AAOD to create further University partnerships for research.
- The AAOD will have further opportunities to create world class remote observatories for international astronomical research.

Among these benefits, perhaps the most simple and overlooked will be that Winton will continue to grow into a world class scientific and research destination for scientists and enthusiasts. That will bring follow-on interest from the general public and provide further reason for local towns and people in regional Queensland to feel proud of their community.

Regards,
Grant Salmond.

JAMES McGRATH

ASSISTANT MINISTER TO THE PRIME MINISTER
ASSISTANT MINISTER FOR REGULATORY REFORM
LNP SENATOR FOR QUEENSLAND

1 December 2017

The Hon Darren Chester MP
Minister for Infrastructure and Transport
M1.26
Parliament House
CANBERRA ACT 2600

Dear Minister, Darren,

I write in support of the Australian Age of Dinosaurs' application for funding under Round Two of the Building Better Regions Fund (BBRF) Infrastructure Projects Stream.

In 2006, the Australian Age of Dinosaurs Museum of Natural History project commenced with the donation of a 1,400 hectare mesa near Winton by the Britton Family.

The Australian Age of Dinosaurs Museum of Natural History project consists of three construction stages. Of these, Stages 1 and 2 of the project have been completed. However, addition funding is needed to complete Stage 3 of the project.

Stage 3 of the project has been divided into three phases: Stage 3.1, the Dinosaur Canyon, which was completed in April 2017; Stage 3.2, the Gondwana Stars Project; and Stage 3.3, the Australian Age of Dinosaurs Museum of Natural History. The Australian Age of Dinosaurs' application for funding under Round Two of the BBRF Infrastructure Projects Stream concerns Stage 3.2 of the project.

Stage 3.2 of the project involves the development of an International Dark Sky Park and construction of an open-air observatory named 'Gondwana Stars Observatory'. The project includes the installation of power and bitumen road to the site and a researcher's cottage to provide university students with easy access to the observatory at all hours of the night and isolated accommodation away from the noise of day-to-day operations at the Museum.

If funding is approved, construction will commence in mid-2018 and is expected to be completed by mid-2019.

This project will increase tourism in the Western Queensland region, grow the local economy and ensure the long-term prosperity of the Australian Age of Dinosaurs site.

Postal Address. PO Box 772, Nambour QLD 4560 **Phone.** 07 5441 1800 **Email.** Senator.McGrath@aph.gov.au
Website. www.jamesmcgrath.com.au @JamesMcGrathLNP @JamesMcGrathLNP

I commend the application for your consideration and look forward to a favourable outcome for Australian Age of Dinosaurs Museum of Natural History.

Yours sincerely

JAMES MCGRATH
Assistant Minister to the Prime Minister
Assistant Minister for Regulatory Reform
Senator for Queensland

15 December 2017

To whom it may concern,

I am writing as the Pro Vice Chancellor of the Faculty of Science, Engineering and Technology at Swinburne University of Technology to give our support for the Australian Age of Dinosaur (AAOD) Museum who are seeking funding through the Federal Government's Building Better Regions Fund, Infrastructure Projects Stream, to build a small observatory.

Swinburne has an existing relationship with the AAOD though our small but very active palaeontology group. Profs Pat Vickers-Rich and Tom Rich are regular visitors to the AAOD site, and we have a joint Swinburne-AAOD appointment of an exceptional young palaeontologist, Dr Stephen Poropat, one of the discoverers of the most complete sample of a sauropod in Australia recently found at the Winton site. Prof Vickers-Rich is developing a new program at Swinburne which will see our undergraduate and postgraduate students visit the unique site at the AAOD as part of a field trip.

Our astronomers are also very keen to work with the AAOD to expand their regional dark sky sites to Winton. The AAOD's plans to build the Gondwana Star Observatory would allow our students to view the amazing outback night sky with a range of telescopes, including a Dodsonian 25". This telescope offers high enough resolution for students to study the surface and atmospheric features planets in detail, allowing them to contribute to our understanding of the turbulent atmospheres of Jupiter and Saturn. It also allows students to study different types of stars in both open clusters and globular clusters, as well as study galaxy morphology. Having a practical observing component to theoretical studies is a vital part of any comprehensive astronomy pedagogy.

The uniqueness of the proposed site for the Gondwana Star Observatory, inside an impact crater, extends the connections between astronomy and dinosaurs which will not be lost of our students. It would also offer an excellent opportunity to share the knowledge and traditional on indigenous astronomy with the public.

The observatory will also be a unique facility for astronomy public outreach in Queensland. Swinburne has a long history of excellence in astronomy public outreach, and we are delighted to offer our support to AAOD in the design of outreach programs they could offer to regional visitors.

With kind regards,

Professor Sarah Maddison

Faculty of Science, Engineering and Technology

Prof Sarah Maddison
Faculty Pro Vice-Chancellor
H44, PO Box 218 Hawthorn
Victoria 3122 Australia

Telephone +61 3 921 4820
Email: smaddison@swin.edu.au
www.swinburne.edu.au

ABN 13 628 586 699
CRICOS Provider 00111D

Tourism and Events Queensland

Level 10
30 Makerston Street
Brisbane, QLD 4000
GPO Box 328
QLD 4001 Australia

T +61 7 3535 3535
E matt.bron@queensland.com
M +61 439 476 106
W teq.queensland.com

ABN 77 745 152 359

5 December 2017

Mr David A. Elliott OAM
Australian Age of Dinosaurs Museum of Natural History
PO Box 139
Winton, Queensland, 4735

Dear David,

RE: Australian Age of Dinosaurs Gondwana Stars Project

I am writing to offer my support of the application for the Building Better Regions Funding for the development of an international dark sky park and open-air observatory.

As a Dark Sky Park, the Museum will be able to offer the use of its observatory facilities and equipment to an Australia-wide and international audience. This will have special benefits to northern hemisphere amateur astronomers as they will be able to access the southern sky with high-end equipment without the need to bring it themselves. Wholesale public tour experiences will be offered to all tour operators and will include a full evening of entertainment that incorporates a barbecue dinner at Dinosaur Canyon Outpost followed by a sound and light show through the Dinosaur Canyon exhibitions while waiting for the sky to darken.

Tourism makes a significant contribution to regional communities, benefiting the economy through visitor spending in small businesses. This impact is particularly important in remote towns and the positive effects flow on as visitors travel throughout the wider region. As one of the regions iconic Outback tourist attractions, Australian Age of Dinosaurs contributes significantly to the strength of the local economy and the broader communities within Outback Queensland.

I strongly support the development of the new dark sky park and observatory attraction at the museum. I wish you all the best with your application.

Yours sincerely,

Matt Bron

Director, Outback and Country Queensland
Tourism and Events Queensland

Queensland Government A statutory body of the Queensland Government

TOURISM & EVENTS Queensland

Winton Business &
Tourism Association Inc
PO Box 44
Winton QLD 4735

Letter of Support: Gondwana Stars Observatory Project

To Whom in May Concern,

The Winton Business and Tourism Association (WBTA) is an incorporated body facilitating the building of business, tourism and community options within the Winton Shire. WBTA has around 30 members comprising local tourism operators, businesses and other stakeholders.

Established in 1967, our mission is to promote Winton and through that promotion to increase visitation to the community and its businesses to generate future income and sustainability.

Our Members buy local and live local because this strengthens the community and benefits everyone. As such, I write on behalf of the Members of the WBTA to express our unreserved support for the development of the Gondwana Stars Observatory.

Further, the proposed Observatory development ticks all the boxes to align with the Outback Queensland Tourism Association (OQTA) plan for tourism development in the region.

We believe that It will deliver significant benefits to the region in terms of increased visitation, longer visitor stays and more dollars spent with local businesses.

Therefore, it is our hope that this project will receive the required funding, support and approvals to proceed without unnecessary delay.

Please do not hesitate to contact me should any further information be required.

Your sincerely,

Hylton Ward
Chairman
Winton Business and Tourism Association
6th December 2017

Winton Shire Council

AR:DM
Ref: 72306
27th November 2017

Mr David Elliott
Executive Chairman
Australian Age of Dinosaurs
Museum of Natural History
PO Box 139
WINTON QLD 4735

Dear David

Re: Winton Shire Council support for the Australian Age of Dinosaurs Museum funding application to the Building Better Regions Fund.

Reference to the above is acknowledged and Council notes that your organisation is seeking funding through the Building Better Regions Fund, Infrastructure Projects Stream, Round 2, for the Gondwana Stars Project which is project 3.2 in a multi staged project. Projects 1, 2 and 3.1 are now complete and are witness to the Australian Age of Dinosaurs (AAoD) commitment to properly managing and completing projects, all of which enhance and lead to the original concept of the Australian Age of Dinosaurs Museum of Natural History.

