moir STUDIO

Shadow Flicker Assessment

Tall Tree Wind Farm

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Tall Tree Wind Farm

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Executive Summary

This Shadow Flicker Assessment has been prepared by Moir Studio to support the environmental assessment of the proposed Tall Tree Wind Farm (the Project), located in Central West Victoria within the Golden Plains Shire. The assessment has been undertaken in accordance with the Draft National Wind Farm Development Guidelines (EPHC, 2010), which provide a consistent national framework for evaluating the visual and amenity impacts of wind farm developments.

The Tall Tree Wind Farm comprises up to 53 turbines, with a maximum blade tip height of 250.5 metres and a blade chord length of 4.3 metres. Shadow flicker modelling was conducted using WindPRO software, applying conservative, worst-case assumptions. The modelling extent was defined by a 1,139.5 metre radius (265 × blade chord length of 4.3 m), beyond which shadow flicker is not considered perceptible.

Thirteen (13) non-associated dwellings were identified within the study area. Of these, six (6) non-associated dwellings were predicted to experience shadow flicker in excess of the 30-hour per year guideline threshold.

The turbines contributing to these exceedances include T10, T18, T22, T45, T47, T70, and T71. Where aerial imagery indicated potential screening by vegetation, on-site inspections have been recommended to verify visibility. For the remaining turbines causing exceedances without evident screening, operational mitigation is recommended to ensure compliance with shadow flicker thresholds.

Overall, with implementation of the proposed mitigation strategies, the project is expected to comply with national shadow flicker guidance.

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1.0 Introduction

1.1 Purpose of this Report

This Shadow Flicker Assessment has been prepared for the proposed Tall Tree Wind Farm. The Project is situated within the proposed Central Highlands Renewable Energy Zone (REZ), in Central West Victoria. The report has been prepared in accordance with the methodology and considerations outlined in the *Draft National Wind Farm Development Guidelines* prepared by the Environment Protection and Heritage Council (July 2010) (referred to hereafter as 'the Draft National Guidelines'). The Draft National Guidelines provide a nationally consistent framework for assessing the environmental and amenity impacts associated with wind farm developments, including the potential for shadow flicker effects on nearby sensitive receptors.

1.2 Overview of Shadow Flicker

Shadow flicker is defined as the visual effect that occurs when rotating turbines cause moving shadows as the blades pass in front of the sun. The effect will occur under circumstances where the turbine is located such that at certain times of day the sun's rays pass through the swept area of the rotating blades, potentially affecting the viewpoint. The effect is diminished by the distance of the viewpoint from the turbine. Shadowing is also influenced by increased cloud cover, and is dependent on the angle of the sun's rays (EPHC, 2010). **Images 01** and **02** provide examples of shadow flicker.

The rate of flicker for a three-bladed, horizontal axis wind turbine is three (3) times the rotational speed of the wind turbine rotor. For example, a three-bladed wind turbine with a rotor speed of 20 revolutions per minute (RPM) results in a flicker frequency of 1 Hertz (once per second). According to the Draft National Guidelines (Section E.2.2 p 149), conventional horizontal axis wind turbines cause shadow flicker at frequencies of around 1 Hz or less which is considered well below the ranges identified for potential human health effects associated with a flicker frequency that may trigger epileptic seizures. Seizures are generally triggered by flashing lights between the frequencies of 5 to 30 flashes per second (Hz).

Image 01 – Example of shadow reducing with distance from WTG

Image 02 – Example of shadow from WTG

2.0 Project Overview

2.1 Project Overview

The Tall Tree Wind Farm is a proposed renewable energy project, located in Central West Victoria. The site is located in the Golden Plains Shire, West of Lethbridge, North of Teesdale & South of Meredith. The project has the potential to generate enough energy to power up to 250,000 homes annually, with up to 53 wind turbines on site. The project is currently in the feasibility stage, preparing referral documents under the Environment Effects Act 1978 and Environment Protection Biodiversity Act 1999 (Acciona, 2025).

The Project is shown on **Figure 01**.

2.2 Turbine Parameters

Parameters used for the assessment have been summarised in **Table 01** and demonstrated as **Figure 02.** Blade Chord is defined as the distance from the trailing edge of the blade to the leading edge of the blade, typically the longest dimension of the blade cross-section.

Turbine Parameters Used:	
Project Component	**Dimension:**
Blade tip height	250.5 m
Hub height	159 m
Blade Length	91.5 m
Blade Chord Length	4.3 m

Table 01 – Turbine Assessment Parameters

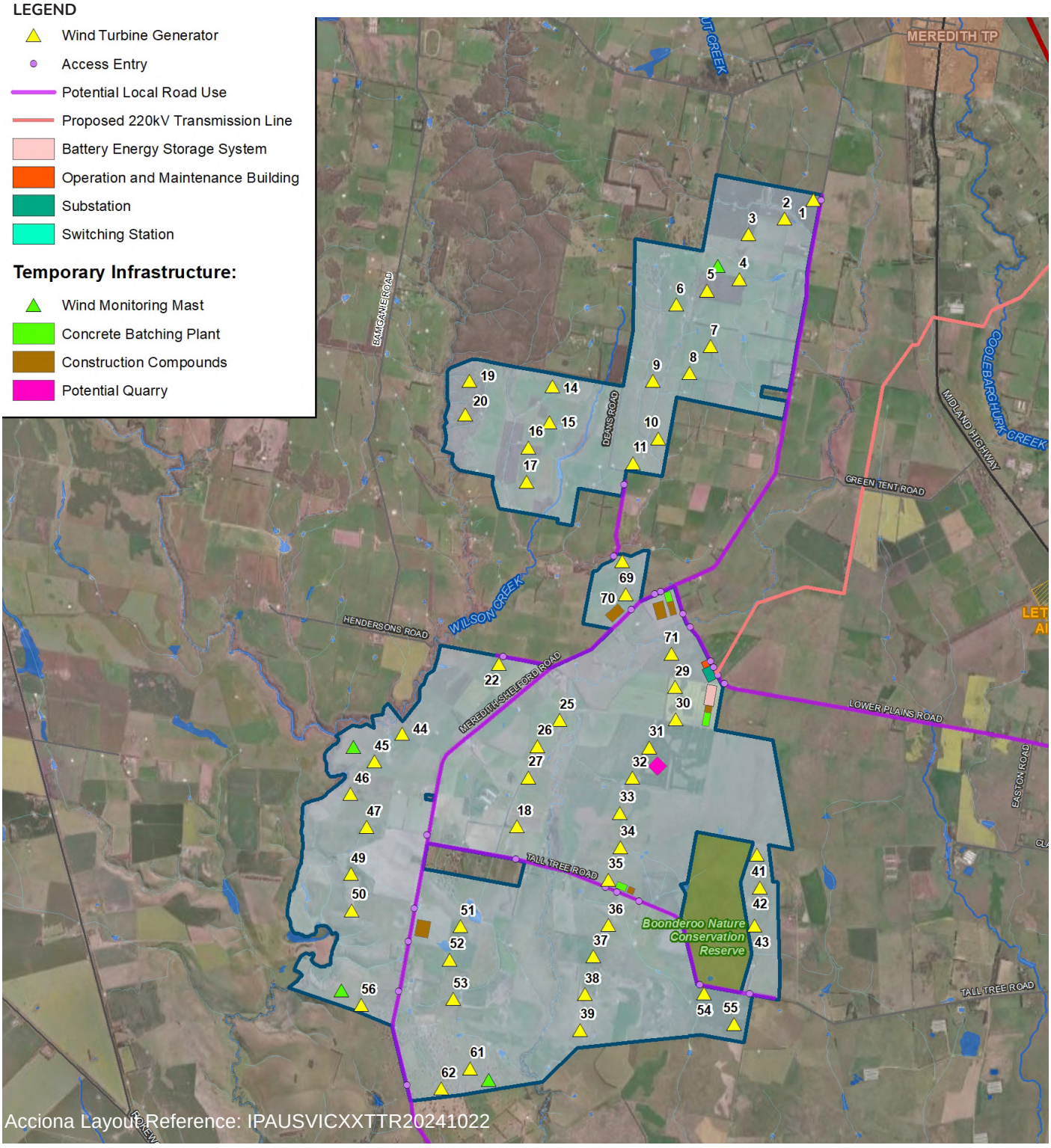


Figure 01 Project Layout

This assessment has been based on the dwelling dataset provided by the Client 23.05.2025 and layout reference IPAUSVICXXTTR20241022. It is assumed that this layout reflects the current design intent and includes all relevant infrastructure components. Any future amendments to the layout or associated data may alter the findings of this report and would require a revised assessment.

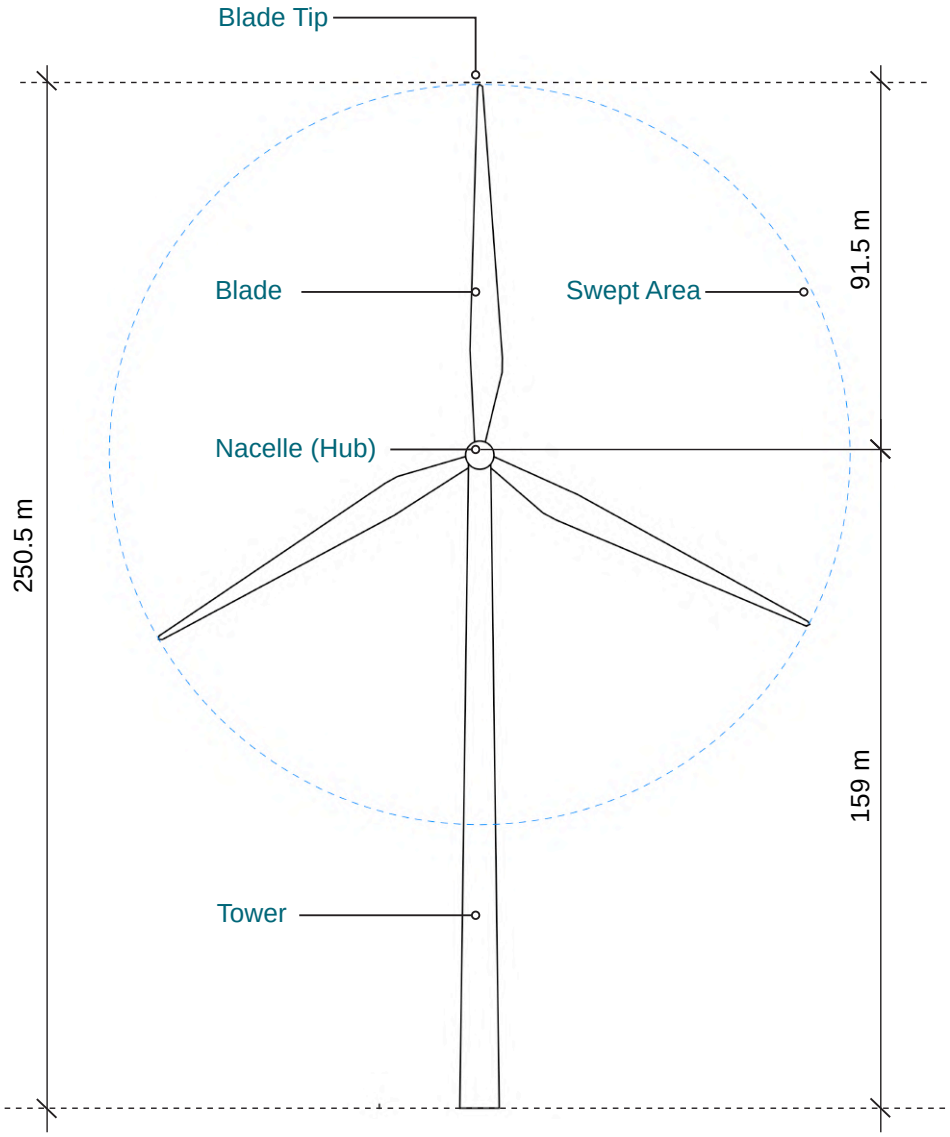


Figure 02 Turbine Parameters for Assessment

3.0 Study Method

3.1 Overview of Study Method

Modelling of the shadow flicker was conducted using specialist industry software (Wind Pro), assessing all turbines proposed for the Project. It is important to note the shadow flicker modelling undertaken for the Project is based on topography and celestial movements alone and therefore the extent of impact may be decreased by a number of variables including:

- The aspect of the residence relative to the turbine(s) (window locations, living area locations etc);
- The extent of natural or screening vegetation between the turbine(s) and the receptor;
- The existence of other screening elements (buildings, structures etc) between the turbine(s) and the receptor;
- The time of year;
- The orientation of turbine rotors relative to the sun's rays when operating (i.e. not always perpendicular);
- The proportion of daylight hours in which the turbines operate; and
- The frequency of bright sunshine and cloudless skies (particularly at low elevations above the horizon).

