FTA107 - Bendigo-Ophir Gold Project

STATEMENT OF DR BRIAN J BOYLE

25 March 2026

Current Position

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1 My full name is Brian J Boyle

2 I am an Emeritus Professor of Astronomy at the University of New South Wales, Sydney, specialising in Astrophysics and Astronomy.

3 I have been engaged by the Sustainable Tarras group to provide expert commentary on the Bendigo-Ophir Gold Project's lighting effects on the brightness of the night sky.

Qualification and Experience

4 I hold the degree of BSc (Hons) in astrophysics from the University of Edinburgh and PhD in Physics from the University of Durham. I am a Fellow of the Australian Academy of Science, elected in 2006.

5 I have thirty years professional experience in the protection of major international astronomical observatory sites, including Siding Spring Mountain (as Director of the Anglo-Australian Observatory 1996-2003), and the leading the creation of the world's protected site for radio astronomy, the Murchison radioastronomy observatory (2006-2015).

6 I have experience leading the development of the successful application for international dark sky Park status awarded to the Kawarau-Gibbston in 2024 and, most recently, a lighting impact study on the proposed FastTrack development by Gibbston Valley Station.

7 I own a vineyard and operate a small astronomy guiding business from my astronomical observatory in Gibbston. The Project is too distant from my vineyard and observatory to any impact (positive or negative) on my vineyard or observatory business.

8 I am chair of Winterstellar, a Charitable Trust located in Alexandra, Central Otago. Winterstellar promotes astronomy and the importance of dark skies to the communities of Otago through exhibitions, presentations and other events. This work is non-remunerated.

Practice Note

9 I acknowledge that I have read and am familiar with the Environment Court's Code of Conduct for Expert Witnesses, contained in the Environment Court Practice Note 2023, and agree to comply with it.

10 Other than where I state that I am relying on the advice on another person, I confirm that the issues addressed in this statement are within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

11 In preparing this statement, I have read materials on the FastTrack website relating to Application FTA107 – the Bendigo-Ophir Gold Project (hereinafter The Project) including B.31 Cosgroves Exterior Lighting Report (hereinafter the Cosgrove's Report).

12 I have also made extensive use of the peer-reviewed work by Falchi et al (2025). Falchi et al regularly produce of map of the night sky brightness across the globe (www.lightpollutionmap.info). This work models in detail

the zenithal[1] brightness of the sky as would be seen from the surface of the Earth at 1km-resolution, based on data taken with the VIIRS (Visible Infrared Imaging Radiometer Suite) on board the Suomi NPP, NOAO-20 and NOAO-21 satellites, providing daily global coverage of visible/infrared light emitted from the surface of the Earth at less than 1km resolution.

13 The modelled sky brightness data is checked against direct measurements of the brightness night sky by professional and amateur astronomers across the globe, and is found to be an extremely robust and accurate measure of the night sky brightness around the world. Combined with my own measurements, I rely on this data to track sky brightness increase at my own observatory in the Kawarau-Gibbston Dark Sky Park due to the encroaching light domes of Queenstown and Cromwell.

14 I viewed the site on March 18 from the public Thompson's Gorge road.

Summary

15 The existing night sky in this region is globally significant. It is only possible to see the aurora, the rich starfields towards the central of our galaxy and our nearest galactic neighbours (the Magellanic Clouds) from 0.1% of the world's inhabited land. This site is part of that 0.1%.

16 Although a detailed lighting ordinance schedule has yet to be provided for the Project, measurements of the lighting impact from Macraes mine, a similar-scale 24/7 operational open-cut gold mine suggests that the lighting impact on the night sky brightness will be substantial.

17 At the core, zenithal night sky brightness from artificial light could rise by over 50 times, with the surrounding communities of Tarras and Bendigo

[1] The words zenith and its adjective zenithal used throughout the text refer to the point in the sky directly above the observer.

experiencing a ten-fold increase in the artificial light pollution at the zenith. Closer to the horizon this issue will be exacerbated. This will be particularly damaging for auroral visibility; effectively the resident of Tarras and the region to the north of the mine will lose sight of the aurora australis.

18 Light pollution from mines is an issue that is repeated the world over. Driven by necessary safety requirements, open-cut mines operating as night cannot be consistent with a dark sky, or the lighting specifications required to deliver a dark sky.

19 I am not aware of any open-cut mine in the world that is consistent with dark sky specifications, so if this Project were to achieve this, it would be a world first.