The Gondwana Stars Project involves the development of an International Dark Sky Park at the home of the Australian Age of Dinosaurs, The Jump Up, and the construction of an open-air observatory named Gondwana Stars Observatory. The Observatory will house a 25" Dobsonian telescope with a go-to tracking system along with a range of medium and small telescopes that will enable the public to observe a wide range of celestial objects in a single evening. The project includes the installation of power and bitumen roads to the site and a researcher's cottage to provide university students with easy access to the observatory at all hours of the night and isolated accommodation away from the noise of day to day operations at the Museum.

As a Dark Sky Park, the Museum will be able to offer the use of its observatory facilities and equipment to an Australia-wide and international audience. This will have special benefits to northern hemisphere amateur astronomers as they will be able to access the southern sky with high-end equipment without having to bring the equipment themselves. It is intended that the Gondwana Stars experience will be quite different to conventional astronomy experiences as it will follow the Museum's theme of palaeontology and deep time meteorite impacts, meteors, the asteroid held, impact craters on the moon and anything else relating to how our planet has been affected through deep time by astronomic forces.

All Communications to:
The C.E.O.,
P.O. Box 288,
WINTON QLD 4735
AUSTRALIA
Telephone: (07) 4657 2666
Facsimile: (07) 4657 1342

As you are aware, Council is a strong supporter of the Australian Age of Dinosaurs and its various projects since the inception of the concept– fossil digs, fossil preparation and particularly the development of the Natural History Museum. Council acknowledges that this Museum is already a national attraction and is constantly widening the visitor base and therefore the economy of our Shire and the region due to the natural appeal of dinosaurs to young people. The development of the Australian Age of Dinosaurs project has garnered support from politicians, organisations and businesses, and continues to receive whole hearted support from Winton Shire Council.

Council understands Australian Age of Dinosaurs has a positive record of appropriately completing and acquitting a variety of projects, both infrastructure and event based. Council is partnering with the Australia Age of Dinosaurs to promote the joint branding initiative – "Winton: Dinosaur Capital of Australia".

The Australian Age of Dinosaurs continued development is of importance to the long-term sustainability of Winton and the broader outback region. Council is emphatically supportive of the Australian Age of Dinosaurs in general and more specifically, the Sondwana Start Project.

Should you require further information concerning this matter, please don't hesitate to contact CEO Alan Rayment on 46572666 for the necessary assistance.

Yours faithfully

Gavin Baskett
MAYOR

Alan Rayment
CHIEF EXECUTIVE OFFICER

Winton State School

Prep to Year 12

Est. 1885

Telephone: 07 4657 2333
Fax: 07 4657 1711
E-mail: the.principal@wintonss.eq.edu.au

71 Cork Street
P.O. Box 298
Winton QLD 4735

30th November 2017

To whom it may concern

I am writing to you today in support in of the Stage 3.2 Project, The Gondwana Stars Observatory.

The plans made by the 'Australian Age of Dinosaurs' for the observatory, including the 'Dobsonian telescope' and the educational links to schools and universities that will come to be associated with this project is to be truly commended for the scope and potential of the project.

Winton is a drought declared town in the guts of Queensland and has is historical linked to: 'Waltzing Matilda' and more recently the Australian Dinosaur capital

Winton State School's long term focus is mathematics and the curriculum links between astronomy and mathematics is a strong one. In fact Winton State School was part of an advertising campaign highlighting that very link earlier this year.

I do not think I would need try and persuade you too much in the benefits to our students and local families of having a high quality Dark Sky Park Observatory in the district for students to access.

I support this project 100% and I know the Winton State School community would be behind this bid for the educational benefits alone.

Regards,

Jason G White

Principal

Unihedron SQM (Average)

21.5-21.74 mpsas | ≥ 21.75 mpsas

C. RAW DATA

SQM 1 (DINOSAUR CANYON) -22.481333, 143.171097						
Date	Total no. of results	Average magnitudes per square arc second (mpsas) 21:00 to 04:00	Standard deviation of average mpsas 21:00 to 04:00	Average temp (C°) from results 21:00 to 04:00	No. 21.5 to 21.74 mpsas *(from total no. of results)*	No. ≥ 21.75 mpsas *(from total no. of results)*
19 March 2017	132	20.36	1.46	25.0	22	20
20 March 2017	144	21.17	0.79	21.6	25	16
21 March 2017	144	21.37	0.68	25.3	29	22
22 March 2017	144	21.70	0.28	25.1	36	24
23 March 2017	144	21.81	0.21	25.8	43	31
24 March 2017	144	21.83	0.11	25.5	47	36
25 March 2017	144	21.86	0.10	26.1	50	38
26 March 2017	144	21.80	0.14	25.5	47	30
27 March 2017	144	21.81	0.10	26.9	54	32
28 March 2017	144	21.87	0.20	25.9	50	33
29 March 2017	144	21.79	0.12	22.9	51	25
30 March 2017	144	21.69	0.15	21.0	45	19
31 March 2017	144	21.73	0.09	17.5	45	18
1 April 2017	144	21.73	0.165	20.1	38	17
2 April 2017	144	21.55	0.22	20.9	27	8
3 April 2017	144	21.41	9.44	21.3	24	13
4 April 2017	144	20.97	0.66	20.5	16	0
5 April 2017	144	20.45	0.88	19.2	7	0
6 April 2017	144	19.78	1.02	20.8	0	0
7 April 2017	144	19.01	1.05	20.5	0	0
8 April 2017	144	18.34	0.87	20.3	0	0
9 April 2017	144	17.66	0.88	20.7	0	0
10 April 2017	144	16.96	1.07	17.2	0	0
11 April 2017	144	16.47	1.43	18.1	0	0
12 April 2017	144	16.58	1.84	19.7	0	0
13 April 2017	144	16.81	2.16	20.3	1	0
14 April 2017	144	17.27	2.37	20.2	6	0
15 April 2017	144	18.13	2.35	20.6	9	0
16 April 2017	144	-0.10	0.00	0	0	0
17 April 2017	144	20.29	1.31	20.8	20	12
18 April 2017	144	20.93	0.86	20.1	25	19
19 April 2017	144	21.27	0.59	19.7	31	19
20 April 2017	144	20.29	0.40	19.3	37	23
21 April 2017	144	20.93	0.29	20.5	42	19
22 April 2017	144	21.27	0.20	20.1	45	22
23 April 2017	144	21.49	0.18	20.8	44	17
24 April 2017	144	21.57	0.20	20.7	44	32
25 April 2017	144	21.65	0.22	22.0	41	15
26 April 2017	144	21.56	0.18	16.9	41	3
27 April 2017	144	21.55	0.22	12.1	38	5
28 April 2017	144	21.54	0.17	11.8	41	0

SQM 1 (DINOSAUR CANYON) -22.481333, 143.171097						
Date	Total no. of results	Average magnitudes per square arc second (mpsas) 21:00 to 04:00	Standard deviation of average mpsas 21:00 to 04:00	Average temp (C°) from results 21:00 to 04:00	No. 21.5 to 21.74 mpsas *(from total no. of results)*	No. ≥ 21.75 mpsas *(from total no. of results)*
29 April 2017	144	21.62	0.26	14.5	41	26
30 April 2017	144	21.63	0.10	18.5	44	3
1 May 2017	144	21.41	0.17	19.0	17	0
2 May 2017	144	21.11	0.63	20.5	15	3
3 May 2017	144	20.87	0.89	20.9	12	3
4 May 2017	144	20.20	1.05	19.7	1	0
5 May 2017	144	19.87	1.01	19.1	0	0
6 May 2017	144	18.81	1.47	19.8	4	0
7 May 2017	144	18.35	1.17	17.4	2	0
8 May 2017	144	17.35	1.23	17.4	2	0
9 May 2017	144	16.64	1.63	17.6	0	0
10 May 2017	144	16.02	1.82	15.8	0	0
11 May 2017	144	15.98	1.94	14.8	0	0
12 May 2017	144	16.29	2.09	16.6	0	0
13 May 2017	144	16.65	2.16	17.6	4	0
14 May 2017	144	17.60	2.33	16.9	8	0
15 May 2017	144	18.65	2.21	16.6	12	0
16 May 2017	144	19.61	1.75	16.8	18	7
17 May 2017	144	20.49	1.01	19.7	24	0
18 May 2017	144	21.27	1.32	16.1	34	33
19 May 2017	144	21.28	1.02	17.2	37	15
20 May 2017	144	21.68	0.77	19.4	42	16
21 May 2017	144	21.46	0.24	19.2	32	16
22 May 2017	144	21.49	0.19	18.3	41	0
23 May 2017	144	21.46	0.23	19.0	41	8
24 May 2017	144	21.52	0.25	19.2	42	11
25 May 2017	144	21.57	0.18	17.7	53	26
26 May 2017	144	21.48	0.16	16.3	46	8
27 May 2017	144	21.54	0.20	16.0	49	30
28 May 2017	144	21.51	0.24	15.1	45	13
29 May 2017	144	21.65	0.41	14.7	45	24
30 May 2017	144	21.46	0.16	13.8	29	6
31 May 2017	144	21.28	0.20	12.2	19	0
1 June 2017	144	21.01	0.43	9.8	16	7
2 June 2017	144	20.67	0.75	12.1	18	14
3 June 2017	144	-0.10	0.00	12.4	0	0
4 June 2017	144	19.20	1.49	12.4	16	14
5 June 2017	144	18.40	1.82	13.7	12	11
6 June 2017	144	17.29	2.16	11.8	7	4
7 June 2017	144	16.57	2.12	9.6	1	0
8 June 2017	144	16.06	2.04	10.2	0	0