Model Parameter	Setting Used:
Zone of Visual Influence of Shadows	265 x 4.3 m (maximum blade chord) = 1,139.5 m **Refer to Section 3.3.**
Minimum angle of sun	3 degrees
Shape of the sun	Disk
Time and duration of modelling	One full year
Orientation of the rotor	The rotor plane is always perpendicular to the line from the WTG to the sun
Time step	1 minute
Effects of topography	Included
Receptor Height	1.5 meters
Grid size	1 meter

Table 02 – Shadow Flicker Assessment Parameters

3.2 Assumptions and Limitations of this Assessment

The following assumptions and limitations have been made:

- Assessment is based on a maximum impact scenario, assuming turbines operate continuously during daylight hours when the sun is shining.
- The model assumes 100% clear skies throughout the year, which does not account for cloud cover, weather variability, or turbine downtime.
- Vegetation, buildings, and other landscape features that may obstruct shadow paths are not included unless specifically modelled.
- Sun position data is based on astronomical calculations (sun path geometry) specific to the project's geographic coordinates.
- Receptors are typically modelled at a fixed height above ground level (e.g. 1.5 m for standing human eye level).
- Shadow flicker is calculated using the turbine layout and specification provided at the time of assessment.
- Modelling is limited to a fixed distance (1,139.5 m), based on the accepted standard of 265 × blade chord length (4.3 m) beyond which flicker is imperceptible (refer to **Section 3.3**). For the purposes of modeling here this distance is measured horizontally from the base of the turbine to the observer; in practice the distance from observer to the blade (the hypotenuse of a triangle formed with its distance above the ground) will be greater - making this assumption more conservative.
- The worst-case approach overestimates actual shadow flicker, as it does not factor the varying pitch of blades at angles that reduce the effective width of the blade relative to the sun's rays. It also assumes that turbine blades have a constant width (equal to the maximum chord length) from root to tip; in reality the maximum width occurs at approximately 20% along the blade from the root, which then tapers towards the tip.
- The assessment may report annual hours, but not how those hours are distributed throughout the year or day, which may influence perceived impact.
- Results are accurate for the current turbine layout and specifications shown in **Table 01**. Any changes to turbine locations, or increases in key turbine dimensions (tip height and blade length) will require an updated assessment.

3.3 Study Area Definition

The Draft National Guidelines state: *Shadow flicker can theoretically extend many kilometres from a wind turbine. However, the intensity of the shadows decreases with distance. While acknowledging that different individuals have different levels of sensitivity and may be annoyed by different levels of shadow intensity, these guidelines limit assessment to moderate levels of intensity (i.e. well above the minimum theoretically detectable threshold) commensurate with the nature of the impact and the environment in which it is experienced.*

For the purpose of this report, shadow flicker beyond the distance of 265 x maximum blade chord length (4.3 m) has not been considered due to the physical limits of shadow formation. This is the distance beyond which, per the Draft National Guidelines, less than 50% of sunlight would be blocked by a turbine blade in the worst case scenario. Beyond this distance shadow flicker is no longer perceivable as per the example provided in **Figure 03.**

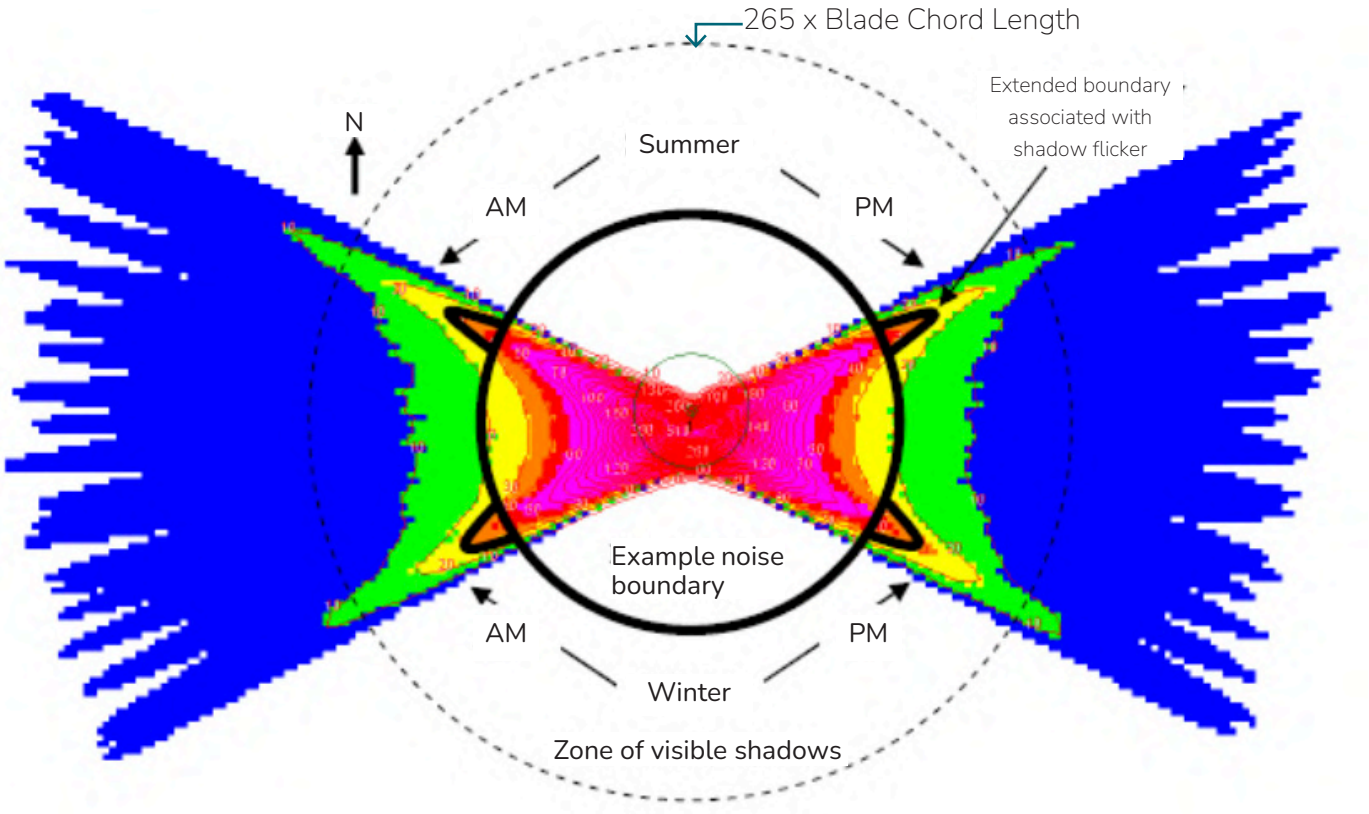


Figure 03 Typical Area of Shadow Flicker from a single turbine showing number of hours of shadow flicker per year (Source: EPHC, 2021)

4.0 Assessment Results

4.1 Non-associated Dwellings Within Study Area

The first step of the assessment is to identify the dwellings located within the 'Study Area' of 1,139.5 m. Thirteen (13) non-associated dwellings have been identified within the Study Area as shown on **Figure 05** and outlined in **Table 02.**

Dwellings Identified within Study Area		
Dwelling ID:	**Number of turbines within 1,139.5m of dwelling:**	**Turbines within 1,139.5 m:**
Dwelling 4	**One (1)**	**T6**
Dwelling 14	**One (1)**	**T69**
Dwelling 20	**One (1)**	**T1**
Dwelling 32	**Two (2)**	**T9, T14**
Dwelling 49	**Two (2)**	**T69, T70**
Dwelling 192	**Three (3)**	**T44, T45, T47**
Dwelling 196	**Two (2)**	**T39, T61**
Dwelling 203	**Three (3)**	**T47, T49, T51**
Dwelling 662	**One (1)**	**T22**
Dwelling 1401	**Two (2)**	**T18, T51**
Dwelling 1694	**Two (2)**	**T8, T10**
Dwelling 1870	**Two (2)**	**T22, T44**
Dwelling 1871	**Two (2)**	**T22, T44**

Table 03 – Non-associated Dwellings located within Study Area

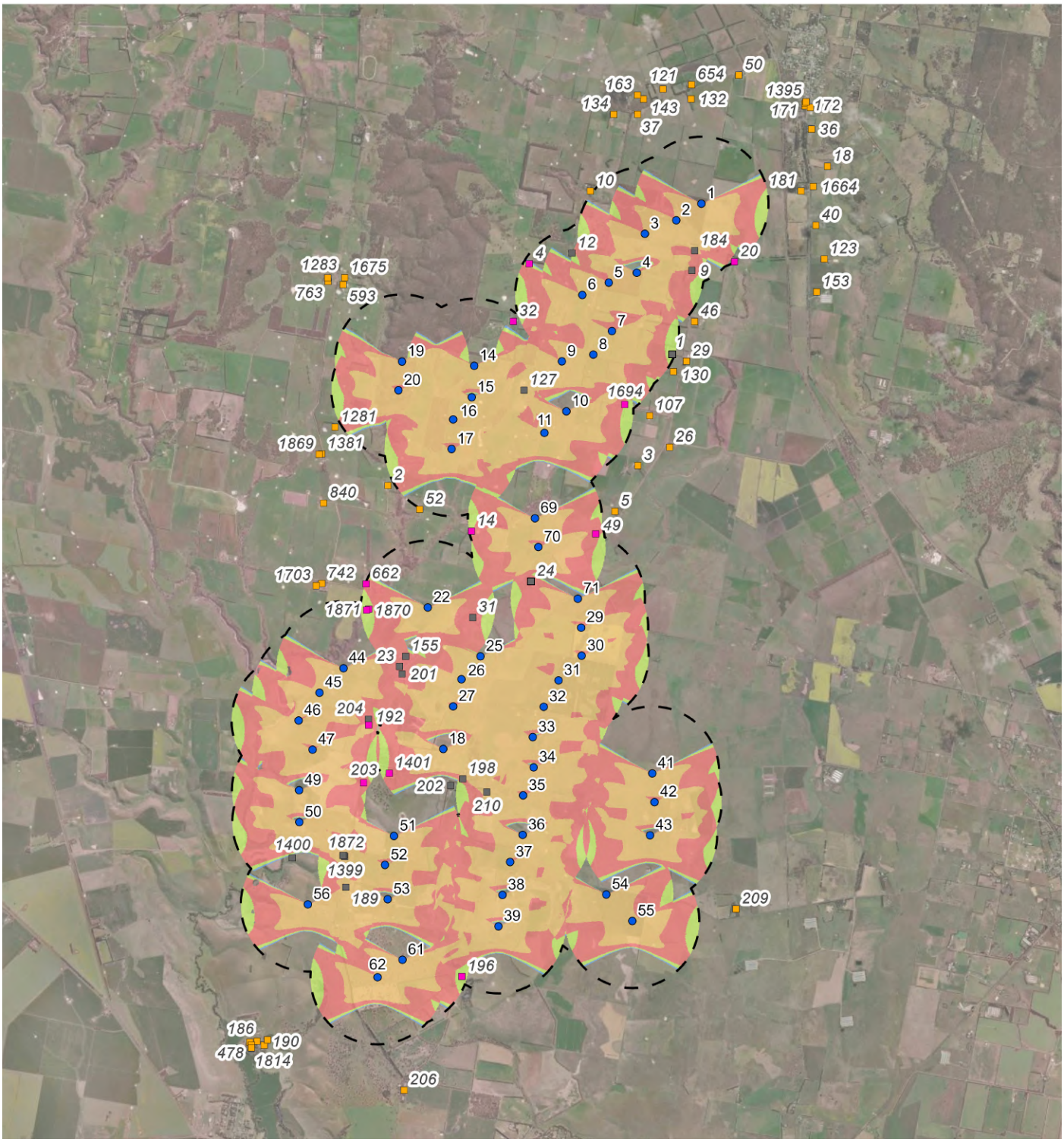


Figure 04 Shadow Flicker Diagram

4.2 Results of Shadow Flicker Assessment at Non-associated Dwellings

The next step of the assessment is to calculate the shadow flicker effect from turbines located within the 1,139.5 m of the Study Area for each of the non-associated dwellings. This has been provided in **Table 04**.