Global significance of the Tarras-Bendigo night sky

20 The Bendigo-Tarras region is one of the most important and unique areas globally for the public's appreciation of the night sky. It is part of only 0.1% of the world's land in which it is possible to see the centre of our milky way galaxy, the Magellanic Clouds (our nearest neighbouring galaxies) and the aurora.

21 The region enjoys an extremely dark sky where the contribution of artificial brightness to the night sky is less than 1.5 microcandela per square metre (Falchi et al. 2025), or less than 1% of the natural brightness of the night sky caused by airglow and low level auroral activity

22 The astrotourism business globally is estimated to be worth between USD1-2billion annually, growing at 10% per annum. Based on this measure alone, access to dark skies is increasingly seen as of importance to the global travelling public.

23 In Central Otago, Naseby has already been recognised as an international dark sky place. Outside the current town, the rest of this region, easily fulfils the requirements for international dark sky recognition. Indeed a number of smaller community groups in the region (Tarras, Lauder, St Bathans, Hawea) have expressed a strong desire to secure international dark sky status for their existing dark sky, but lack the resources to develop an application for international recognition.

24 Winterstellar Charitable Trust is working with these communities, to investigate submitting an application for an International Dark Sky Reserve.

25 Rather than provide protection, the international recognition of the existing dark sky simply acknowledges the relevant authorities' commitment to protect, preserve and promote this globally but important but diminishing resource. [In the last eight years, the night sky brightness has, on average, doubled across the world].

26 Consequently, approval of this Project by the relevant authorities would effectively end any regional aspiration for international recognition of its dark sky.

Observations on the Proposal and Cosgrove's Report

27 The Proposal make no mention of the lighting impact from the mine on the visibility of the night sky.

28 The Cosgrove report addresses lighting visibility and amenity effects and the Proposal's compliance with CODC's Plan change 22 (Dark Sky Precinct) lighting specifications. However, in most cases, commitments are given to meet specifications, *only as far as is reasonably practical*. Moreover, the requirement to use only lights with a colour temperature of 3000K or less is

noted in the report as not being appropriate for high risk tasks due to health and safety.

29 The Cosgrove's report also provides examples of light fittings which may be used. Many examples shown were fully shielded, but some were also hinged to provide illumination above the horizontal.

30 The Cosgrove's report also provides a visual simulation sheet markup in appendix B. This not accompanied by any quantitative information on the detailed lighting ordinance to be used (numbers, lumens, colour temperature), nor is any attempt made to assess the quantitative impact on sky brightness through e.g. sky illumination levels in candela/m^2.

31 Given this lack of detail to assess, I have considered likely lighting impact by referring to similar 24/7 open cut mining projects and their lighting impacts.

32 In this respect, the Macraes mine in East Otago can serve as a useful comparison. For this comparison, I use the measure of gold production as a proxy for the scale of operational activity, and with it the scale of lighting required. Macraes production is currently 130000-200000 ounces/yr, whereas The Project is proposed to have a production of up 120000 ounces/yr. Thus the Project will have above 70% of the production capability as Macraes mine. This number will be used in determining potential impacts.

33 Using the latest 2025 sky brightness data from Falchi et al (2025) data, it can be seen that the light dome created by the Macraes mine is approximately equivalent to the light dome of Cromwell; a town of 8000 people (see figure 1).

34 At the centre of the Macraes light dome (orange/yellow contour), the zenithal sky brightness due to artificial light is 90 times brighter than the levels of light

pollution caused by existing artificial light in the Tarras-Bendigo region (grey contour).

35 At 70% of the scale of the Macraes mine, the Project would result in a sky brightness level *at the zenith* over 50 times greater than current levels. At this level, the contribution from artificial light exceeds the natural sky brightness. At this level the brightness of the night sky would exceed the level required for international dark sky Sanctuary, Park or Reserve status.[2]

36 The light dome from the Macraes mine extends contributes the majority of artificial light at the zenith over an area of at least 50square kilometres around its location. Scaling such a light dome by 70% at the location of the Project, would in a measureable impact *at the zenith* over more than 30 square kilometres.

37 Note that that is the contribution of light to the sky brightness at the zenith. Closer to the horizon, the contribution to the brightness will be much greater. Figure 2a shows an image of Macraes mine taken on the night of 13 March 2026. It illustrates the strong illumination from Macraes, which is brighter than the aurora that night. This image was taken 19 km from the mine site. The reduced scale of this Project's operation (70%) would appear to have the same brightness at a distance of 16km

[2] Technically, the larger region (e.g. Cental Otago) could still meet the requirements for an international Dark Sky Reserve status, since it is permissible to have brighter "buffer zones" within a large Dark Sky Reserve (e,g Tekapo within the international Aoraki/Mackenzie Dark Sky Reserve). However, buffer zones are only permit to restrict lighting to existing settlements, protecting the larger dark sky Reserve. Government approval of a new development with significant light pollution in an existing dark sky area, would effectively remove any chance for this broader area to achieve international dark sky status as per points 25 and 26 in the text. Having a dark sky is a necessary but not sufficient requirement for international status. Protecting, protecting and preserving our existing dark sky resource is.