Unihedron SQM (Average)

21.5-21.74 mpsas | ≥ 21.75 mpsas

SQM 1 (DINOSAUR CANYON) -22.481333, 143.171097						
Date	Total no. of results	Average magnitudes per square arc second (mpsas) 21:00 to 04:00	Standard deviation of average mpsas 21:00 to 04:00	Average temp (C°) from results 21:00 to 04:00	No. 21.5 to 21.74 mpsas *(from total no. of results)*	No. ≥ 21.75 mpsas *(from total no. of results)*
9 June 2017	144	15.70	2.02	11.8	0	0
10 June 2017	144	15.94	1.99	11.4	0	0
11 June 2017	144	16.49	2.26	9.3	1	0
12 June 2017	144	17.18	2.38	12.4	6	0
13 June 2017	144	17.92	2.12	12.6	12	4
14 June 2017	144	19.33	1.89	14.4	17	4
15 June 2017	144	20.24	1.12	15.0	22	7
16 June 2017	144	20.78	0.71	15.6	25	0
17 June 2017	144	21.14	0.43	17.2	25	13
18 June 2017	144	21.31	0.21	14.7	23	9
19 June2017	144	21.44	0.17	13.1	33	6
20 June 2017	144	21.51	0.22	14.1	42	12
21 June 2017	144	21.49	0.24	13.4	44	18
22 June 2017	144	21.63	0.29	12.9	50	36
23 June 2017	144	21.58	0.28	13.6	50	30
24 June 2017	144	21.57	0.28	14.6	49	34
25 June 2017	144	21.58	0.25	15.6	48	34
26 June 2017	144	21.62	0.26	17.1	51	24
27 June 2017	144	21.64	0.21	16.8	55	23
28 June 2017	144	21.58	0.25	17.1	35	24
29 June 2017	144	21.35	0.49	11.3	29	23
30 June 2017	144	21.33	0.57	10.9	30	27
1 July 2017	144	21.13	0.99	15.7	31	28
2 July 2017	144	20.57	1.09	17.2	26	24
3 July 2017	144	19.84	1.59	18.3	21	19
4 July 2017	144	18.95	1.59	20.1	16	14
5 July 2017	144	17.58	1.88	18.9	11	9
6 July 2017	144	17.74	1.10	17.2	8	8
7 July 2017	144	15.99	1.77	14.5	0	0
8 July 2017	144	16.63	0.36	15.7	0	0
9 July 2017	144	16.55	1.07	14.3	0	0
10 July 2017	144	16.03	1.28	13.8	0	0
11 July 2017	144	16.83	2.22	15.0	4	2
12 July 2017	144	17.62	2.08	15.3	4	0
13 July 2017	144	18.90	1.81	14.8	7	0
14 July 2017	144	18.95	1.09	15.2	3	0
15 July 2017	144	20.60	0.68	14.0	11	0
16 July 2017	144	21.04	0.37	14.3	13	0
17 July 2017	144	21.33	0.20	15.6	20	0
18 July 2017	144	21.53	0.25	15.1	32	11
19 July 2017	144	21.61	0.30	9.6	44	24

SQM 1 (DINOSAUR CANYON) -22.481333, 143.171097						
Date	Total no. of results	Average magnitudes per square arc second (mpsas) 21:00 to 04:00	Standard deviation of average mpsas 21:00 to 04:00	Average temp (C°) from results 21:00 to 04:00	No. 21.5 to 21.74 mpsas *(from total no. of results)*	No. ≥ 21.75 mpsas *(from total no. of results)*
20 July 2017	144	21.63	0.31	10.1	44	31
21 July 2017	144	21.67	0.33	11.4	46	32
22 July 2017	144	21.62	0.26	14.0	47	29
23 July 2017	144	21.74	0.35	15.3	51	36
24 July 2017	144	21.69	0.29	14.8	51	33
25 July 2017	144	21.63	0.29	14.8	44	32
26 July 2017	144	21.69	0.30	13.4	40	34
27 July 2017	144	21.46	0.29	15.3	35	20
28 July 2017	144	21.69	0.47	14.7	40	36
29 July 2017	144	21.52	0.56	15.9	37	34
30 July 2017	144	21.35	0.81	14.7	33	32
31 July 2017	144	20.80	1.00	16.7	28	27
1 August 2017	144	20.33	1.49	17.2	23	22
2 August 2017	144	19.35	2.03	16.5	18	17
3 August 2017	144	18.30	2.35	11.0	13	12
4 August 2017	144	17.24	2.40	10.3	7	7
5 August 2017	144	16.51	2.24	12.1	2	2
6 August 2017	144	16.03	2.05	11.2	0	0
7 August 2017	144	15.68	2.13	12.2	0	0
8 August 2017	144	16.11	1.92	12.4	0	0
9 August 2017	144	16.94	1.81	14.5	0	0
10 August 2017	144	17.92	1.54	16.0	0	0
11 August 2017	144	19.01	1.24	17.4	0	0
12 August 2017	144	19.86	1.01	17.2	0	0
13 August 2017	144	20.57	0.77	18.1	4	0
14 August 2017	144	21.13	0.54	18.0	13	6
15 August 2017	144	21.55	0.37	18.4	23	17
16 August 2017	144	21.61	0.21	17.2	31	16
17 August 2017	144	21.66	0.25	19.6	37	20
18 August 2017	144	21.76	0.22	16.4	46	40
19 August 2017	144	21.61	0.18	11.8	44	16
20 August 2017	144	21.81	0.26	11.5	46	40
21 August 2017	144	21.81	0.24	15.5	47	41
22 August 2017	144	21.80	0.26	13.9	46	40
23 August 2017	144	21.75	0.23	15.7	46	36
24 August 2017	144	21.74	0.20	13.2	47	39
25 August 2017	144	21.82	0.26	11.0	47	41
26 August 2017	144	21.67	0.28	13.5	44	25
27 August 2017	144	21.73	0.39	13.8	42	38
28 August 2017	144	21.57	0.60	12.1	36	33
29 August 2017	144	21.19	0.86	13.0	30	28

Unihedron SQM (Average)

21.5-21.74 mpsas | ≥ 21.75 mpsas

SQM 1 (DINOSAUR CANYON) -22.481333, 143.171097

Date	Total no. of results	Average magnitudes per square arc second (mpsas) 21:00 to 04:00	Standard deviation of average mpsas 21:00 to 04:00	Average temp (C°) from results 21:00 to 04:00	No. 21.5 to 21.74 mpsas *(from total no. of results)*	No. ≥ 21.75 mpsas *(from total no. of results)*
30 August 2017	144	20.75	1.05	14.7	24	22
31 August 2017	144	19.78	1.74	17.4	18	18
1 September 2017	144	18.91	2.18	18.3	14	13
2 September 2017	144	17.82	2.32	18.3	8	7
3 September 2017	144	16.91	2.24	18.4	3	2
4 September 2017	144	16.40	2.02	14.4	0	0
5 September 2017	144	16.16	1.75	13.9	0	0
6 September 2017	144	16.37	1.38	13.4	0	0
7 September 2017	144	17.34	0.97	15.2	0	0
8 September 2017	144	17.86	1.11	15.9	0	0
9 September 2017	144	18.41	1.22	14.5	0	0
10 September 2017	144	19.86	1.09	17.5	6	0
11 September 2017	144	20.56	0.89	19.3	13	1
12 September 2017	144	21.20	0.69	20.7	21	15
13 September 2017	144	21.43	0.41	20.1	26	14
14 September 2017	144	21.73	0.19	12.9	38	23
15 September 2017	144	21.89	0.13	14.6	50	37
16 September 2017	144	21.86	0.13	15.9	52	39
17 September 2017	144	21.73	0.10	18.0	51	27
18 September 2017	144	21.74	0.07	18.9	50	25
19 September 2017	144	21.84	0.08	19.8	54	46
20 September 2017	144	21.96	0.12	18.1	54	48
21 September 2017	144	21.91	0.08	20.2	54	46
22 September 2017	144	21.93	0.09	20.2	54	47
23 September 2017	144	21.91	0.15	21.4	52	40
24 September 2017	144	21.87	0.16	21.1	49	42
25 September 2017	144	21.82	0.26	22.0	43	39
26 September 2017	144	21.57	0.43	23.7	36	32
27 September 2017	144	21.36	0.63	22.1	30	28
28 September 2017	144	21.00	0.93	22.6	24	23
29 September 2017	144	20.30	1.25	22.5	19	16
30 September 2017	144	19.36	1.75	24.4	14	11
1 October 2017	144	18.52	1.98	17.3	9	6
2 October 2017	144	17.59	2.23	17.6	5	3
3 October 2017	144	16.83	1.55	22.2	0	0
4 October 2017	144	16.74	1.04	22.1	0	0
5 October 2017	144	16.45	0.68	25.5	0	0
6 October 2017	144	16.44	0.38	25.5	0	0
7 October 2017	144	17.32	0.79	22.5	0	0
8 October 2017	144	18.58	0.84	25.1	8	2
9 October 2017	144	19.70	1.15	26.2	15	8