Dwelling ID:	Total Shadow Hours Per Year:	Shadow Days Per Year:	Max Shadow Hours Per Day:	Exceeds 30 hrs?:	Turbine:	Notes:
Dwelling 4	15:34	46	0:26	No	**T6: 15:34**	**Refer to Appendix A1**
Dwelling 14	23:26	48	0:37	No	**T69: 23:26**	**Refer to Appendix A2**
Dwelling 20	Nil	Nil	Nil	No	T1: 0:00	**Refer to Appendix A3**
Dwelling 32	Nil	Nil	Nil	No	T6: 0:00 T14: 0:00	**Refer to Appendix A4**
Dwelling 49	**67:03**	129	0:43	**Yes**	**T69: 25:09** **T70: 41:54**	**Refer to Appendix A5**
Dwelling 192	**89:35**	174	0:43	**Yes**	T44: 0:00 **T45: 55:43** **T47: 33:52**	**Refer to Appendix A6**
Dwelling 196	25:31	51	0:39	No	T39: 0:00 **T61: 25:31**	**Refer to Appendix A7**
Dwelling 203	**74:21**	148	0:42	**Yes**	**T47: 48:29** **T49: 25:52** T51: 0:00	**Refer to Appendix A8**
Dwelling 662	**48:51**	90	0:39	**Yes**	**T22: 48:51**	**Refer to Appendix A9**
Dwelling 1401	**35:51**	66	0:42	**Yes**	**T18: 35:51** T51: 0:00	**Refer to Appendix A10**
Dwelling 1694	**31:41**	60	0:42	**Yes**	T8: 0:00 **T10: 31:41**	**Refer to Appendix A11**
Dwelling 1870	24:52	50	0:39	No	**T22: 24:52** T44: 0:00	**Refer to Appendix A12**
Dwelling 1871	26:53	53	0:40	No	**T22: 26:53** T44: 0:00	**Refer to Appendix A13**

TXX: XX:XX Turbine = No hours of shadow flicker

TXX: XX:XX Turbine = Shadow Flicker < 30 hours / year

TXX: XX:XX Turbine = Shadow Flicker > 30 hours / year

Table 04 – Results of Shadow Flicker Assessment - Non-associated Dwellings

4.3 Overview of Turbines causing Shadow Flicker

A total of six (6) turbines were identified as contributing to shadow flicker levels exceeding 30 hours per year at non-associated dwellings. A summary of these turbines is provided in **Table 05**. Detailed graphical outputs illustrating the predicted shadow flicker durations for each of these turbines are included in **Appendix B**.

Dwelling ID:	Total Shadow Hours Per Year:	Notes:
Turbine 10	**31:41 (Dwelling 1694)**	Calendar indicates turbine 10 will have the potential to cause shadow flicker to Dwelling 1694 between the hours of 7 pm and 8 pm in the months of Feb - early March and 6pm - 8pm in the months of October until early November. Refer to **Appendix B, Figure 20**.
Turbine 18	**35:51 (Dwelling 1401)**	Calendar indicates turbine 18 will have the potential to cause shadow flicker to Dwelling 1401 between the hours of 7:30 am - 8:30 am in the months of mid-April to mid-May and late July to late August. Refer to **Appendix B, Figure 21.**
Turbine 22	**48:51 (Dwelling 662)**	Calendar indicates turbine 22 will have the potential to cause shadow flicker to Dwelling 662 between the hours of 6:30 am until 8 am in the months of November until early February. Refer to **Appendix B, Figure 22.**
Turbine 45	**55:43 (Dwelling 192)**	Calendar indicates turbine 45 will have the potential to cause shadow flicker to Dwelling 192 between the hours of 4 pm until 5 pm between the months of late April until mid August. Refer to **Appendix B, Figure 23.**
Turbine 47	**33:52 (Dwelling 192)** **48:29 (Dwelling 203)**	Calendar indicates turbine 47 will have the potential to cause shadow flicker to Dwelling 192 between the hours of 7:30 pm until 8:30 pm between the months of late November until mid January. Turbine 47 will also have the potential to cause shadow flicker to Dwelling 203 between the hours of 4 pm and 5 pm in late April to mid June, then July until mid August. Refer to **Appendix B, Figure 24.**
Turbine 70	**41:54 (Dwelling 49)**	Calendar indicates turbine 70 will have the potential to cause shadow flicker to Dwelling 49 between the hours of 7 pm and 8 pm between the months of January and February and then late October to early December. Refer to **Appendix B, Figure 25.**

Table 05 – Results of shadow flicker from turbines

5.0 Summary & Recommendations

5.1 Summary of Results

A total of 13 non-associated dwellings were identified within the Study Area of 1,139.5 m from the nearest turbine.

The shadow flicker was assessed for each of the 13 dwellings, identifying that a total of six (6) non-associated dwellings had the potential to experience shadow flicker levels exceeding 30 hours per year. These dwellings are:

- Dwelling 49
- Dwelling 192
- Dwelling 203
- Dwelling 662
- Dwelling 1401
- Dwelling 1694

5.2 Recommendations

A total of six (6) turbines were identified as contributing to over 30 hours per year of shadow flicker at at six (6) non-associated dwellings. It is noted that the status of dwellings can change over time, for instance if ownership changes between host and non-associated landowners, or if a non-associated landowner enters into a Neighbour Agreement. These recommendations are based on the status of dwellings at the time of this report. The turbines contributing to shadow flicker in excess of the limit include T10, T18, T22, T45, T47 and T70.

Aerial Imagery has determined that intervening vegetation is likely to limit visibility of turbines T47 and T70 from the dwellings identified as having potential shadow flicker. It is recommended on site inspections are undertaken at these dwellings to ground truth the aerial imagery.

Operational controls are recommended to be implemented for the remaining turbines (T10, T18, T22 and T45) to prevent shadow flicker during identified periods of potential exceedance at nearby sensitive receptors. These controls may include automated turbine shutdowns during critical sun angles and times of day to ensure compliance with shadow flicker thresholds.

An overview of recommendations has been provided in **Table 06**.

Dwelling ID:	Total Shadow Hours Per Year:	Recommendation:
Turbine 10	**31:41 (Dwelling 1694)**	Consider applying turbine curtailment during periods when shadow flicker at Dwelling 1694 may exceed acceptable limits, ensuring impacts remain within guideline thresholds.
Turbine 18	**35:51 (Dwelling 1401)**	Consider applying turbine curtailment during periods when shadow flicker at Dwelling 1401 may exceed acceptable limits, ensuring impacts remain within guideline thresholds.
Turbine 22	**48:51 (Dwelling 662)**	Consider applying turbine curtailment during periods when shadow flicker at Dwelling 662 may exceed acceptable limits, ensuring impacts remain within guideline thresholds.
Turbine 45	**55:43 (Dwelling 192)**	Consider applying turbine curtailment during periods when shadow flicker at Dwelling 192 may exceed acceptable limits, ensuring impacts remain within guideline thresholds.
Turbine 47	**33:52 (Dwelling 192)** **48:29 (Dwelling 203)**	Aerial imagery indicates intervening vegetation may reduce visibility of turbine 47 from both Dwelling 192 and 203. It is recommended ground truthing of intervening vegetation is undertaken on site to determine level of visibility of turbine 47 from dwellings.
Turbine 70	**41:54 (Dwelling 49)**	Aerial imagery indicates intervening vegetation may reduce visibility of turbine 70 from Dwelling 49. It is recommended ground truthing of intervening vegetation is undertaken on site to determine level of visibility of turbine 70 from the dwelling.

Table 06 – Recommendations to mitigate shadow flicker

These findings are subject to the parameters assumed for this study. It is recommended that this study is repeated if any of the following changes are made relative to the input parameters used in this study:

- overall tip height is greater than 250.5 m
- blade length is greater than 91.5 m
- final turbine locations change more than 50 m
- additional non-involved dwellings are identified

References

Environment Protection and Heritage Council (EPHC) & National Wind Farm Development Guidelines Steering Committee, *Draft National Wind Farm Development Guidelines* (July 2010).

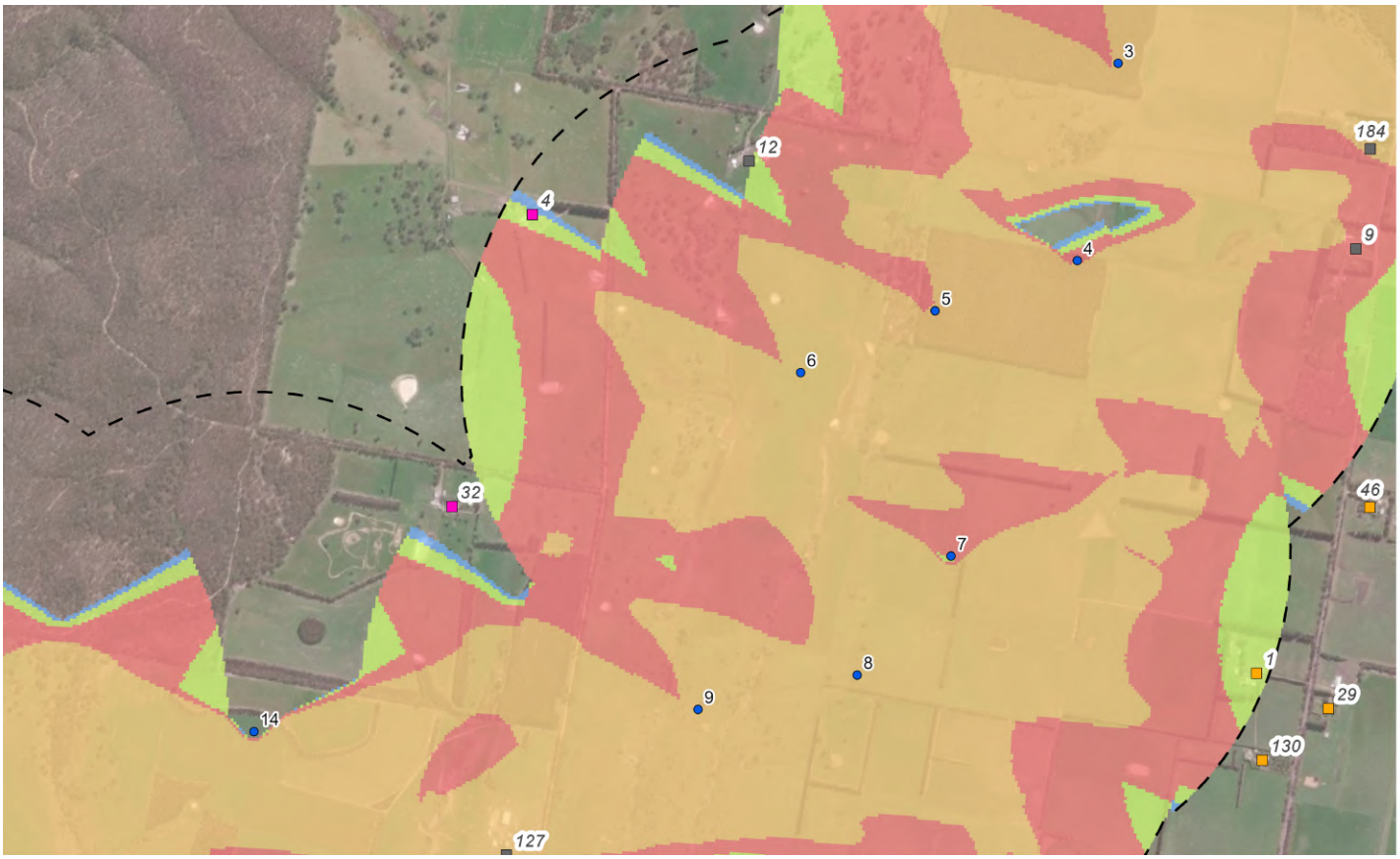
ACCIONA Energía, 2025. *Tall Tree Wind Farm*. [online] Available at: https://community.acciona.com.au/talltree [Accessed 01 May 2025].