38 Figure 2a demonstrates that terrain-shielding does not mitigate this form light pollution as Macraes mine is below the horizon in this image. This is because the increase in sky brightness is caused by light from sources on the ground back scattered into our line-of-sight from the atmosphere.

39 The direction of the Macraes mine in the image is Southwest (Figure 2b). The For the largest settlement in the area (Tarras), the proposed mine will be further round to the south and approximately 12km distant. The light domes from Tarras would therefore appear 70% brighter than Figure 2a, once the closer distance and assumed lower light intensity is taken in account.

40 This brighter glow would also sit closer to the direction of the aurora (south). Such a glow would effectively prevent those who live to the north of the mine from seeing the vast majority of auroral events.

41 Local views of the most important features of the night sky would also be significantly degraded. This would include views of our nearest galactic neighbours, the Magellanic Clouds (low in the southern sky, particularly duing the long nights of winter) and the rising central regions of our Milky Way in autumn (south-east). The level of degradation would depend on distance and viewing orientation with respect to the Project, but based on the example of Macraes, the scattered light form the Project would impact on most visual observations and wide-field (e.g smartphone) photography of the night sky from distance of at least 20 km.

42 Further inspections of the Falchi et al (2025) night sky map reveal that open cut mines globally are invariably accompanied by a substantial light dome (figure 3). The scale of the light dome depends on the scale of the activity, but the understandable importance that the mining industry attaches to the safety of its workers at night means that open cut mining is not consistent with preserving the darkness of the night sky.

Figure 1 Falchi et al map of modelled zenithal sky brightness based on VIIRS satellite data from 2025. Sky brightnesses are plotted in logarithmic contours with each colour (from grey – red) being double the previous colours. Grey corresponds to artificial light levels at the zenith of 1.75microcandela/m^2 , light grey is 3microcandela/m^2 , blue is 3microcandela/m^2 , light blue is 14microcandela/m^2 , green is 24 microcandela/m^2 , orange is 48 microcandela/m^2 and yellow is 96 microcandela/m^2 .The Project location is shown by a small black circle, and the Macraes mine location (discussed in the text) is centred at the large red circle.

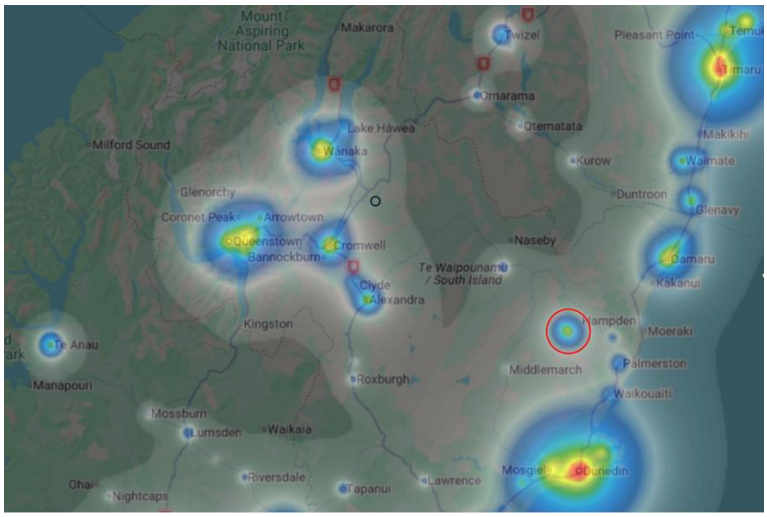

Figure 2. a) Image of the light dome from Macraes mine at a distance of 19km. Image taken by Andy Davey on 14 March 2026. b) Orientation and distance of image from Macraes mine.

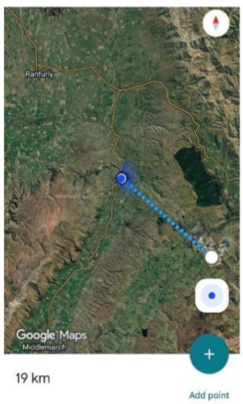

Figure 3. Section of Falchi et al (2025) night sky brightness map covering Western Australia. Open cut mining activity (iron ore and gold) dominant the visible light domes in the interior of the State.