SQM 1 (DINOSAUR CANYON) -22.481333, 143.171097

Date	Total no. of results	Average magnitudes per square arc second (mpsas) 21:00 to 04:00	Standard deviation of average mpsas 21:00 to 04:00	Average temp (C°) from results 21:00 to 04:00	No. 21.5 to 21.74 mpsas *(from total no. of results)*	No. ≥ 21.75 mpsas *(from total no. of results)*
10 October 2017	144	20.52	1.10	26.3	22	17
11 October 2017	144	21.35	1.11	26.7	30	27
12 October 2017	144	21.54	0.62	25.8	35	31
13 October 2017	144	21.77	0.30	19.9	41	30
14 October 2017	144	21.80	0.19	21.2	46	36
15 October 2017	144	22.07	0.47	18.4	54	44
16 October 2017	144	21.90	0.11	17.3	53	41
17 October 2017	144	21.85	0.10	17.0	54	43
18 October 2017	144	21.85	0.15	21.8	52	31
19 October 2017	144	22.22	0.35	21.6	54	49
20 October 2017	144	22.46	0.44	15.8	56	53
21 October 2017	144	21.93	0.15	16.9	51	37
22 October 2017	144	21.86	0.16	17.9	46	32
23 October 2017	144	21.89	0.15	18.9	48	35
24 October 2017	144	21.56	0.17	22.0	44	31
25 October 2017	144	21.76	0.22	23.6	37	27
26 October 2017	144	21.58	0.48	22.6	30	23
27 October 2017	144	21.10	1.17	25.2	23	16
28 October 2017	144	20.74	1.04	21.5	19	12
29 October 2017	144	20.37	1.15	23.7	14	6
30 October 2017	144	19.45	1.69	21.5	7	0
31 October 2017	144	18.64	1.83	19.2	4	0
1 November 2017	144	18.24	1.28	20.3	0	0
2 November 2017	144	17.82	0.86	23.0	0	0
3 November 2017	144	17.19	0.67	25.5	0	0
4 November 2017	144	17.21	0.63	26.0	0	0
5 November 2017	144	18.04	0.54	28.5	0	0
6 November 2017	144					
7 November 2017	144					
8 November 2017	144					
9 November 2017	144					
10 November 2017	144					
11 November 2017	144					
12 November 2017	144					
13 November 2017	144					
14 November 2017	144					
15 November 2017	144					
16 November 2017	144					
17 November 2017	144					
18 November 2017	144					
19 November 2017	144					

Unihedron SQM (Average)

21.5-21.74 mpsas | ≥ 21.75 mpsas

SQM 1 (DINOSAUR CANYON) -22.481333, 143.171097						
Date	Total no. of results	Average magnitudes per square arc second (mpsas) 21:00 to 04:00	Standard deviation of average mpsas 21:00 to 04:00	Average temp (C°) from results 21:00 to 04:00	No. 21.5 to 21.74 mpsas *(from total no. of results)*	No. ≥ 21.75 mpsas *(from total no. of results)*
20 November 2017	144					
21 November 2017	144					
22 November 2017	144					
23 November 2017	144					
24 November 2017	144					
25 November 2017	144					
26 November 2017	144					
27 November 2017	144					
28 November 2017	144					
29 November 2017	144					
30 November 2017	144					
1 December 2017	144					
2 December 2017	144					
3 December 2017	144					
4 December 2017	144					
5 December 2017	144					
6 December 2017	144					
7 December 2017	144					
8 December 2017	144					
9 December 2017	144					
10 December 2017	144					
11 December 2017	144					
12 December 2017	144					
13 December 2017	144					
14 December 2017	144					
15 December 2017	144					
16 December 2017	144					
17 December 2017	144					
18 December 2017	144					
19 December 2017	144					
20 December 2017	144					
21 December 2017	144					
22 December 2017	144					
23 December 2017	144					
24 December 2017	144					
25 December 2017	144					
26 December 2017	144					
27 December 2017	144					
28 December 2017	144					
29 December 2017	144					
30 December 2017	144					

SQM 1 (DINOSAUR CANYON) -22.481333, 143.171097						
Date	Total no. of results	Average magnitudes per square arc second (mpsas) 21:00 to 04:00	Standard deviation of average mpsas 21:00 to 04:00	Average temp (C°) from results 21:00 to 04:00	No. 21.5 to 21.74 mpsas *(from total no. of results)*	No. ≥ 21.75 mpsas *(from total no. of results)*
31 December 2017	144					
1 January 2018	144					
2 January 2018	144					
3 January 2018	144					
4 January 2018	144					
5 January 2018	144					
6 January 2018	144					
7 January 2018	144					
8 January 2018	144					
9 January 2018	144					
10 January 2018	144					
11 January 2018	144					
12 January 2018	144					
13 January 2018	144					
14 January 2018	144					
15 January 2018	144					
16 January 2018	144					
17 January 2018	144					
18 January 2018	144					
19 January 2018	144					
20 January 2018	144					
21 January 2018	144					
22 January 2018	144					
23 January 2018	144					
24 January 2018	144					
25 January 2018	144					
26 January 2018	144					
27 January 2018	144					
28 January 2018	144					
29 January 2018	144					
30 January 2018	144					
31 January 2018	144					
1 February 2018	144					
2 February 2018	144					
3 February 2018	144					
4 February 2018	144					
5 February 2018	144					
6 February 2018	144					
7 February 2018	144					
8 February 2018	144					
9 February 2018	144	21.65	0.24	23.2	40	19

Unihedron SQM (Average)

21.5-21.74 mpsas | ≥ 21.75 mpsas

SQM 1 (DINOSAUR CANYON) -22.481333, 143.171097						
Date	Total no. of results	Average magnitudes per square arc second (mpsas) 21:00 to 04:00	Standard deviation of average mpsas 21:00 to 04:00	Average temp (C°) from results 21:00 to 04:00	No. 21.5 to 21.74 mpsas *(from total no. of results)*	No. ≥ 21.75 mpsas *(from total no. of results)*
10 February 2018	144	21.77	0.18	23.8	48	26
11 February 2018	144	21.79	0.18	27.2	52	30
12 February 2018	144	21.77	0.13	31.2	52	36
13 February 2018	144	22.35	0.39	31.5	55	54
14 February 2018	144	21.96	0.32	30.7	51	40
15 February 2018	144	21.80	0.14	30.4	53	36
16 February 2018	144	21.83	0.14	29.8	55	38
17 February 2018	144	21.79	0.17	28.3	54	33
18 February 2018	144	21.81	0.25	27.0	51	38
19 February 2018	144	21.99	0.18	26.0	55	47
20 February 2018	144	21.76	0.17	25.9	43	32
21 February 2018	144	21.86	0.34	23.8	41	35
22 February 2018	144	21.73	0.66	23.6	37	32
23 February 2018	144	21.27	0.95	21.9	31	25
24 February 2018	144	20.59	1.21	21.1	26	16
25 February 2018	144	20.09	1.27	21.7	18	9
26 February 2018	144	18.88	1.49	25.3	8	0
27 February 2018	144	18.27	0.86	25.9	6	0
28 February 2018	144	17.57	0.67	25.9	0	0
1 March 2018	144	16.46	0.51	24.4	0	0
2 March 2018	144	17.05	0.47	21.8	0	0
3 March 2018	144	17.12	0.90	20.0	1	0
4 March 2018	144	18.82	0.97	19.3	8	7
5 March 2018	144	18.19	1.59	19.5	8	6
6 March 2018	144	19.95	1.44	19.8	16	16
7 March 2018	144	19.81	1.53	20.6	17	14
8 March 2018	144	19.81	1.7	19.2	22	20
9 March 2018	144	21.01	1.18	20.8	28	26
10 March 2018	144	21.56	0.55	20.5	34	28
11 March 2018	144	21.74	0.32	20.7	36	26
12 March 2018	144	21.83	0.22	20.5	41	30
13 March 2018	144	21.82	0.18	21.5	42	31
14 March 2018	144	21.85	0.18	21.4	42	32
15 March 2018	144	21.87	0.18	22.9	45	32
16 March 2018	144	21.83	0.19	21.8	42	32
17 March 2018	144	21.75	0.18	22.4	38	25
18 March 2018	144	21.83	0.15	24.0	45	32
19 March 2018	144	21.77	0.17	24.4	40	29
20 March 2018	144	21.81	0.20	25.2	43	34
21 March 2018	144	21.82	0.16	23.0	42	31
22 March 2018	144	21.75	0.23	22.4	38	26