Google Earth [Accessed 01 May 2025]

Appendix A

Shadow Flicker Assessments at Non-associated Dwellings

A.1 Dwelling 4



Acciona Layout Reference: IPAUSVICXXTTR20241022

Figure 05 Shadow Flicker Diagram - Dwelling 4

Legend

- Wind Turbine (WTG)

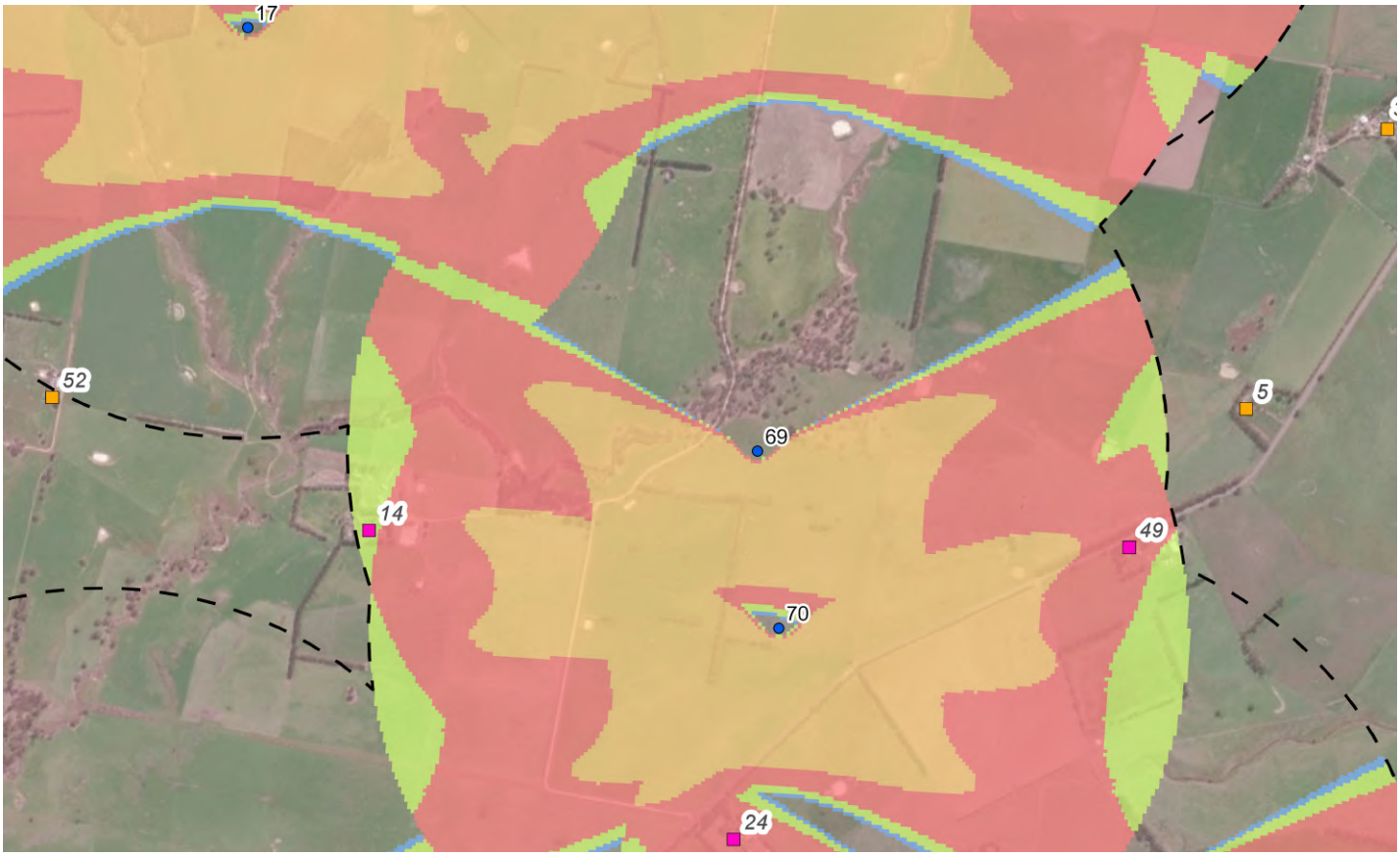
Shadow Flicker Hours Per Year:

- 0.1 - 10 hrs
- 10 - 30 hrs
- 30 - 100 hrs
- 100 - 2000 hrs

Aerial Image - Dwelling 4

(Source Google Earth 2025, Imagery Date 08.01.2023)

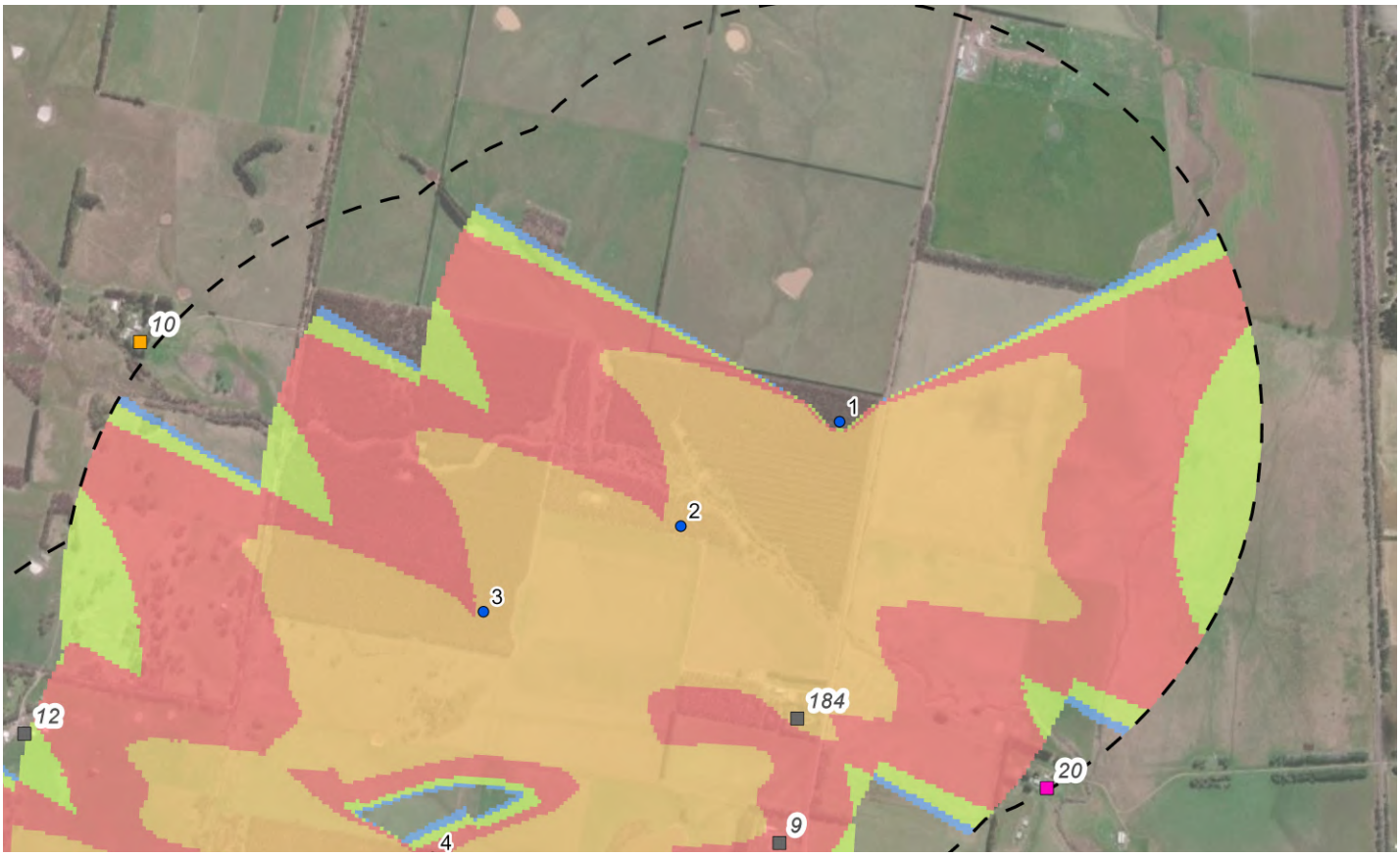
A.2 Dwelling 14



Acciona Layout Reference: IPAUSVICXXTTR20241022

Figure 06 Shadow Flicker Diagram - Dwelling 14

A.3 Dwelling 20



Acciona Layout Reference: IPAUSVICXXTTR20241022

Figure 07 Shadow Flicker Diagram - Dwelling 20

0 0.3 0.5 0.8 1 km

Legend

- Wind Turbine (WTG)

Shadow Flicker Hours Per Year:

- 0.1 - 10 hrs
- 10 - 30 hrs
- 30 - 100 hrs
- 100 - 2000 hrs

A.4 Dwelling 32

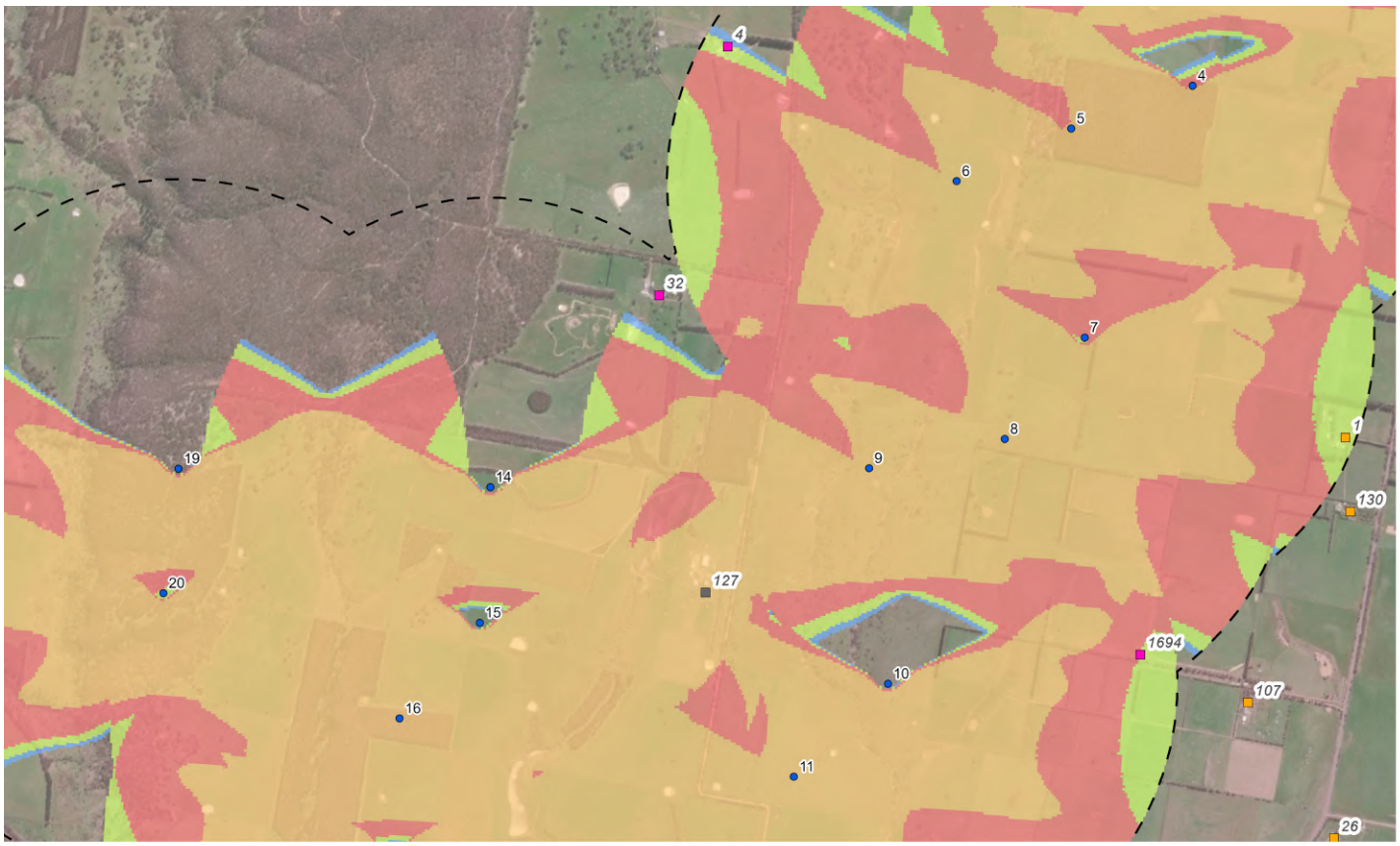


Figure 08 Shadow Flicker Diagram - Dwelling 32

Legend

- Wind Turbine (WTG)

Shadow Flicker Hours Per Year:

- 0.1 - 10 hrs
- 10 - 30 hrs
- 30 - 100 hrs
- 100 - 2000 hrs

A.5 Dwelling 49

Figure 09 Shadow Flicker Diagram - Dwelling 49

Legend

- Wind Turbine (WTG)

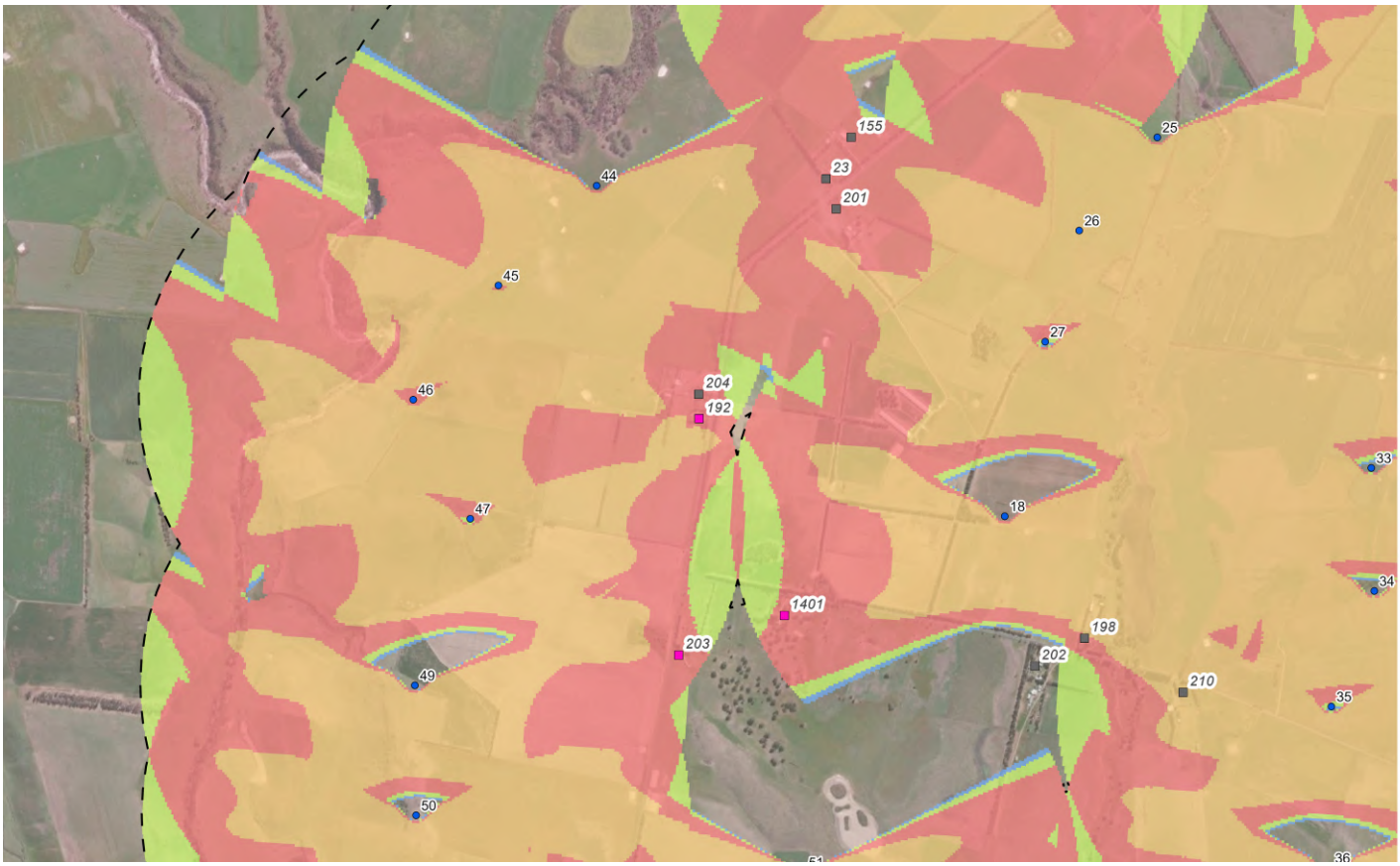
Shadow Flicker Hours Per Year:

- 0.1 - 10 hrs
- 10 - 30 hrs
- 30 - 100 hrs
- 100 - 2000 hrs

Aerial Image - Dwelling 49

(Source Google Earth 2025, Imagery Date 08.01.2023)

A.6 Dwelling 192



Acciona Layout Reference: IPAUSVICXXTTR20241022

Figure 10 Shadow Flicker Diagram - Dwelling 192

0 0.3 0.5 0.8 1 km

Legend

- Wind Turbine (WTG)

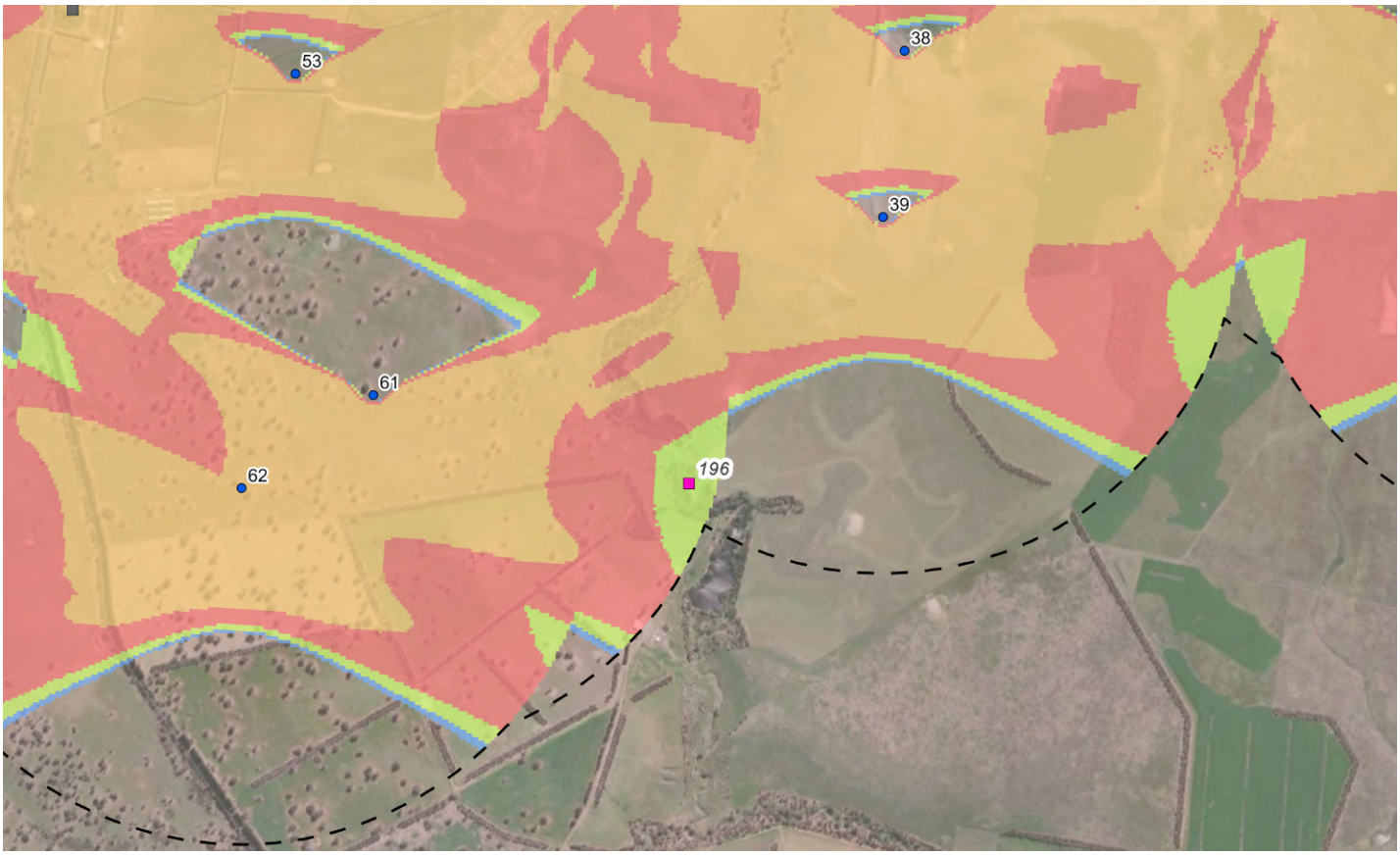
Shadow Flicker Hours Per Year:

- 0.1 - 10 hrs
- 10 - 30 hrs
- 30 - 100 hrs
- 100 - 2000 hrs

Aerial Image - Dwelling 192

(Source Google Earth 2025, Imagery Date 08.01.2023)

A.7 Dwelling 196



Acciona Layout Reference: IPAUSVICXXTTR20241022

Figure 11 Shadow Flicker Diagram - Dwelling 196

Legend

- Wind Turbine (WTG)

Shadow Flicker Hours Per Year:

- 0.1 - 10 hrs
- 10 - 30 hrs
- 30 - 100 hrs
- 100 - 2000 hrs

A.8 Dwelling 203

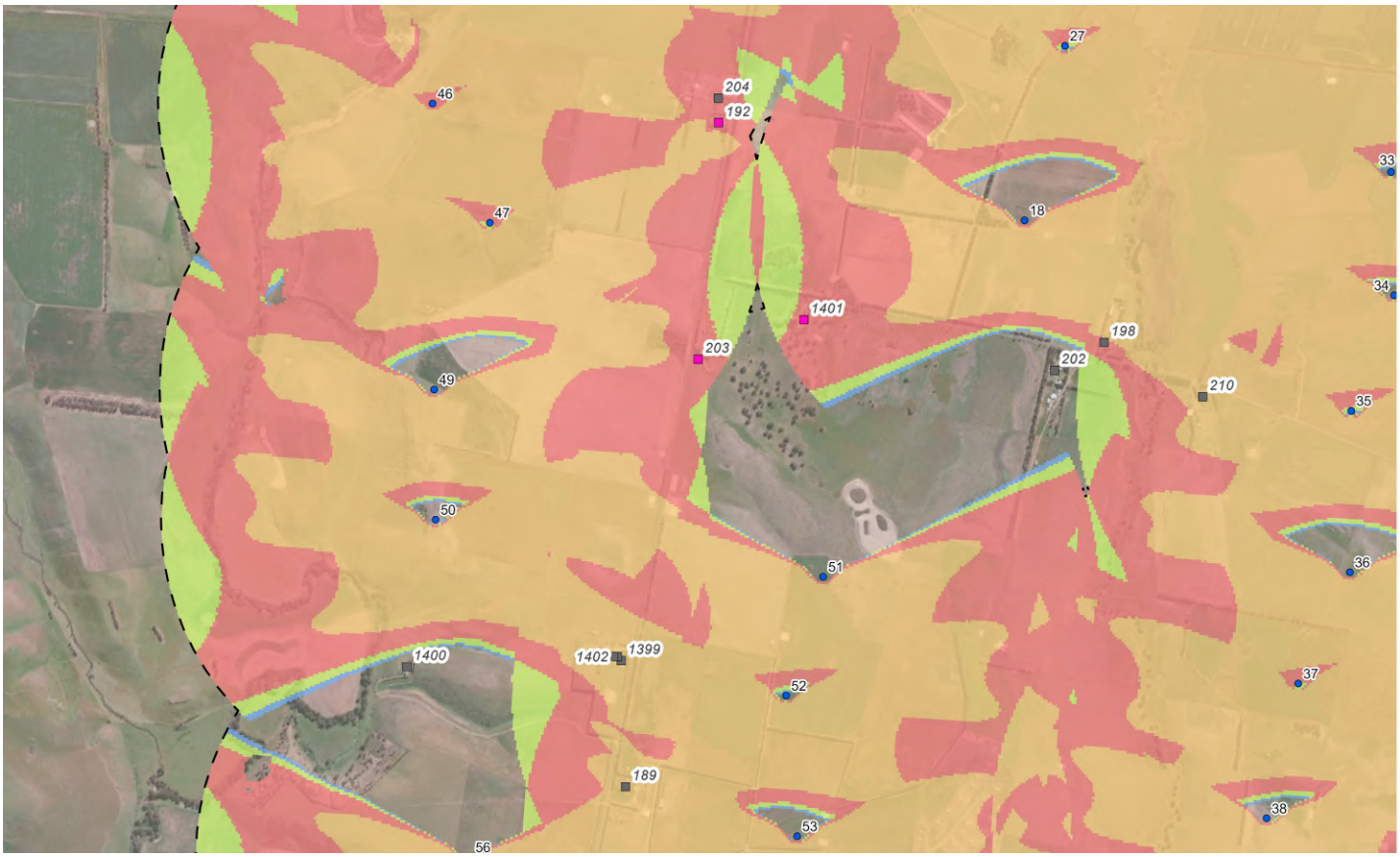


Figure 12 Shadow Flicker Diagram - Dwelling 203

Legend

- Wind Turbine (WTG)

Shadow Flicker Hours Per Year:

- 0.1 - 10 hrs
- 10 - 30 hrs
- 30 - 100 hrs
- 100 - 2000 hrs

Aerial Image - Dwelling 203

(Source Google Earth 2025, Imagery Date 08.01.2023)