SQM 1 (DINOSAUR CANYON) -22.481333, 143.171097						
Date	Total no. of results	Average magnitudes per square arc second (mpsas) 21:00 to 04:00	Standard deviation of average mpsas 21:00 to 04:00	Average temp (C°) from results 21:00 to 04:00	No. 21.5 to 21.74 mpsas *(from total no. of results)*	No. ≥ 21.75 mpsas *(from total no. of results)*
23 March 2018	144	21.80	0.43	19.6	41	36
24 March 2018	144	21.30	0.41	20.9	17	7
25 March 2018	144	20.97	0.64	21.8	13	4
26 March 2018	144	20.10	1.23	20.5	8	0
27 March 2018	144	19.14	1.34	24.5	0	0
28 March 2018	144	18.65	1.03	24.8	0	0
29 March 2018	144	18.18	0.73	24.4	0	0
30 March 2018	144	17.43	0.85	24.8	0	0
31 March 2018	144	16.46	1.28	24.8	0	0
1 April 2018	144	16.27	1.74	24.4	0	0
2 April 2018	144	16.27	1.82	24.3	1	0
3 April 2018	144	17.15	2.22	23.8	8	5
4 April 2018	144	18.32	2.33	21.7	10	4
5 April 2018	144	19.30	1.93	22.8	11	0
6 April 2018	144	20.14	1.40	22.9	19	11
7 April 2018	144	20.91	0.85	22.7	23	13
8 April 2018	144	21.32	0.63	23.0	31	22
9 April 2018	144	21.48	0.41	22.9	34	21
10 April 2018	144	21.49	0.27	21.5	34	5
11 April 2018	144	21.63	0.25	22.3	35	10
12 April 2018	144	21.90	0.39	19.8	41	36
13 April 2018	144	21.66	0.21	21.0	39	26
14 April 2018	144	21.62	0.16	23.1	40	16
15 April 2018	144	21.62	0.19	21.4	36	23
16 April 2018	144	22.19	0.22	22.1	34	21
17 April 2018	144	21.61	0.24	23.6	34	24
18 April 2018	144	21.62	0.20	22.2	36	23

Unihedron SQM (Average)

21.5-21.74 mpsas | ≥ 21.75 mpsas

SQM 1 (DINOSAUR CANYON) -22.481333, 143.171097						
Date	Total no. of results	Average magnitudes per square arc second (mpsas) 21:00 to 04:00	Standard deviation of average mpsas 21:00 to 04:00	Average temp (C°) from results 21:00 to 04:00	No. 21.5 to 21.74 mpsas *(from total no. of results)*	No. ≥ 21.75 mpsas *(from total no. of results)*
22 April 2018	144	21.26	0.38	20.3	12	0
23 April 2018	144	20.87	0.57	19.5	0	0
24 April 2018	144	20.32	0.80	18.4	0	0
25 April 2018	144	19.54	1.25	18.3	0	0
26 April 2018	144	18.49	1.61	19.4	1	0
27 April 2018	144	17.39	1.75	18.0	0	0
28 April 2018	144	16.45	1.82	18.0	0	0
29 April 2018	144	15.80	1.68	18.8	0	0
30 April 2018	144	15.46	1.75	18.6	0	0
1 May 2018	144	16.09	2.10	18.0	0	0
2 May 2018	144	16.71	2.33	19.3	4	2
3 May 2018	144	17.66	2.40	19.2	9	7
4 May 2018	144	18.10	1.96	20.6	14	12
5 May 2018	144	19.70	1.72	19.4	19	16
6 May 2018	144	20.78	1.44	16.7	19	18
7 May 2018	144	21.05	0.74	18.7	28	22
8 May 2018	144	21.25	0.49	18.3	29	17
9 May 2018	144	21.35	0.31	1.1	26	2
10 May 2018	144	21.45	0.28	16.2	27	17
11 May 2018	144	21.44	0.23	10.7	25	20
12 May 2018	144	21.54	0.18	10.6	40	20
13 May 2018	144	21.49	0.16	12.5	34	12
14 May 2018	144	21.50	0.18	13.2	33	16
15 May 2018	144	21.54	0.20	14.4	43	21
16 May 2018	144	21.62	0.29	15.8	42	27
17 May 2018	144	21.61	0.20	13.1	51	21
18 May 2018	144	21.59	0.17	14.1	51	14
19 May 2018	144	21.62	0.19	15.5	47	13
20 May 2018	144	21.44	0.10	14.9	25	0
21 May 2018	144	21.25	0.26	13.2	16	0
22 May 2018	144	20.91	0.58	12.6	16	0
23 May 2018	144	20.20	1.45	14.5	23	14
24 May 2018	144	19.64	1.31	14.9	11	0
25 May 2018	144	18.55	1.99	16.4	13	4
26 May 2018	144	17.35	2.20	16.7	8	6
27 May 2018	144	16.40	2.21	16.5	3	1
28 May 2018	144	5.86	2.08	16.9	0	0
29 May 2018	144	15.51	2.00	16.6	0	0
30 May 2018	144	15.89	2.06	14.4	0	0
31 May 2018	144	16.38	2.07	10.9	2	0
1 June 2018	144	17.14	2.42	11.2	7	5

SQM 2 (DINOSAUR CANYON) -22.481333, 143.171097 (ALIGN)						
Date	Total no. of results	Average magnitudes per square arc second (mpsas) 21:00 to 04:00	Standard deviation of average mpsas 21:00 to 04:00	Average temp (C°) from results 21:00 to 04:00	No. 21.5 to 21.74 mpsas *(from total no. of results)*	No. ≥ 21.75 mpsas *(from total no. of results)*
22 April 2018	132	21.25	0.37	21.6	10	1
23 April 2018	144	20.86	0.56	20.7	0	0
24 April 2018	144	20.26	0.81	19.6	0	0
25 April 2018	144	19.61	1.01	19.6	0	0
26 April 2018	144	18.82	1.04	20.5	0	0
27 April 2018	144	17.96	0.94	19.1	0	0
28 April 2018	144	17.20	1.08	19.2	0	0
29 April 2018	144	16.31	1.25	19.9	0	0
30 April 2018	144	15.90	1.59	19.6	0	0
1 May 2018	144	16.30	2.05	19.0	0	0
2 May 2018	144	16.92	2.30	20.3	4	0
3 May 2018	144	17.86	2.27	20.1	9	4
4 May 2018	144	18.24	1.84	21.7	14	10
5 May 2018	144	19.84	1.49	20.6	19	12
6 May 2018	144	20.85	1.49	17.8	19	18
7 May 2018	144	21.08	1.37	19.9	29	22
8 May 2018	144	21.26	0.73	19.7	30	17
9 May 2018	144	21.34	0.50	18.6	28	0
10 May 2018	144	21.43	0.33	17.6	29	15
11 May 2018	144	21.42	0.31	12.1	27	19
12 May 2018	144	21.52	0.22	12.0	30	20
13 May 2018	144	21.45	0.21	13.8	29	11
14 May 2018	144	21.46	0.22	14.6	30	14
15 May 2018	144	21.51	0.26	15.8	35	21
16 May 2018	144	21.58	0.30	17.3	42	24
17 May 2018	144	21.57	0.26	14.6	42	23
18 May 2018	144	21.55	0.23	15.5	39	15
19 May 2018	144	21.58	0.25	17.0	40	15
20 May 2018	144	21.40	0.15	16.3	18	0
21 May 2018	144	21.20	0.21	14.6	6	0
22 May 2018	144	20.84	0.55	13.9	8	0
23 May 2018	144	20.17	1.45	15.8	21	13
24 May 2018	144	19.58	1.20	16.1	9	0
25 May 2018	144	18.75	1.43	17.5	11	3
26 May 2018	144	17.71	1.55	17.7	8	4
27 May 2018	144	16.80	1.75	17.5	2	0
28 May 2018	144	16.05	1.85	17.9	0	0
29 May 2018	144	15.52	1.91	17.7	0	0
30 May 2018	144	15.83	2.05	15.6	0	0
31 May 2018	144	16.40	2.10	12.1	2	0
1 June 2018	144	17.29	2.39	12.5	7	5

Unihedron SQM (Average)

21.5-21.74 mpsas | ≥ 21.75 mpsas

SQM 1 (DINOSAUR CANYON) -22.481333, 143.171097

Date	Total no. of results	Average magnitudes per square arc second (mpsas) 21:00 to 04:00	Standard deviation of average mpsas 21:00 to 04:00	Average temp (C°) from results 21:00 to 04:00	No. 21.5 to 21.74 mpsas *(from total no. of results)*	No. ≥ 21.75 mpsas *(from total no. of results)*
2 June 2018	144	17.14	2.37	10.9	12	9
3 June 2018	144	18.10	2.15	9.7	17	14
4 June 2018	144	20.04	1.54	11.5	22	12
5 June 2018	144	20.68	0.81	12.5	16	7
6 June 2018	144	21.02	0.61	14.1	28	3
7 June 2018	144	21.35	0.29	14.0	35	7
8 June 2018	144	21.44	0.14	14.3	32	0
9 June 2018	144	21.55	0.09	16.3	48	11
10 June 2018	144	21.54	0.11	17.0	53	11
11 June 2018	144	21.53	0.11	16.8	52	19
12 June 2018	144	20.82	3.43	15.8	38	13
13 June 2018	144	22.07	3.43	13.9	67	66
14 June 2018	144	21.51	0.15	10.1	47	20
15 June 2018	144	21.60	0.11	8.8	58	24
16 June 2018	144	21.64	0.14	10.3	57	27
17 June 2018	144	21.49	0.15	7.4	32	15
18 June 2018	144	21.44	0.19	6.6	27	15
19 June 2018	144	21.35	0.29	7.8	25	16
20 June 2018	144	21.04	0.57	9.2	25	17
21 June 2018	144	20.61	0.87	10.9	24	11
22 June 2018	144	19.99	1.30	14.1	21	17
23 June 2018	144	18.85	2.11	15.1	16	11
24 June 2018	144	17.23	1.70	15.2	11	9
25 June 2018	144	16.56	1.32	13.4	6	5
26 June 2018	144	16.18	1.52	14.3	0	0
27 June 2018	144	15.77	2.03	14.1	0	0
28 June 2018	144	15.30	1.60	15.5	0	0
29 June 2018	144	15.71	1.62	17.8	0	0
30 June 2018	144	16.75	2.22	17.1	3	1
1 July 2018	144	17.63	2.26	16.7	8	0
2 July 2018	144	18.60	2.20	16.2	13	0
3 July 2018	144	19.64	1.64	13.9	18	0
4 July 2018	144	20.41	0.92	14.4	11	0
5 July 2018	144	20.81	0.53	15.2	6	0
6 July 2018	144	21.19	0.31	15.3	19	0
7 July 2018	144	21.35	0.11	10.7	18	0
8 July 2018	144	21.48	0.12	8.6	44	0
9 July 2018	144	21.55	0.26	9.7	45	19
10 July 2018	144	21.52	0.28	10.1	39	20
11 July 2018	144	21.51	0.27	10.2	36	19

SQM 2 (DINOSAUR CANYON) -22.481333, 143.171097 (ALIGN)

Date	Total no. of results	Average magnitudes per square arc second (mpsas) 21:00 to 04:00	Standard deviation of average mpsas 21:00 to 04:00	Average temp (C°) from results 21:00 to 04:00	No. 21.5 to 21.74 mpsas *(from total no. of results)*	No. ≥ 21.75 mpsas *(from total no. of results)*
2 June 2018	144	18.30	2.23	12.2	12	8
3 June 2018	144	19.39	1.84	11.0	17	15
4 June 2018	144	20.28	1.11	12.8	21	15
5 June 2018	144	20.74	0.70	13.8	18	7
6 June 2018	144	21.04	0.55	15.3	29	3
7 June 2018	144	21.31	0.30	15.3	31	10
8 June 2018	144	21.38	0.17	15.6	24	0
9 June 2018	144	21.48	0.14	17.7	36	14
10 June 2018	144	21.47	0.15	18.4	43	13
11 June 2018	144	21.47	0.15	18.1	38	20
12 June 2018	144	20.74	3.44	17.2	35	12
13 June 2018	144	22.06	3.48	15.4	65	64
14 June 2018	144	21.44	0.17	11.4	37	21
15 June 2018	144	21.53	0.13	10.4	52	25
16 June 2018	144	21.58	0.16	11.7	49	22

SQM 2 (THE STAR GALLERY) -22.463375, 143.193489

Date	Total no. of results	Average magnitudes per square arc second (mpsas) 21:00 to 04:00	Standard deviation of average mpsas 21:00 to 04:00	Average temp (C°) from results 21:00 to 04:00	No. 21.5 to 21.74 mpsas *(from total no. of results)*	No. ≥ 21.75 mpsas *(from total no. of results)*
17 June 2018	144	21.40	0.16	8.6	21	13
18 June 2018	144	21.36	0.19	7.9	22	14
19 June 2018	132	21.35	0.29	9.0	25	16
20 June 2018	144	21.07	0.53	10.4	25	16
21 June 2018	144	20.65	0.82	12.1	24	12
22 June 2018	144	19.99	1.35	15.3	22	16
23 June 2018	144	18.94	2.01	16.3	16	11
24 June 2018	144	17.28	1.69	16.3	11	9
25 June 2018	144	16.52	1.36	14.6	6	4
26 June 2018	144	16.14	1.52	15.5	0	0
27 June 2018	144	15.60	1.97	15.2	0	0
28 June 2018	144	15.17	1.60	16.6	0	0
29 June 2018	144	15.67	1.56	18.8	0	0
30 June 2018	144	16.67	2.19	18.2	3	0
1 July 2018	144	17.43	2.33	17.7	7	0
2 July 2018	144	18.36	2.35	17.3	13	0
3 July 2018	144	19.38	1.92	15.2	18	0
4 July 2018	144	20.35	0.97	12.1	7	0
5 July 2018	144	20.78	0.54	13.6	3	0
6 July 2018	144	21.17	0.31	16.5	17	0
7 July 2018	144	21.34	0.11	12.3	9	0
8 July 2018	144	21.47	0.13	9.5	32	0
9 July 2018	144	21.55	0.27	11.3	34	20
10 July 2018	144	21.51	0.29	11.2	35	20
11 July 2018	144	21.50	0.28	11.6	32	20

Unihedron SQM (Average)

21.5-21.74 mpsas | ≥ 21.75 mpsas

SQM 1 (DINOSAUR CANYON) -22.481333, 143.171097						
Date	**Total no. of results**	**Average magnitudes per square arc second (mpsas) 21:00 to 04:00**	**Standard deviation of average mpsas 21:00 to 04:00**	**Average temp (C°) from results 21:00 to 04:00**	**No. 21.5 to 21.74 mpsas** *(from total no. of results)*	**No. ≥ 21.75 mpsas** *(from total no. of results)*
12 July 2018	144	21.51	0.27	11.3	37	19
13 July 2018	144	21.54	0.25	9.9	34	20
14 July 2018	144	21.57	0.27	10.1	44	19
15 July 2018	144	21.59	0.26	10.6	41	19
16 July 2018	144	21.60	0.27	10.1	41	20
17 July 2018	144	21.52	0.27	12.3	30	21
18 July 2018	144	21.43	0.47	15.4	32	25
19 July 2018	144	21.20	1.14	16.1	38	34
20 July 2018	144	20.83	0.89	8.8	28	22
21 July 2018	144	20.37	1.32	8.5	24	22
22 July 2018	144	19.43	1.99	11.2	19	17
23 July 2018	144	18.32	2.31	11.2	13	12
24 July 2018	144	17.25	2.36	12.5	8	7
25 July 2018	144	16.51	2.23	14.9	3	2
26 July 2018	144	16.03	2.04	16.3	0	0
27 July 2018	144	15.49	1.89	15.6	6	4
28 July 2018	144	16.55	1.05	17.3	0	0
29 July 2018	144	16.48	2.09	12.7	0	0
30 July 2018	144	17.19	2.17	11.5	1	0
31 July 2018	144	18.18	1.94	13.6	4	0
1 August 2018	144	19.32	1.38	14.1	4	0
2 August 2018	144	20.08	0.90	15.6	0	0
3 August 2018	144	20.54	0.66	12.7	0	0
4 August 2018	144	20.90	0.72	14.8	4	0
5 August 2018	144	21.68	0.58	19.3	33	27
6 August 2018	144	21.73	0.19	11.6	53	18
7 August 2018	144	21.74	0.35	9.1	39	30
8 August 2018	144	21.72	0.37	10.1	37	32
9 August 2018	144	21.67	0.29	12.3	40	32
10 August 2018	144	21.74	0.37	13.9	37	33
11 August 2018	144	21.73	0.32	14.5	39	32
12 August 2018	144	21.75	0.38	9.4	39	33
13 August 2018	144	21.74	0.33	9.9	41	34
14 August 2018	144	21.76	0.40	11.0	39	34
15 August 2018	144	21.81	0.37	12.9	43	36
16 August 2018	144	21.72	0.50	13.7	40	36
17 August 2018	144	21.53	0.62	14.8	36	34
18 August 2018	144	21.25	0.86	15.6	30	29
19 August 2018	144	20.78	1.07	10.3	25	24
20 August 2018	144	20.05	1.60	9.0	19	19
21 August 2018	144	18.93	2.14	10.7	14	13