A.9 Dwelling 662

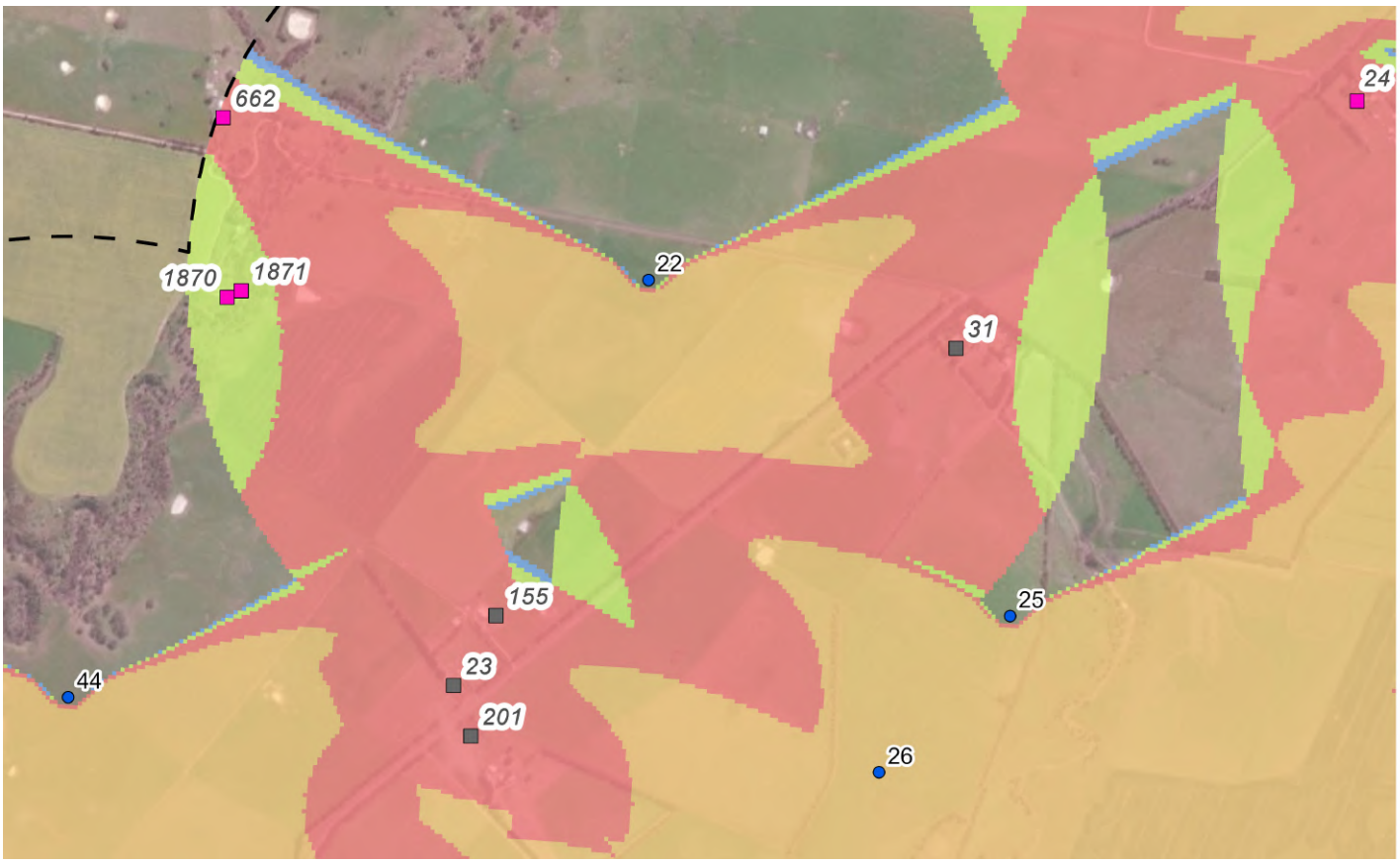


Figure 13 Shadow Flicker Diagram - Dwelling 662

0 0.3 0.5 0.8 1 km

Legend

- Wind Turbine (WTG)

Shadow Flicker Hours Per Year:

- 0.1 - 10 hrs
- 10 - 30 hrs
- 30 - 100 hrs
- 100 - 2000 hrs

Aerial Image - Dwelling 662

(Source Google Earth 2025, Imagery Date 08.01.2023)

A.10 Dwelling 1401

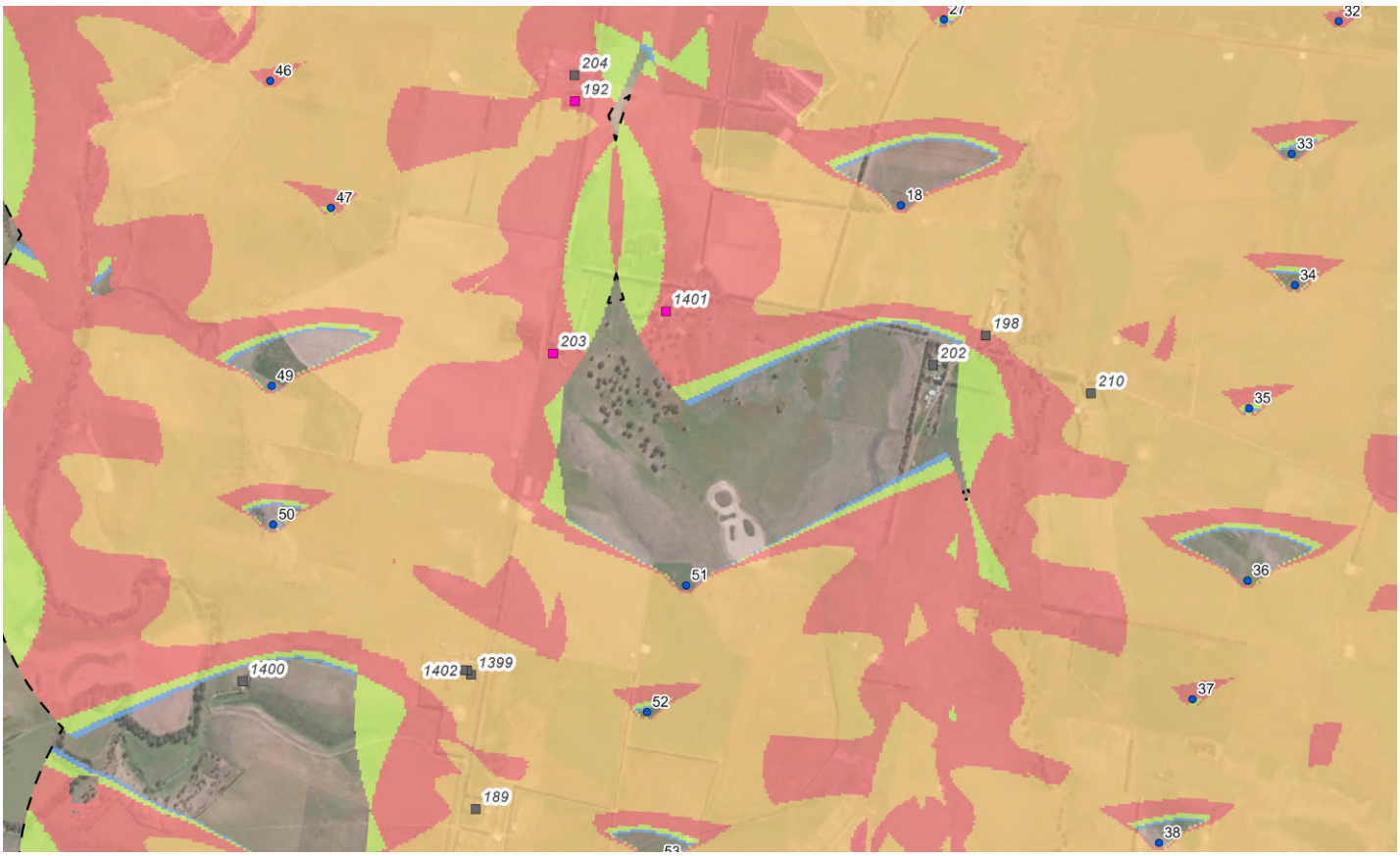


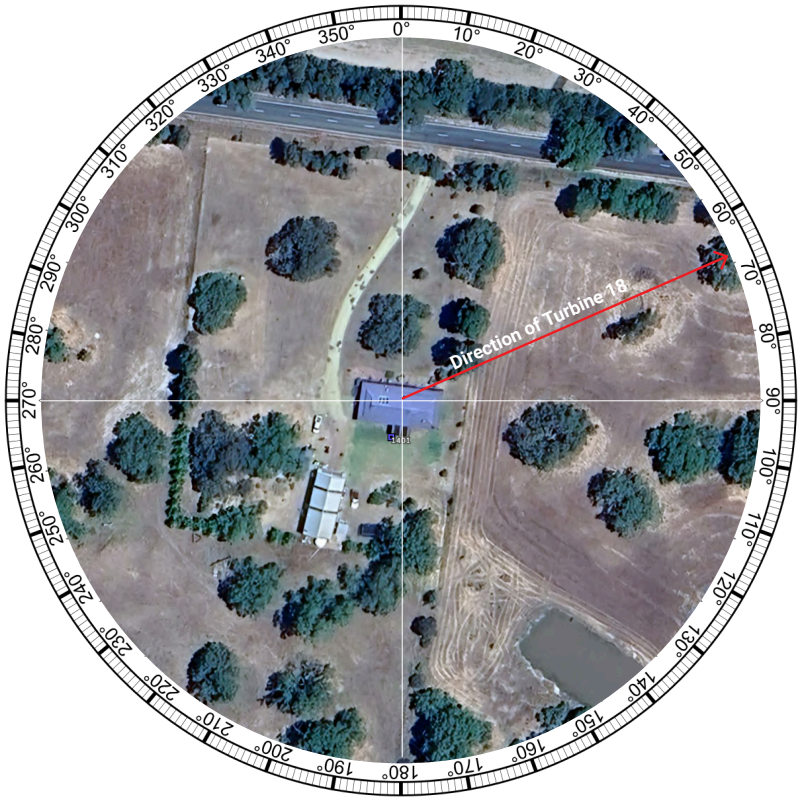
Figure 14 Shadow Flicker Diagram - Dwelling 1401

Legend

- Wind Turbine (WTG)

Shadow Flicker Hours Per Year:

- 0.1 - 10 hrs
- 10 - 30 hrs
- 30 - 100 hrs
- 100 - 2000 hrs



Aerial Image - Dwelling 1401

(Source Google Earth 2025, Imagery Date 08.01.2023)

A.11 Dwelling 1694

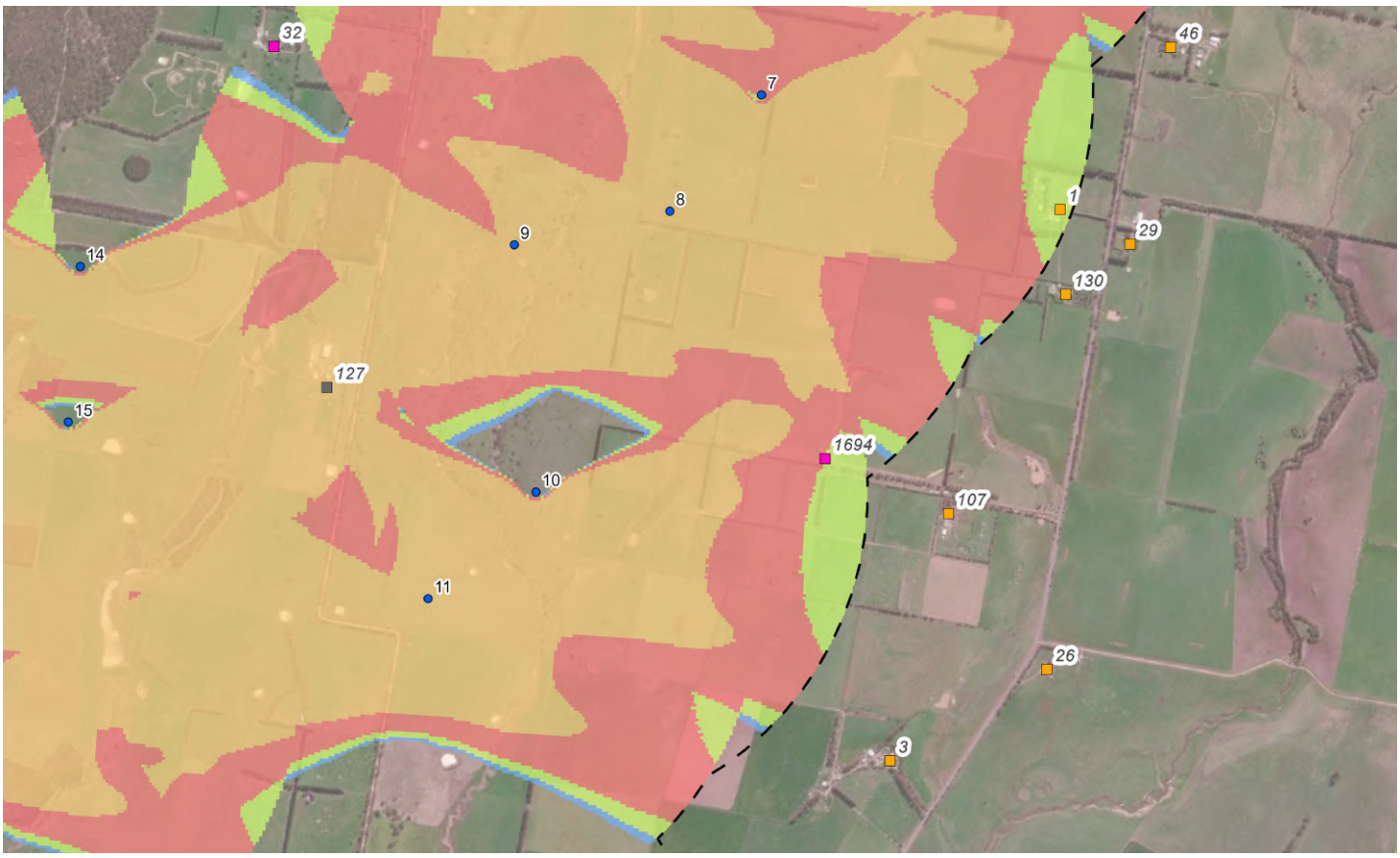


Figure 15 Shadow Flicker Diagram - Dwelling 1694

0 0.3 0.5 0.8 1 km

Legend

- Wind Turbine (WTG)