SQM 2 (THE STAR GALLERY) -22.463375, 143.193489						
Date	**Total no. of results**	**Average magnitudes per square arc second (mpsas) 21:00 to 04:00**	**Standard deviation of average mpsas 21:00 to 04:00**	**Average temp (C°) from results 21:00 to 04:00**	**No. 21.5 to 21.74 mpsas** *(from total no. of results)*	**No. ≥ 21.75 mpsas** *(from total no. of results)*
12 July 2018	144	21.50	0.29	12.9	34	20
13 July 2018	144	21.52	0.25	11.8	34	20
14 July 2018	144	21.56	0.27	11.1	41	21
15 July 2018	144	21.58	0.28	14.0	35	22
16 July 2018	144	21.59	0.27	6.69	36	22
17 July 2018	144	21.51	0.28	12.0	31	22
18 July 2018	144	21.43	0.46	13.8	33	25
19 July 2018	144	21.21	1.11	18.0	39	35
20 July 2018	144	20.83	0.89	10.7	28	23
21 July 2018	144	20.40	1.25	9.0	24	22
22 July 2018	144	19.52	1.80	10.2	19	17
23 July 2018	144	18.37	2.20	10.0	13	12
24 July 2018	144	17.29	2.28	13.4	8	7
25 July 2018	144	16.43	2.22	14.2	3	2
26 July 2018	144	15.80	1.98	13.6	0	0
27 July 2018	144	15.26	1.80	13.9	6	4
28 July 2018	144	16.75	0.91	17.5	0	0
29 July 2018	144	16.34	2.01	14.1	0	0
30 July 2018	144	17.14	2.07	8.4	3	0
31 July 2018	144	18.15	1.91	12.9	4	0
1 August 2018	144	19.23	1.50	13.2	2	0
2 August 2018	144	20.04	0.95	14.7	0	0
3 August 2018	144	20.53	0.66	15.4	0	0
4 August 2018	144	20.91	0.75	14.6	6	0
5 August 2018	144	21.67	0.61	19.3	35	27
6 August 2018	144	21.75	0.18	13.7	52	17
7 August 2018	144	21.76	0.34	6.4	40	30
8 August 2018	144	21.74	0.37	10.6	39	33
9 August 2018	144	21.70	0.29	10.3	40	32
10 August 2018	144	21.76	0.37	11.4	40	34
11 August 2018	144	21.75	0.30	16.	41	33
12 August 2018	144	21.78	0.38	11.6	41	34
13 August 2018	144	21.77	0.32	11.1	43	35
14 August 2018	144	21.79	0.39	10.3	41	35
15 August 2018	144	21.84	0.36	11.3	44	36
16 August 2018	144	21.73	0.49	13.1	40	36
17 August 2018	144	21.54	0.62	11.7	36	35
18 August 2018	144	21.23	0.87	17.3	30	29
19 August 2018	144	20.75	1.11	11.6	25	24
20 August 2018	144	20.09	1.44	8.3	19	19
21 August 2018	144	19.02	1.97	8.6	14	13

Unihedron SQM (Average)

21.5-21.74 mpsas | ≥ 21.75 mpsas

SQM 1 (DINOSAUR CANYON) -22.481333, 143.171097							SQM 2 (THE STAR GALLERY) -22.463375, 143.193489						
Date	Total no. of results	Average magnitudes per square arc second (mpsas) 21:00 to 04:00	Standard deviation of average mpsas 21:00 to 04:00	Average temp (C°) from results 21:00 to 04:00	No. 21.5 to 21.74 mpsas *(from total no. of results)*	No. ≥ 21.75 mpsas *(from total no. of results)*	Date	Total no. of results	Average magnitudes per square arc second (mpsas) 21:00 to 04:00	Standard deviation of average mpsas 21:00 to 04:00	Average temp (C°) from results 21:00 to 04:00	No. 21.5 to 21.74 mpsas *(from total no. of results)*	No. ≥ 21.75 mpsas *(from total no. of results)*
22 August 2018	144	17.93	2.36	9.6	9	8	22 August 2018	144	18.01	2.22	5.7	9	8
23 August 2018	144	16.96	2.34	12.4	4	2	23 August 2018	144	17.01	2.27	9.9	4	2
24 August 2018	144	16.41	2.12	14.5	0	0	24 August 2018	144	16.25	2.12	15.7	0	0
25 August 2018	144	16.02	2.02	12.0	0	0	25 August 2018	144	15.87	1.98	15.7	0	0
26 August 2018	144	15.73	1.89	13.1	0	0	26 August 2018	144	15.58	1.86	11.9	0	0
27 August 2018	144	16.43	1.65	13.5	0	0	27 August 2018	144	16.27	1.71	13.7	0	0
28 August 2018	144	17.44	1.38	13.9	0	0	28 August 2018	144	17.12	1.65	13.1	0	0
29 August 2018	144	18.39	1.08	15.6	0	0	29 August 2018	144	18.16	1.35	14.8	0	0
30 August 2018	144	19.22	1.14	17.5	0	0	30 August 2018	144	19.15	1.23	15.8	0	0
31 August 2018	144	20.00	1.16	17.6	12	5	31 August 2018	144	19.92	1.13	19.2	11	4
1 September 2018	144	20.67	0.83	15.2	10	2	1 September 2018	144	20.68	0.84	15.8	11	3
2 September 2018	144	21.23	0.56	14.3	17	10	2 September 2018	144	21.24	0.56	17.2	18	10
3 September 2018	144	21.64	0.34	13.2	27	18	3 September 2018	144	21.64	0.35	15.9	29	19
4 September 2018	144	21.81	0.25	12.3	39	25	4 September 2018	144	21.82	0.24	15.6	38	26
5 September 2018	144	21.93	0.24	12.3	48	39	5 September 2018	144	21.93	0.21	9.6	49	37
6 September 2018	144	22.02	0.27	17.5	49	42	6 September 2018	144	22.02	0.24	15.9	51	43
7 September 2018	144	21.98	0.27	18.5	49	41	7 September 2018	144	21.97	0.20	20.5	50	42
8 September 2018	144	21.96	0.23	14.6	50	42	8 September 2018	144	21.95	0.13	15.5	50	43
9 September 2018	144	21.96	0.16	14.7	52	45	9 September 2018	144	21.96	0.16	16.2	52	46
10 September 2018	144	21.96	0.19	15.2	50	44	10 September 2018	144	21.95	0.17	14.5	51	44
11 September 2018	144	21.98	0.19	17.4	51	44	11 September 2018	144	21.97	0.17	15.2	52	45
12 September 2018	144	21.87	0.17	18.4	50	41	12 September 2018	144	21.86	0.15	16.8	51	42
13 September 2018	144	22.02	0.23	19.3	49	45	13 September 2018	144	22.01	0.21	17.9	50	45
14 September 2018	144	21.93	0.46	21.9	43	41	14 September 2018	144	21.91	0.45	21.1	44	40
15 September 2018	144	21.73	0.53	19.0	37	34	15 September 2018	144	21.71	0.52	20.5	37	34
16 September 2018	144	21.49	0.71	12.5	32	29	16 September 2018	144	21.47	0.71	4.3	32	29
17 September 2018	144	21.08	0.87	14.9	26	24	17 September 2018	144	21.04	0.91	15.0	25	24
18 September 2018	144	20.57	1.23	17.0	20	19	18 September 2018	144	20.52	1.25	14.8	19	19
19 September 2018	144	19.58	1.84	17.8	14	13	19 September 2018	144	19.65	1.62	19.9	14	13
20 September 2018	144	18.67	2.29	15.6	10	9	20 September 2018	144	18.70	2.11	16.8	10	9
21 September 2018	144	17.43	2.18	16.1	4	0	21 September 2018	144	17.51	2.02	17.3	4	0
22 September 2018	144	16.89	2.21	16.9	0	0	22 September 2018	144	16.86	2.23	17.2	0	0
23 September 2018	144	16.57	1.94	17.7	0	0	23 September 2018	144	16.40	1.96	16.8	0	0
24 September 2018	144	16.40	1.01	20.1	0	0	24 September 2018	144	16.16	1.12	20.4	0	0
25 September 2018	144	16.45	0.51	19.9	0	0	25 September 2018	144	16.18	0.73	18.1	0	0
26 September 2018	144	17.54	0.66	19.9	0	0	26 September 2018	144	17.39	0.70	17.9	0	0
27 September 2018	144	18.29	0.76	18.9	1	0	27 September 2018	144	18.30	0.74	17.5	0	0
28 September 2018	144	19.06	1.05	20.0	7	0	28 September 2018	144	19.09	1.00	18.3	8	0
29 September 2018	144	19.86	1.15	21.2	14	4	29 September 2018	144	19.88	1.11	20.6	15	5
30 September 2018	144	20.64	1.01	22.3	21	12	30 September 2018	144	20.64	0.98	22.5	22	12
1 October 2018	144	21.24	0.79	21.9	29	21	1 October 2018	144	21.22	0.79	21.4	29	21