Shadow Flicker Hours Per Year:

- 0.1 - 10 hrs
- 10 - 30 hrs
- 30 - 100 hrs
- 100 - 2000 hrs

Aerial Image - Dwelling 1694

(Source Google Earth 2025, Imagery Date 08.01.2023)

A.12 Dwelling 1870

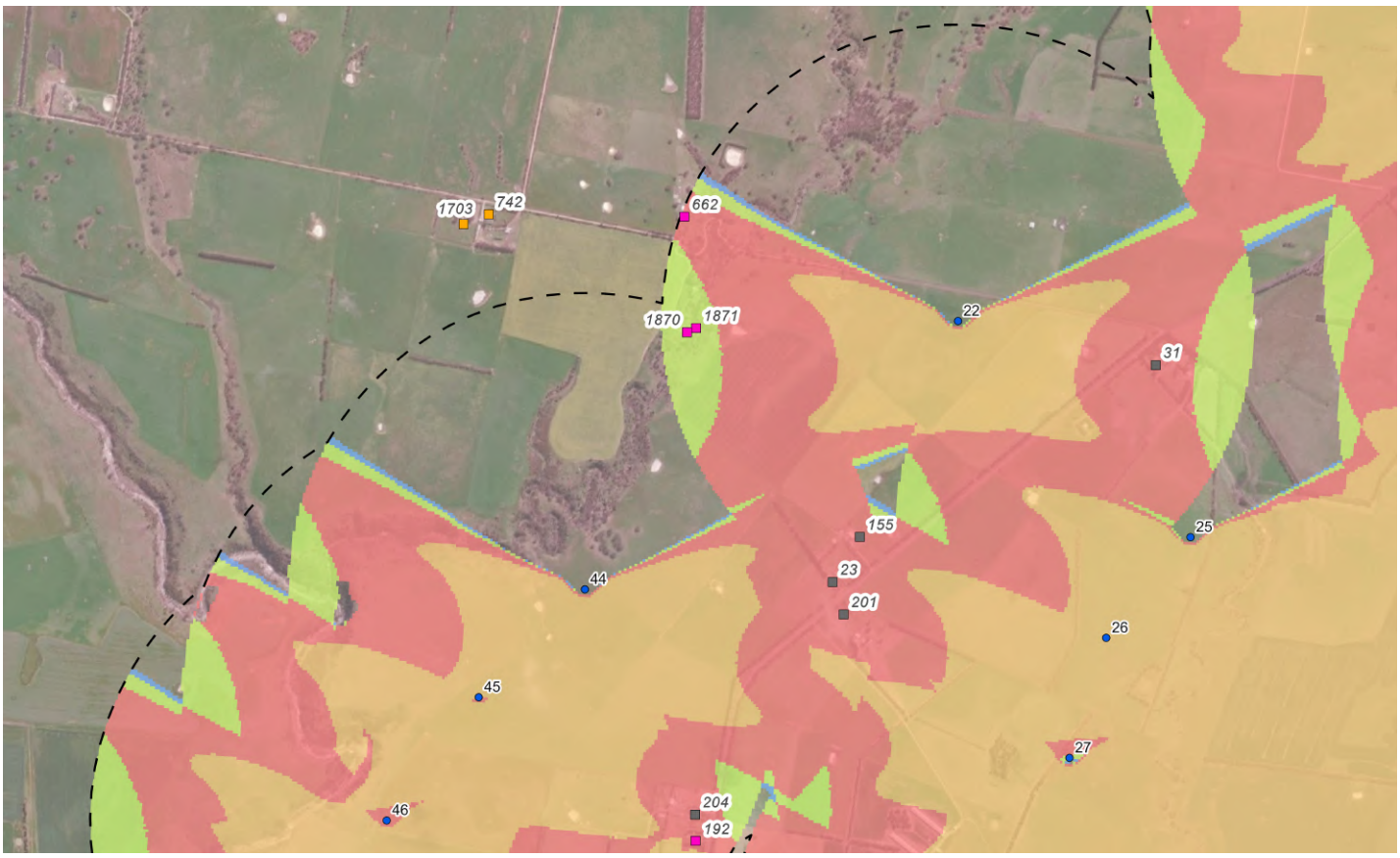


Figure 16 Shadow Flicker Diagram - Dwelling 1870

Legend

- Wind Turbine (WTG)

Shadow Flicker Hours Per Year:

- 0.1 - 10 hrs
- 10 - 30 hrs
- 30 - 100 hrs
- 100 - 2000 hrs

A.13 Dwelling 1871

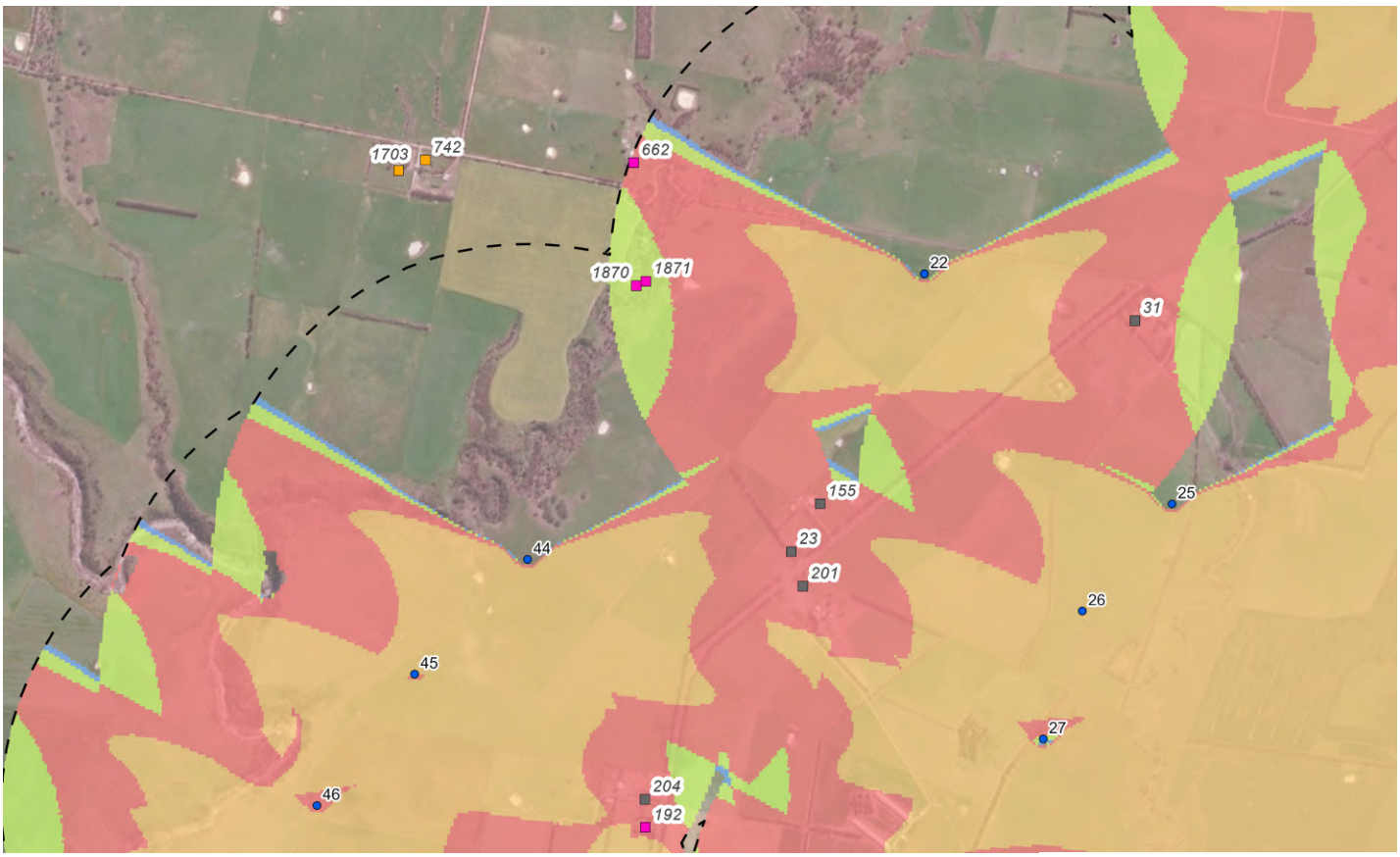


Figure 17 Shadow Flicker Diagram - Dwelling 1871

Legend

- Wind Turbine (WTG)

Shadow Flicker Hours Per Year:

- 0.1 - 10 hrs
- 10 - 30 hrs
- 30 - 100 hrs
- 100 - 2000 hrs

Appendix B

Shadow Calendar Per Turbine - Graphical

Turbine 10

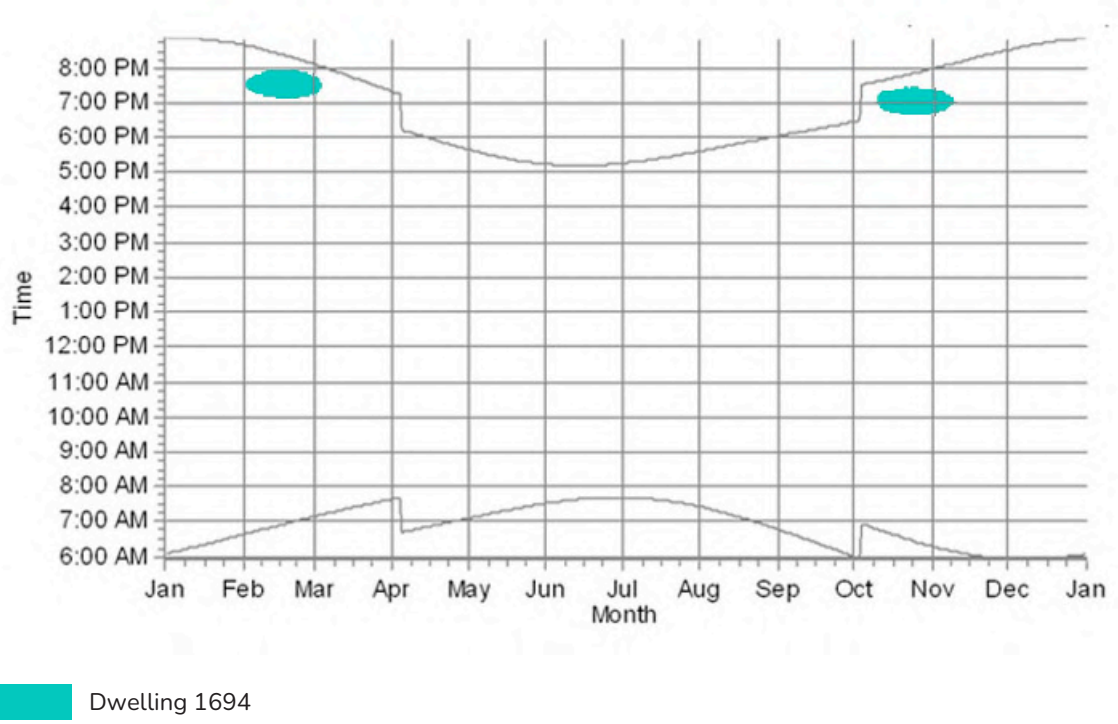


Figure 18 Graphical Hours Per Year - Turbine 10

Turbine 18

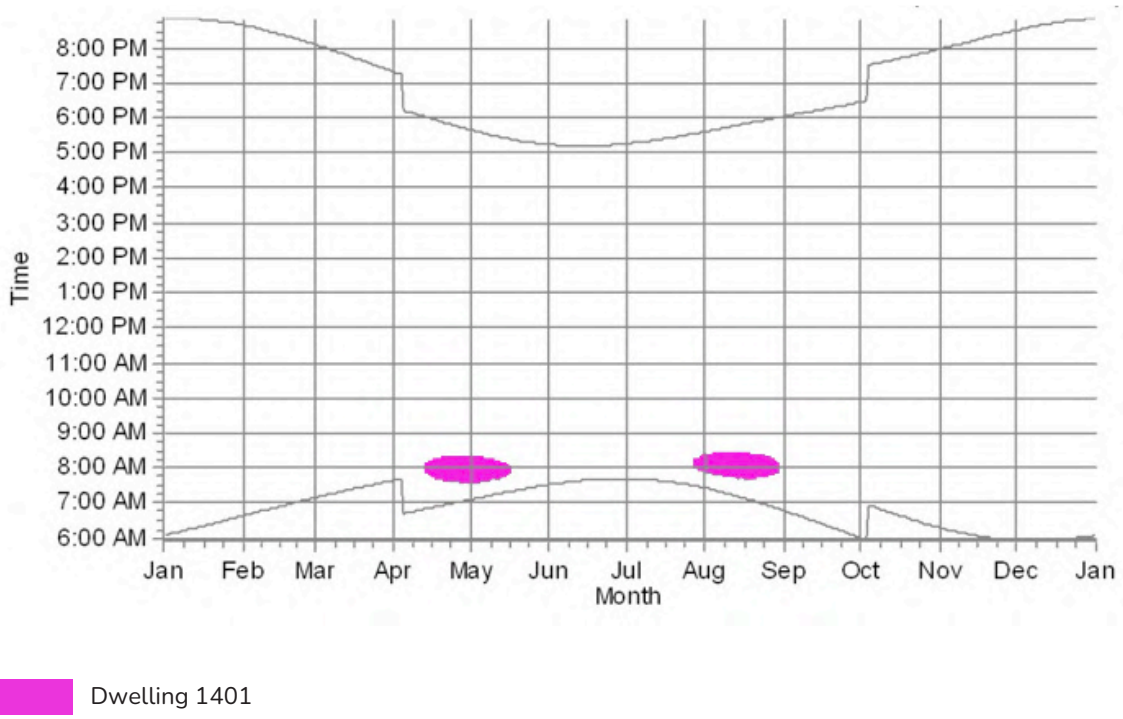


Figure 19 Graphical Hours Per Year - Turbine 18

Turbine 22

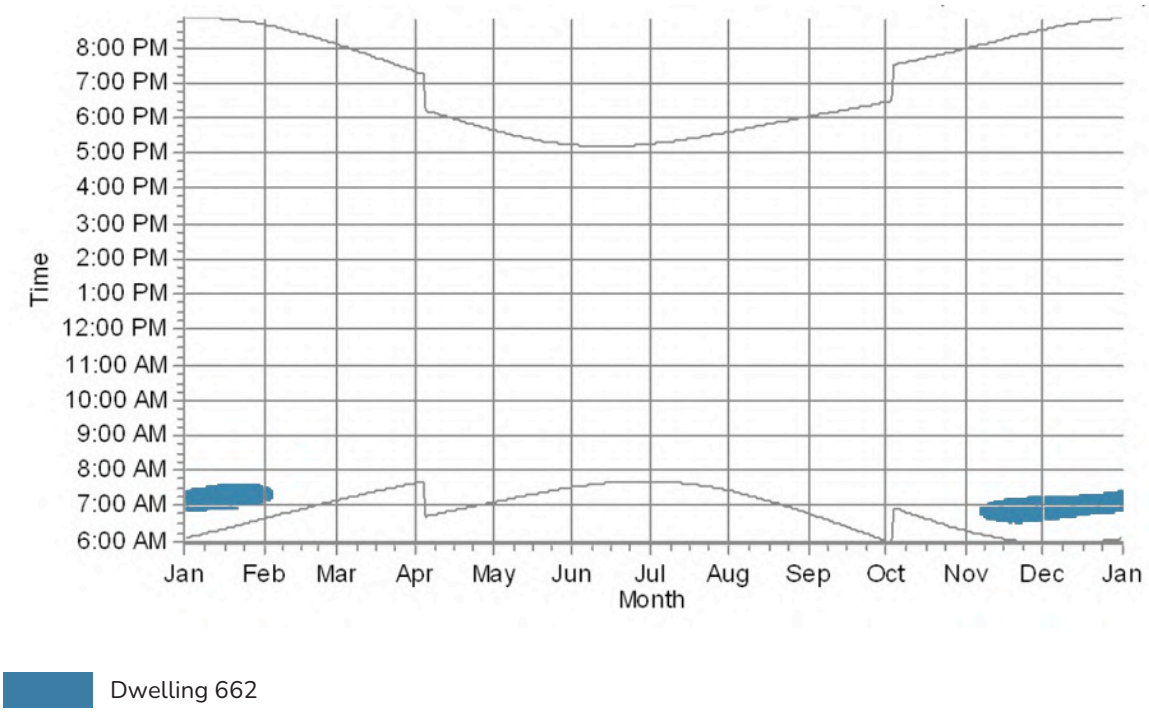


Figure 20 Graphical Hours Per Year - Turbine 22

Turbine 45

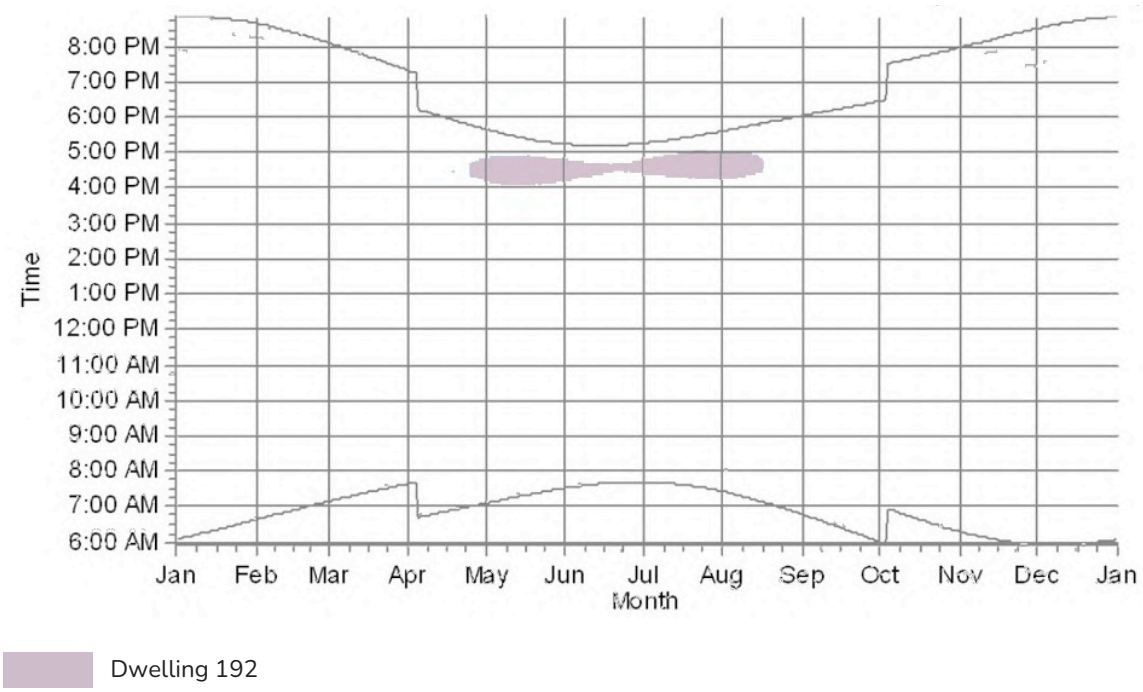


Figure 21 Graphical Hours Per Year - Turbine 45

Turbine 47

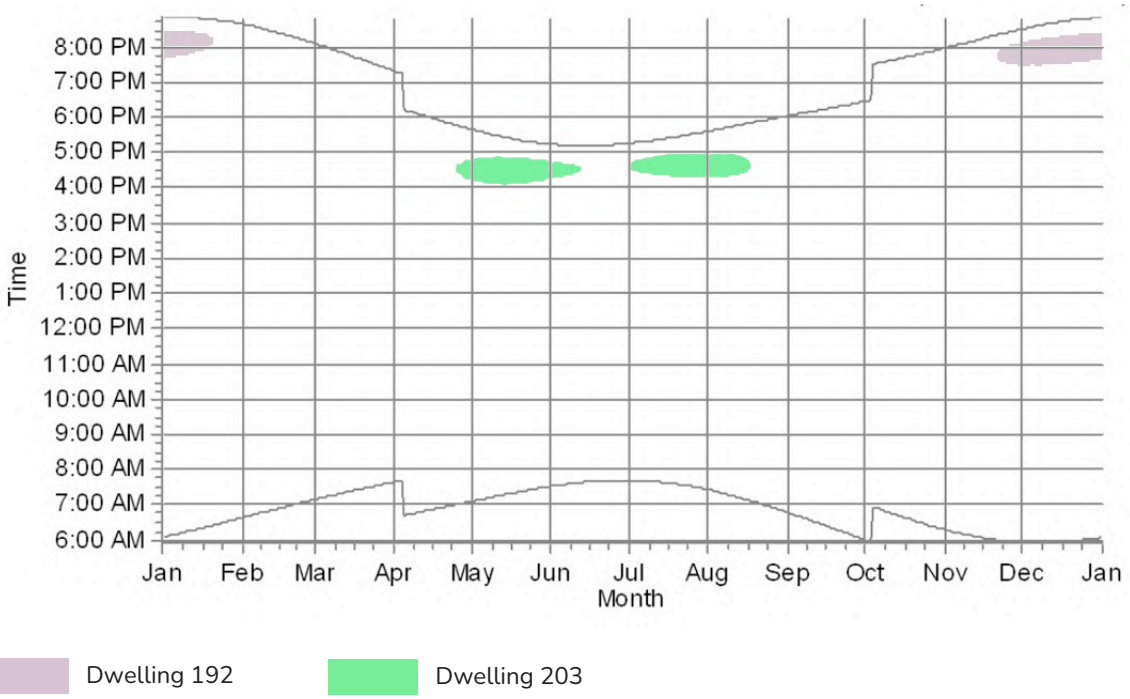


Figure 22 Graphical Hours Per Year - Turbine 47

Turbine 70

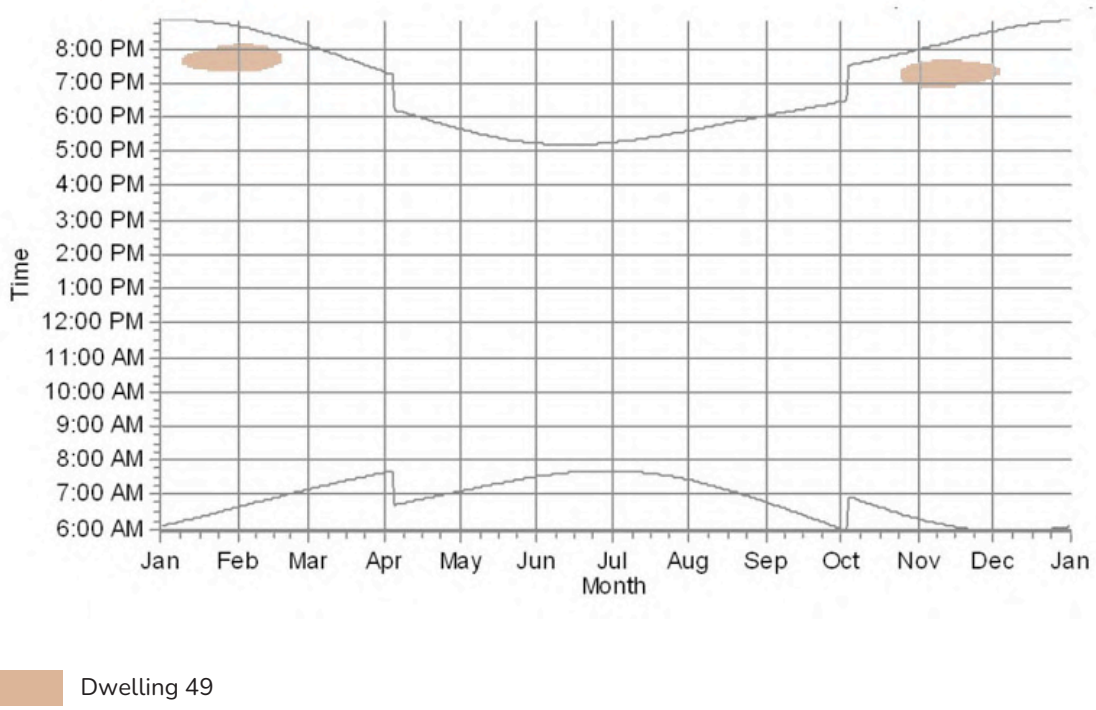


Figure 23 Graphical Hours Per Year - Turbine 70