Unihedron SQM (Average)

21.5-21.74 mpsas | ≥ 21.75 mpsas

SQM 1 (DINOSAUR CANYON) -22.481333, 143.171097							SQM 2 (THE STAR GALLERY) -22.463375, 143.193489						
Date	Total no. of results	Average magnitudes per square arc second (mpsas) 21:00 to 04:00	Standard deviation of average mpsas 21:00 to 04:00	Average temp (C°) from results 21:00 to 04:00	No. 21.5 to 21.74 mpsas *(from total no. of results)*	No. ≥ 21.75 mpsas *(from total no. of results)*	Date	Total no. of results	Average magnitudes per square arc second (mpsas) 21:00 to 04:00	Standard deviation of average mpsas 21:00 to 04:00	Average temp (C°) from results 21:00 to 04:00	No. 21.5 to 21.74 mpsas *(from total no. of results)*	No. ≥ 21.75 mpsas *(from total no. of results)*
2 October 2018	144	21.68	0.53	19.6	37	30	2 October 2018	144	21.67	0.53	17.4	37	30
3 October 2018	144	21.89	0.31	19.4	44	36	3 October 2018	144	21.87	0.33	16.9	44	35
4 October 2018	144	21.97	0.13	17.8	53	40	4 October 2018	144	21.93	0.13	19.9	52	39
5 October 2018	144	21.96	0.10	18.4	54	43	5 October 2018	144	21.92	0.09	21.3	53	41
6 October 2018	144	22.01	0.08	19.8	57	49	6 October 2018	144	21.98	0.07	21.0	56	47
7 October 2018	144	22.07	0.10	22.6	56	49	7 October 2018	144	22.04	0.09	22.4	56	47
8 October 2018	144	22.15	0.09	22.9	56	51	8 October 2018	144	22.11	0.09	25.3	56	49
9 October 2018	144	22.04	0.10	22.6	56	48	9 October 2018	144	22.00	0.09	21.9	56	46
10 October 2018	144	22.61	0.61	25.6	57	56	10 October 2018	144	21.90	3.50	28.1	55	51
11 October 2018	144	22.08	3.49	23.0	54	46	11 October 2018	144	22.10	3.50	25.4	52	44
12 October 2018	144	22.03	0.11	20.0	55	47	12 October 2018	144	22.00	0.12	21.3	55	45
13 October 2018	144	21.93	0.16	20.7	48	38	13 October 2018	144	21.88	0.16	22.8	46	34
14 October 2018	144	21.92	0.27	23.6	43	35	14 October 2018	144	21.87	0.26	26.1	41	32
15 October 2018	0	0	0	0	0	0	15 October 2018	0	-0.10	0	0	0	0
16 October 2018	144	21.21	0.88	20.8	27	23	16 October 2018	143	21.06	1.04	22.1	26	22
17 October 2018	144	20.86	0.92	21.2	20	16	17 October 2018	144	20.74	1.00	23.4	20	11
18 October 2018	144	20.27	1.34	19.5	15	10	18 October 2018	144	20.01	1.67	18.9	14	7
19 October 2018	144	19.43	1.93	22.6	10	4	19 October 2018	144	19.08	2.23	21.0	9	0
20 October 2018	144	18.19	1.65	25.3	6	0	20 October 2018	144	17.88	1.92	26.7	5	1
21 October 2018	144	17.95	1.82	22.6	2	0	21 October 2018	144	17.25	2.31	24.5	0	0
22 October 2018	144	17.90	1.14	24.2	0	0	22 October 2018	144	16.89	1.93	26.0	0	0
23 October 2018	144	17.06	1.01	26.3	0	0	23 October 2018	144	16.67	1.24	26.0	0	0
24 October 2018	144	17.40	0.57	25.4	0	0	24 October 2018	144	16.89	0.81	23.7	0	0
25 October 2018	144	17.83	0.48	25.7	0	0	25 October 2018	144	17.55	0.56	23.8	0	0
26 October 2018	144	18.17	0.45	26.2	2	0	26 October 2018	144	17.98	0.49	25.0	2	0
27 October 2018	144	19.01	0.95	27.4	8	5	27 October 2018	144	18.84	1.03	27.3	8	1
28 October 2018	144	19.92	1.14	27.3	15	11	28 October 2018	144	19.77	1.19	29.1	15	7
29 October 2018	144	20.63	1.20	27.1	22	20	29 October 2018	144	20.48	1.25	28.9	21	20
30 October 2018	144	21.25	0.93	26.1	28	26	30 October 2018	144	21.14	0.94	29.1	28	24
31 October 2018	144	21.61	0.64	26.5	34	31	31 October 2018	144	21.50	0.64	27.6	34	29
1 November 2018	144	21.74	0.43	27.2	39	35	1 November 2018	144	21.66	0.43	28.9	38	32
2 November 2018	144	21.93	0.28	25.4	45	39	2 November 2018	144	21.85	0.25	26.4	44	35
3 November 2018	144	22.01	9.98	24.7	49	44	3 November 2018	144	21.92	9.95	24.2	48	42
4 November 2018	144	21.92	0.16	25.7	49	41	4 November 2018	144	21.84	0.16	23.9	47	33
5 November 2018	144	22.02	0.24	26.4	47	39	5 November 2018	144	21.93	0.23	25.2	45	35
6 November 2018	144	22.00	0.17	27.3	50	41	6 November 2018	144	21.91	0.16	26.3	48	38
7 November 2018	144	22.25	0.22	20.6	51	51	7 November 2018	144	22.13	0.19	22.8	51	48
8 November 2018	144	22.04	0.21	18.0	48	43	8 November 2018	144	21.95	0.20	19.7	47	41
9 November 2018	144	22.03	0.19	23.5	49	45	9 November 2018	144	21.93	0.18	26.7	47	41
10 November 2018	144	21.15	4.78	20.9	42	38	10 November 2018	144					
11 November 2018	144	22.08	0.27	23.8	48	37	11 November 2018	144					

Unihedron SQM (Average)

21.5-21.74 mpsas | ≥ 21.75 mpsas

SQM 1 (DINOSAUR CANYON) -22.481333, 143.171097						
Date	**Total no. of results**	**Average magnitudes per square arc second (mpsas) 21:00 to 04:00**	**Standard deviation of average mpsas 21:00 to 04:00**	**Average temp (C°) from results 21:00 to 04:00**	**No. 21.5 to 21.74 mpsas** *(from total no. of results)*	**No. ≥ 21.75 mpsas** *(from total no. of results)*
12 November 2018	144	21.90	0.27	23.0	39	30
13 November 2018	144	21.93	0.63	25.3	36	30
14 November 2018	144	21.44	0.91	25.6	29	26
15 November 2018	144	21.09	0.89	24.5	20	12
16 November 2018	144	20.46	1.36	26.8	18	15
17 November 2018	144	20.26	1.75	27.7	15	14
18 November 2018	144	19.09	1.78	24.5	10	8
19 November 2018	144	18.50	1.49	25.5	5	5
20 November 2018	144	18.36	0.96	23.6	2	2
21 November 2018	144	17.36	0.52	20.8	0	0
22 November 2018	144	17.95	0.51	19.3	0	0
23 November 2018	144	18.00	0.42	18.3	0	0
24 November 2018	144	18.42	0.42	22.5	0	0
25 November 2018	144	19.12	0.77	24.5	6	5
26 November 2018	144	19.27	1.65	26.1	12	12
27 November 2018	144	20.47	1.24	26.9	18	17
28 November 2018	144	21.13	1.04	19.6	24	23
29 November 2018	144	21.54	0.79	21.4	29	27
30 November 2018	144	21.79	0.61	24.6	34	32

SQM 2 (THE STAR GALLERY) -22.463375, 143.193489						
Date	**Total no. of results**	**Average magnitudes per square arc second (mpsas) 21:00 to 04:00**	**Standard deviation of average mpsas 21:00 to 04:00**	**Average temp (C°) from results 21:00 to 04:00**	**No. 21.5 to 21.74 mpsas** *(from total no. of results)*	**No. ≥ 21.75 mpsas** *(from total no. of results)*
12 November 2018	144					
13 November 2018	144					
14 November 2018	144					
15 November 2018	144					
16 November 2018	144					
17 November 2018	144					
18 November 2018	144					
19 November 2018	144					
20 November 2018	144					
21 November 2018	144					
22 November 2018	144					
23 November 2018	144					
24 November 2018	144					
25 November 2018	144					
26 November 2018	144					
27 November 2018	144					
28 November 2018	144					
29 November 2018	144					
30 November 2018	144					